Volume 9, Issue 7, July – 2024 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1844

Evaluating Interior Space Perception using Virtual Reality

[1]Rehab Moussa
Assistant Professor, College of Engineering
University of Buraimi
Buraimi, OMAN

[2]Ahmed Kandil
Assistant Professor, College of Engineering
University of Buraimi
Buraimi, OMAN

Abstract:- This study evaluates the effectiveness of Virtual Reality (VR) in enhancing spatial perception compared to traditional 2D representations in the context of interior design education. Conducted with Interior Architecture students at the University of Buraimi, the research utilized the Oculus Quest 2 VR headset to create an immersive environment. Participants assessed various spatial characteristics, such as depth, scale, and spatial relationships, using both printed materials and VR immersion. Findings indicate that VR significantly improves the accuracy and realism of spatial perception, providing a more comprehensive understanding of interior spaces. This research contributes to the growing body of knowledge on VR applications in architectural education, highlighting its potential benefits and challenges.

Keywords:- *Space Perception, Virtual Reality, Color Tone Impact, Interior Space.*

I. INTRODUCTION

The advancement of technology has significantly impacted various fields, including architecture and interior design. One of the most promising technologies in this realm is Virtual Reality (VR), which offers immersive experiences that can transform the way we perceive and interact with space. This paper aims to explore the effectiveness of VR in enhancing spatial perception compared to traditional methods.

Virtual Reality has the potential to revolutionize architectural education and practice by providing a realistic and immersive environment where users can experience spaces as if they were physically present. This study focuses on evaluating the spatial perception of Interior Architecture students at the University of Buraimi, Sultanate of Oman, using the Oculus Quest 2 VR headset. The primary objective is to compare the students' perception of spaces presented through printed materials with those experienced through VR immersion.

To achieve this, a comprehensive questionnaire was designed and administered to the students. The questionnaire assesses various aspects of spatial perception, such as depth, scale, and spatial relationships. By analyzing the responses, the study seeks to determine whether VR provides a more accurate and enhanced understanding of space compared to traditional 2D representations.

The findings of this research will contribute to the growing body of knowledge on the application of VR in architectural education and practice. It will also provide insights into the potential benefits and challenges of integrating VR technology into the curriculum of Interior Architecture programs. Ultimately, this study aims to highlight the significance of VR as a tool for improving spatial perception and its implications for the future of architectural design and education.

Fig 1 Oculus Quest 2 VR Headset used in the Study.

II. METHODOLOGY

The methodology section of this paper outlines the systematic approach taken to evaluate the space perception of Interior Architecture students using Virtual Reality (VR) and traditional printed materials. The study was conducted in several phases, including the selection of participants, the preparation of materials, the administration of the questionnaire, and the analysis of data.

A. Participant Selection

Participants for this study were selected from the Interior Architecture program at the University of Buraimi. A total of 20 students, comprising undergraduate different levels, were chosen to ensure a diverse sample representing different stages of their academic journey.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1844

B. Preparation of Materials

Two sets of materials were prepared for the evaluation:

- *Printed Materials:*

Detailed architectural plans and 2D images of a selected space were printed and provided to the participants. These materials were designed to represent the spatial characteristics and dimensions of the spaces accurately as possible.

- *Virtual Reality Environment:*

The same space was recreated in a VR environment using 3D modeling software. The VR environment was accessible through the Oculus Quest 2 headset, allowing participants to navigate and experience the space immersively.

C. Administration of the Questionnaire

The study employed a simple questionnaire designed to assess various aspects of space perception, including depth perception, scale, spatial relationships, and overall spatial understanding. The questionnaire was administered in two sessions:

- *Session 1 (Printed Materials):*

Participants first reviewed the printed materials and then completed the questionnaire based on their perception of the space.

- *Session 2 (Virtual Reality):*

After a brief interval, participants experienced the same space using the Oculus Quest 2 VR headset. They were then asked to complete the same questionnaire, focusing on their perception while immersed in the VR environment.

D. Data Analysis

The responses from the questionnaire were collected and analyzed using statistical methods to compare the space perception between the two conditions (printed materials and VR). Limitations

The study acknowledges potential limitations, such as the sample size and the specific characteristics of the chosen space, which may affect the generalizability of the findings. Future research could expand on this study by including a larger and more diverse sample and exploring different types of spaces.

This methodology provides a structured approach to evaluate the effectiveness of VR in enhancing space perception and offers a basis for further research in the field of architectural education and practice.

III. PERCEPTIONS OF SPACE BASED ON 2D IMAGE STUDIES

Various studies on space perception have explored how the use of light and dark colors influences users' spatial experiences. These studies have demonstrated that light colors can enhance the feeling of spaciousness within an environment by reflecting natural light, making surfaces appear larger and more open. Conversely, dark colors tend to absorb light, creating a sense of a smaller, more enclosed space, which can be utilized to achieve a cozy and intimate atmosphere, [1].

To investigate these effects, the space was rendered under different conditions, with variations in the application of light and dark colors on the ceiling and walls. Additionally, simple furniture was incorporated into the space to further enhance spatial perception. This approach aimed to provide a more comprehensive understanding of how color tone impacts the overall perception of space. Fig. 2 to Fig. 9 show the rendered images illustrating the space perceptions based on 2D images according to various studies.

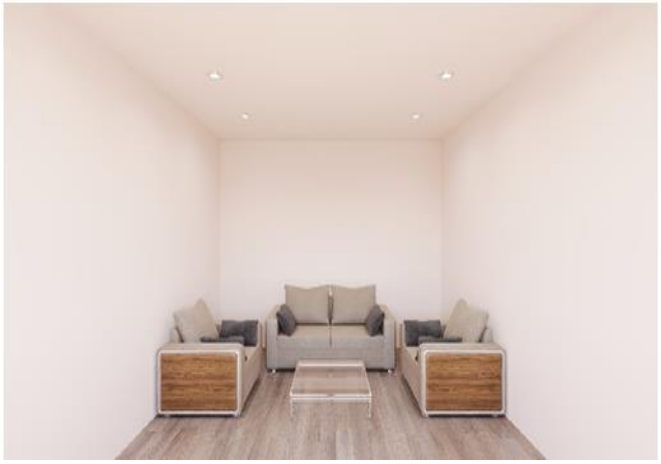

Fig 2 Case A: Increasing the Space Volume (2D image)

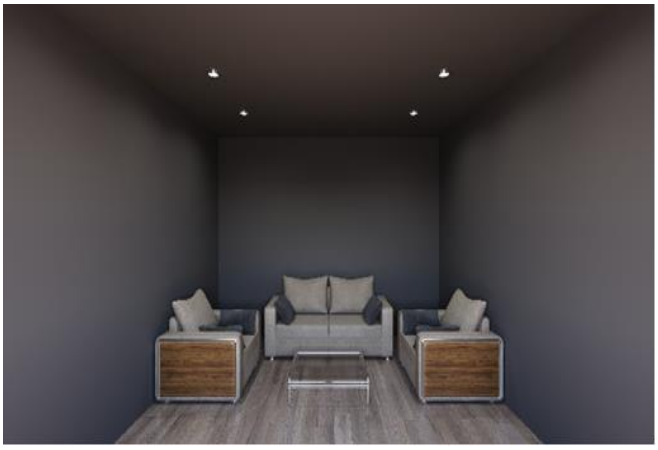

Fig 3 Case B: Decreasing the Space Volume (2D image)

Fig 4 Case C: Decreasing the Height (2D image)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1844

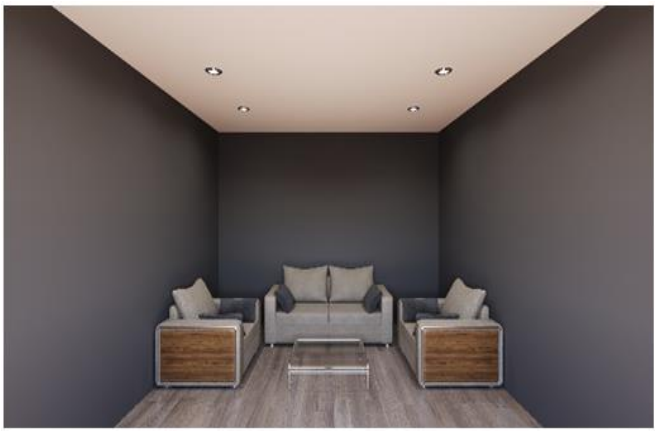
Fig 5 Case D: Increasing the Height (2D image)


Fig 6 Case E: Increasing the Space Volume (2D image)


Fig 7 Case F: Decreasing the Space Volume (2D image)


Fig 8 Case G: Decreasing the Height (2D image)

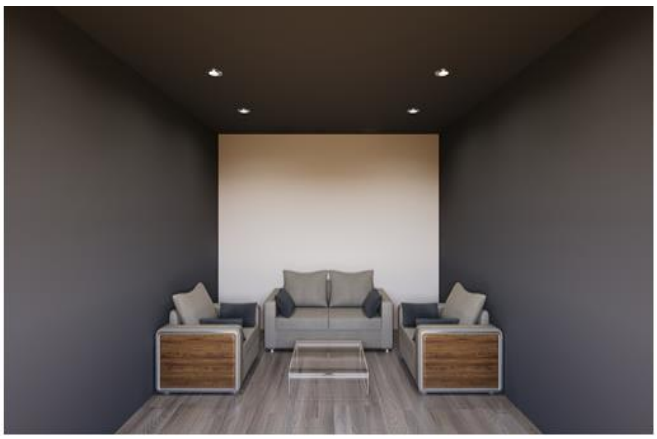
Fig 9 Case H: Increasing the Height (2D image)

These findings are crucial for comparing traditional 2D representations with immersive VR environments, as they establish a baseline for evaluating how similar design elements are perceived across different media.

IV. PERCEPTIONS OF SPACE BASED ON VR INVIRONMENT

The same space that was rendered using 2D images was also rendered as 3D panoramic images to be experienced through a VR environment. The objective was to assess whether the perceptions of spatial characteristics differ when the space is experienced immersively through VR as opposed to traditional 2D representations.

The VR environment was created using high-resolution 3D modeling software to ensure accuracy and consistency with the 2D images previously used. The space was rendered under the same conditions, with variations in the application of light and dark colors on the ceiling and walls, as shown in the attached images. Simple furniture was also included in the VR model to enhance spatial perception and provide context. Fig. 10 to Fig. 17 show the rendered images illustrating the space perceptions based on VR environment.


Fig 10 Case A: Increasing the Space Volume (VR Environment)

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1844


Fig 11 Case B: Decreasing the Space Volume (VR Environment)


Fig 12 Case C: Decreasing the Height (VR Environment)


Fig 13 Case D: Increasing the Height (VR Environment)

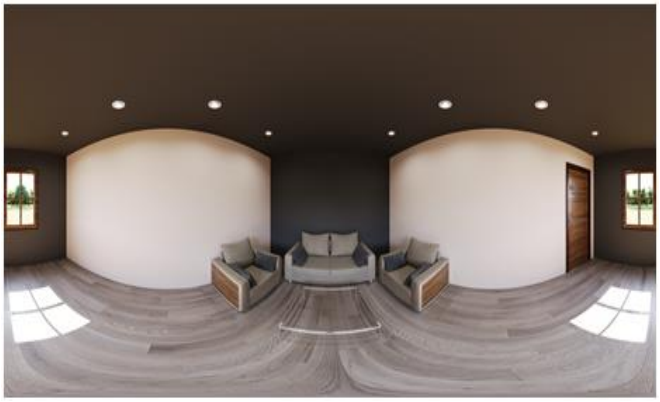
Fig 14 Case E: Increasing the Space Volume (VR Environment)


Fig 15 Case F: Decreasing the Space Volume (VR Environment)


Fig 16 Case G: Decreasing the Height (VR Environment)

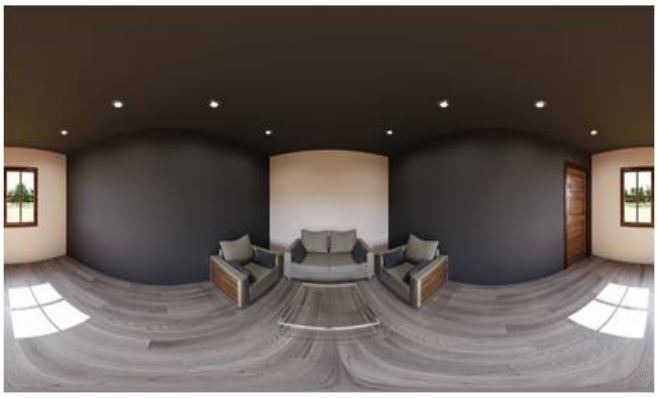
Fig 17 Case H: Increasing the Height (VR Environment)

V. EVALUATION RESULTS

The evaluation process aimed to understand how virtual reality (VR) impacts the perception of interior space compared to traditional 2D representations. The study involved participants evaluating various spatial characteristics under different conditions rendered in VR. The attached table provides a detailed breakdown of the percentage effectiveness of VR images in achieving specific spatial perceptions.

A. Methodology of Evaluation

The VR environment was created to match the same space rendered in 2D images, ensuring consistency across both media. Participants were asked to evaluate the space under eight different conditions:

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1844

- Increasing the Space Volume
- Decreasing the Space Volume
- Decreasing the Height
- Increasing the Height
- Elongating the Space
- Closing the Space
- Shortening the Space
- Highlighting the Wall

Each condition was designed to test specific aspects of spatial perception. Participants rated the effectiveness of VR in achieving these spatial characteristics, and their responses were recorded as percentages.

B. Results

The table 1 summarizes the average percentages across all participants for each condition:

- Increasing the Space Volume: 35.75%
- Decreasing the Space Volume: 24.75%
- Decreasing the Height: 22.75%
- Increasing the Height: 36.25%
- Elongating the Space: 36.00%
- Closing the Space: 34.00%
- Shortening the Space: 43.50%
- Highlighting the Wall: 52.00%

The highest effectiveness was observed in the "Highlighting the Wall" condition, with an average of 52.00%. This indicates that participants found VR particularly effective in emphasizing vertical surfaces. Conversely, "Decreasing the Height" scored the lowest at 22.75%, suggesting that VR may be less effective in conveying reductions in vertical space, Table 1.

Table 1 The Percentage that VR Images Achieved (%)

Student No.	 Case 1 Increasing the Space Volume	 Case 2 Decreasing the Space Volume	 Case 3 Decreasing the Height	 Case 4 Increasing the Height	 Case 5 Elongating the Space	 Case 6 Closing the Space	 Case 7 Shortening the Space	 Case 8 Highlighting the Wall
1	40	20	10	50	40	60	70	80
2	30	15	15	50	40	25	50	40
3	30	10	20	40	40	10	55	30
4	30	20	20	30	35	30	20	35
5	35	20	40	35	30	25	40	35
6	40	25	15	45	45	50	50	45
7	35	20	20	35	30	30	35	50
8	50	45	20	20	35	30	40	70
9	35	25	35	40	35	25	40	40
10	40	25	20	45	40	45	55	60
11	30	35	25	25	20	25	35	50
12	45	20	25	30	40	35	20	50
13	40	25	20	55	40	55	60	70
14	35	20	25	30	40	30	30	40
15	35	25	35	25	35	25	45	50
16	40	30	15	40	45	55	50	55
17	35	20	15	35	25	35	35	60
18	35	40	20	25	35	25	45	70
19	35	30	35	25	35	30	40	50
20	20	25	25	45	35	35	55	60
Average	35.75 %	24.75 %	22.75 %	36.25 %	36.00 %	34.00 %	43.50 %	52.00%

C. Discussion

These results provide valuable insights into how VR can be utilized to enhance spatial perception in interior design. The effectiveness of VR in certain conditions, such as increasing space volume and highlighting walls, supports its use as a powerful tool for visualizing and experiencing design elements. However, the lower effectiveness in conditions like decreasing height suggests areas where VR shows that 2D images do not give a full understanding of the space.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1844

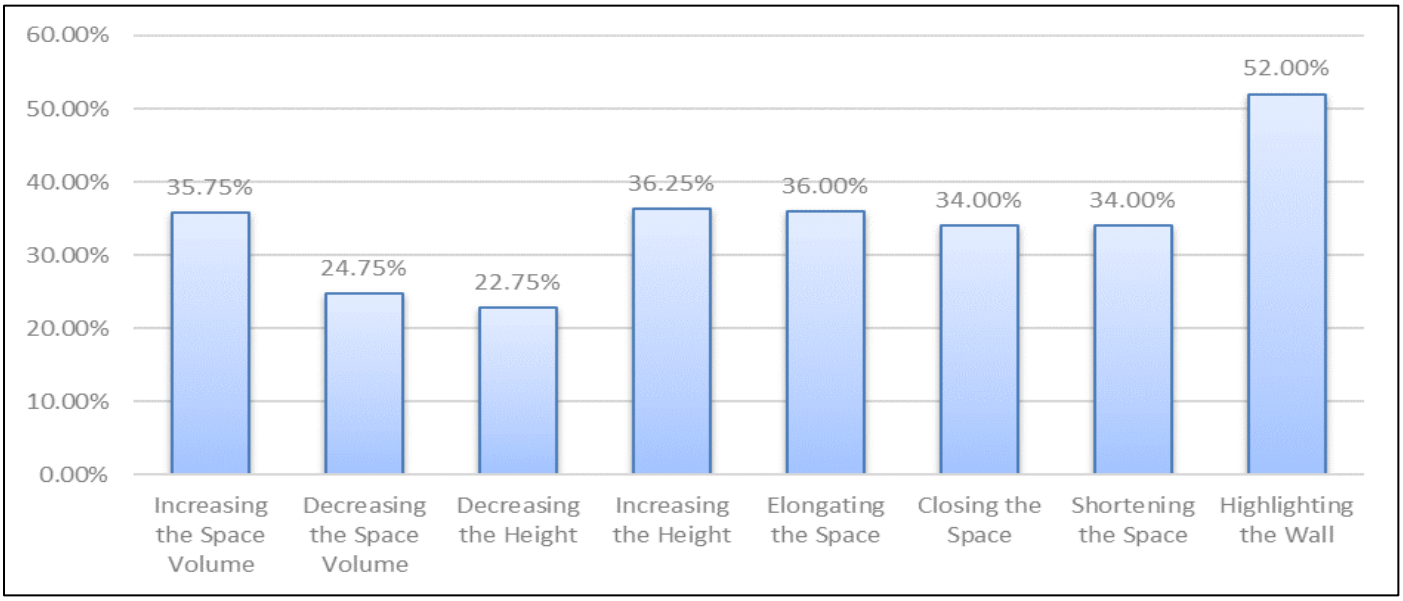

Fig 18 The Results of the Percentage of the VR Environment Achieved Compared to 2D Images.

Additionally, the study shows that relying on 2D images to understand spatial perception is not as accurate as using immersive VR environments. When students were immersed in the virtual space, their perceptions of the spatial characteristics were more effective and realistic compared to the 2D images. This highlights the limitations of 2D images in conveying a true sense of space and reinforces the advantages of VR in providing a more immersive and accurate spatial experience.

Overall, the findings highlight the potential of VR in architectural education and practice, offering a more immersive and accurate way to evaluate and communicate spatial designs compared to traditional 2D methods.

VI. CONCLUSION

The integration of Virtual Reality (VR) in evaluating interior space perception offers significant advancements over traditional 2D methods. This study highlights that VR provides a more comprehensive and realistic experience of space, crucial for both educational and practical applications.

The findings indicate that VR environments enhance the perception of spatial characteristics, such as highlighting walls and increasing space volume, more effectively than 2D images. The immersive nature of VR allows users to experience spaces in a manner that closely mimics real-world interactions, providing a deeper understanding of spatial relationships and dimensions. This is particularly valuable in educational settings, where students can better grasp design principles.

Traditional 2D images often fall short in depicting changes in height and space volume, leading to misinterpretations. In contrast, VR offers a multi-dimensional perspective, enhancing the user's ability to perceive and interact with the space effectively. This capability is valuable for architects and designers in creating compelling presentations, leading to better-informed decision-making and greater client satisfaction.

While VR is effective in many aspects, there are challenges to address, such as improving the representation of certain spatial changes and refining the user experience. Continued advancements in VR technology will likely enhance its capabilities and broaden its applications in design.

In conclusion, VR significantly improves the accuracy and immersion of spatial perception studies, benefiting both education and practice in architectural design. As VR technology evolves, its integration into the design process will become increasingly indispensable, offering new opportunities for innovation in the field.

ACHNOWLEDGMENT

This paper was reviewed and refined with AI assistance to enhance clarity and coherence, reflecting our commitment to leveraging advanced technologies for high-quality scholarly work.

REFERENCES

[1]. ArchDaily, “How Colors Change the Perception of Interior Spaces”, Retrieved from ArchDaily, 2023: https://www.archdaily.com/935067/how-colors-change-the-perception-of-interior-spaces
[2]. Iman Alkhanjari, Reham Sanad, “A Study of Color Impact on Spaceperception”, Journal of Engineering and Architecture, June 2023, Vol. 11, No. 1, pp. 24-28, 2023, USA.
[3]. Fawzi A. Al-Zamil, “The Impact of Design Elements on the perception of spaciousness in Interior Design”, International Design Journal, Volume 7, Issue 2, 2017.
[4]. Ji Young Cho, Joori Suh, “Spatial Ability Performance in Interior Design and Architecture: Comparison of Static and Virtual Reality Modes”, Buildings Journal, 2023.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24JUL1844

[5]. Nattha Savavibool, Chumporn Moorapun, “Effects of Colour, Area, and Height on Space Perception”, E-B, Environment-Behaviour Proceeding Journal, 2017, UK.
[6]. Jingjing Zhang, Xiaoliang Bai, Thammathip Piumsomboon, Simon Hoermann, Ze Dong, Rob Lindeman, “Exploring Spatial Scale Perception in Immersive Virtual Reality for Risk Assessment in Interior Design”, University of Canterbury, 2020, New Zealand.
[7]. Francis D.K. Ching, “Architecture Form, Space, & Order”, John Wiley & Sons, Inc., Third Edition, 2007.
[8]. Ola Hashim, Ashraf Hussain, Rasha Hussein El Sallanty, “Interior Design Perception and Evaluation”, Journal of Design Sciences and Applied Arts, Helwan University, 2022, Egypt.
[9]. AI was used in reviewing the text