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Research Paper

An Analysis of User Experience Based on Physical Environmental Components in VR-Supported Educational Spaces Using a Mixed-Methods Approach

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ABSTRACT

Background: Virtual reality (VR) technology offers an innovative learning environment that enriches user experience in education. However, there is limited research on the impact of physical environmental components within VR-supported educational spaces on user perception and satisfaction.
Objectives: This study aims to evaluate user experience and satisfaction levels in VR-supported educational environments through a mixed-methods approach, focusing on the influence of physical environmental components.
Methodology/Approach: Four distinct VR platforms (Mozilla Hubs, Engage, Meta Horizon, and MeetinVR) were selected as experimental settings. Twenty participants, comprising ten interior architecture students and ten faculty members from Istanbul Gelisim University, received orientation sessions to familiarize themselves with the VR equipment and platforms. Each participant engaged in 10-minute sessions on each platform, experiencing four different virtual environments in total. Following each session, participants completed structured experience questionnaires and open-ended feedback forms addressing physical environmental elements such as material, texture, lighting, form, color, size, and scale. The collected data were analyzed using IBM SPSS and MAXQDA software.
Findings and Discussion: The results demonstrate that the design elements of VR-based learning spaces have a direct effect on user perception and satisfaction. In particular, material, lighting, and scale components play a significant role in enhancing users' sense of realism and educational effectiveness. The study offers practical recommendations for the user-centered design of VR-supported educational environments, contributing to the advancement of virtual learning spaces within interior architecture education.

INTRODUCTION

Virtual Reality (VR) technology has become an increasingly prominent and innovative tool in the field of education in recent years. The potential of VR to deliver course content in a more interactive, participatory, and experiential manner makes it an appealing medium for contemporary educational practices. Numerous studies in the literature emphasize that VR enriches learning, enhances motivation, and supports learners' attention and concentration on course content. However, the majority of existing research primarily focuses on the pedagogical contributions of VR, while the impact of environmental design components of virtual learning spaces on user experience has received limited attention. Yet, the spatial qualities of learning environments play a decisive role in shaping students' spatial perception, sense of belonging, and overall satisfaction.

The aim of this study is to systematically evaluate the influence of design components—such as material, texture, lighting, form, color, size, and scale—on user experience in VR-supported learning environments. In this context, it is essential to examine VR-based educational spaces not only in terms of content but also with regard to their environmental and design characteristics. By highlighting not only the delivery of content but also the way virtual spaces are designed and experienced, this study seeks to address a critical gap in literature. Thus, the research proposes a holistic approach that considers both the pedagogical advantages and the spatial design dimensions of VR-supported learning environments.

This study is specifically situated within the context of higher education. University students represent an appropriate user group, as they are capable of quickly adapting to VR technologies, possess high levels of digital literacy, and are able to critically assess the physical and perceptual components of space. For this reason, interior architecture students and faculty members were selected as the sample group. Interior architecture education equips students with the ability to analyze and interpret spatial components, making them well-suited to evaluate the spatial qualities of VR environments. The inclusion of faculty members, on the other hand, is significant for two reasons: first, their prior experiences and professional perspectives introduce different expectations; second, they are capable of assessing the environments both from an instructional and user standpoint. Accordingly, the study enables a comparative analysis between learner and educator perspectives.

To address these objectives, the research was designed around standardized experimental scenarios conducted across four different VR platforms. Data were collected through both quantitative measures and qualitative feedback, providing insights into how VR-supported learning environments are perceived differently depending on their environmental design features.
The central research question guiding the study is formulated as follows: *"How do environmental design components in VR-supported learning environments influence users' perceptions and levels of satisfaction?"*

The findings indicate that design elements such as material, lighting, and scale have a direct impact on users' sense of realism and educational effectiveness. This result underscores the necessity of reinforcing VR-based learning environments not only through technological infrastructure but also by integrating principles of spatial design.

The unique contribution of this research lies in its shift beyond the pedagogical benefits of VR by focusing on design-oriented spatial components and systematically revealing their impact on user experience. In doing so, the study demonstrates that, in the context of higher education, VR is not only an innovative educational technology but also a transformative design tool capable of redefining the quality of learning spaces.

In conclusion, this research aims to offer recommendations for the future development of VR-based learning environments in higher education, emphasizing user-centered design, spatial quality, and the delivery of multidimensional learning experiences.

Virtual Learning Spaces Enabled by Virtual Reality Technology

Virtual reality (VR) technology offers a student-centered approach that enhances interaction in education and introduces an innovative dimension to learning processes. In VR environments, both students and instructors experience a sense of immersion and real-time engagement, which contributes positively to cognitive learning outcomes. This technology is particularly effective in the comprehension of abstract concepts, the exploration of complex details, and the enhancement of learning motivation (Schwienhorst, 2002).

VR environments provide students with an exploratory learning experience through three-dimensional interactive graphics, facilitated by head-mounted displays, monitor screens, and projection systems. These tools help concretize complex subjects, thereby supporting the retention of knowledge (Aiello, 2012). Moreover, the integration of VR in education aims to improve the efficiency of the learning process in line with pedagogical and psychological principles (Saxena, 2016).

Unlike traditional physical classrooms, virtual classrooms do not contain physical elements such as windows, doors, or walls. This absence facilitates accessibility for individuals with disabilities and enables learners to assume greater responsibility for their own learning processes. Features such as online interaction, screen sharing, and breakout rooms promote collaborative learning and group work. These environments also allow for interaction between students and instructors regardless of time and place (Kaya, 2011; Von Horn, 1997).

VR technology enables the safe and cost-effective simulation of experiences that are difficult or dangerous to conduct in real life. The ability to perform chemistry lab experiments in a virtual environment serves as a notable example. The use of VR in education not only increases student motivation and supports long-term retention, but also facilitates interdisciplinary applications. Fields such as architecture, engineering, and medicine benefit from the three-dimensional exploration of complex structures (Byrne, 1996; McGonigle, 1998).

In conclusion, virtual reality technology holds strong potential for enhancing quality in education, improving accessibility, and strengthening students' cognitive skills. However, the effective implementation of this technology requires careful planning in areas such as content development, technical infrastructure, and instructor training.

The reason this section is specifically structured around the requirements of higher education spaces is that the aim of the study is directly built upon examining the experiences of students and faculty members within higher education institutions in VR-supported learning environments. The university context represents the most suitable setting in which not only the delivery of content but also the impact of spatial and design components on user experience can be holistically observed. While students engage in design-oriented learning experiences firsthand, faculty members contribute both through their pedagogical roles and from the perspective of users. Therefore, the focus on the higher education context directly aligns with the purpose of the research and serves to identify the design criteria and requirements of virtual learning spaces.

Virtual Environments as Learning Spaces in Higher Education and Their Requirements

Virtual learning environments adapt the structure of physical classrooms to the digital world by delivering components such as student interaction, instructional materials, and instructor guidance through online platforms (Mikropoulos et al., 2011). Virtual classrooms transcend the limitations of traditional learning spaces through the use of three-dimensional modeling, simulations, and interactive applications, offering more flexible and accessible learning opportunities. These environments are built upon core

elements such as user interfaces, interaction tools, and content management systems. Tools like text and voice communication, video conferencing, and interactive whiteboards support real-time engagement, while systems such as Moodle, Blackboard, and Canvas facilitate the management of course materials. Simulation and VR technologies allow abstract concepts to be concretely experienced, thus supporting students' deeper learning processes (Dede, 2009). These technological components enhance the quality of interaction within virtual classrooms and contribute to the overall efficiency of learning.

Comfort as perceived in virtual environments differs from that in physical spaces, relying instead on visual, auditory, and tactile elements. Lighting design, through the use of appropriate illumination, reduces eye strain and enhances spatial perception (Graetz, 2006). Color usage directs the psychological tone of the environment and supports learning motivation. Materials and textures enrich the virtual experience by simulating a sense of touch (Jamieson, 2000). Auditory components increase the realism of the space, while feedback sounds strengthen interaction. In addition, the perception of depth and motion supports users' spatial awareness and reduces disorientation or dizziness in virtual settings (Baber, 2020; Ashby, 2011). Haptic feedback technologies further enhance users' ability to interact realistically with virtual objects.

In conclusion, all of these perceptual and sensory elements directly affect the quality of virtual classrooms, learning efficiency, and user satisfaction, positioning virtual environment design as a contemporary field of design in its own right. As the transition from physical to virtual learning spaces continues, it is anticipated that fundamental design criteria will evolve in response to user experience.

METHOD

This study was designed as a six-phase process to evaluate user experience and satisfaction levels in virtual reality (VR)-supported educational spaces. A mixed-methods approach was adopted, integrating both quantitative and qualitative data collection techniques. In this way, not only the pedagogical aspects of VR-based learning environments but also their spatial and design-oriented components were examined in a holistic manner. The fieldwork was structured within the framework of a spatial analysis based on design elements. Participants experienced virtual learning spaces that were designed and prepared for this study on four different VR platforms (Mozilla Hubs, Meta Horizon, Engage, and MeetinVR). These spaces were developed by the researcher to simulate a physical classroom setup and were then transferred into VR environments. While the instructional content was kept constant, the effects of design elements—such as material, texture, lighting, color, form, size, and scale—on user experience were comparatively analyzed. Since the environments were not publicly available pre-designed models but rather virtual spaces created specifically for the research, participant experiences were directly aligned with the objectives of the study. Accordingly, the fieldwork enabled both students and faculty members to evaluate the influence of spatial features in VR-based environments on perception, satisfaction, and learning effectiveness under the same controlled conditions.

Phase 1: Participant Selection and Sample Size Calculation

The participant group consisted of 10 third-year students and 10 academics from the Department of Interior Architecture at Istanbul Gelisim University. Students were selected from the same academic level in order to minimize variations in experience and perception, thus ensuring a comparable sample. The choice of interior architecture students was deliberate, as they possess aesthetic awareness and prior design knowledge of interior spaces. Academics from the same department were selected for their expertise and professional background. Following orientation sessions, both groups were introduced to VR experiences before the analysis began. Although participants represented two distinct groups—students and academics—the same procedures and forms were applied to both, allowing for evaluation from both learner and instructor perspectives.
In this study, students and faculty members participated in the same VR sessions and in similar roles. The rationale for this approach was to enable both groups to experience VR-supported learning environments from the perspective of users. Faculty members did not participate as instructors but rather as co-learners alongside students. This ensured that variations in perception based on age, prior experience, and professional background could be comparatively analyzed. Such a setup created a homogeneous experimental scenario and allowed for more reliable examination of differences in expectations and perceptions across user groups.

The research was conducted in offices and studio spaces at Istanbul Gelisim University. These environments were chosen to provide a controlled setting, minimizing distractions and external stimuli, thereby ensuring that participants could focus fully on the VR experience. Sessions were conducted individually by appointment, which guaranteed equal conditions of participation for all. This increased the validity and reliability of the collected data.

The sample size (n) was calculated using the formula proposed by Arlı and Nazik (2001):
$n = (N * Z^2 * p * (1 - p)) / ((N - 1) * E^2 + Z^2 * p * (1 - p))$
Here, N refers to the total population (127 refers to the total number of students and faculty members in the Department of Interior Architecture.), Z is the z-score for a 95% confidence level (1.96), p is the expected proportion (0.5), and E is the margin of error (0.05). The calculation yielded a sample size of approximately 96 participants. However, in descriptive research, sampling 10% of the population is acceptable, while 20% is recommended for smaller populations. Therefore, the inclusion of 20 participants (20% of the population) was considered sufficient. Participants were informed in advance about the four-month experimental process, and separate communication groups were created for students and academics.

Phase 2: Orientation Training

Before the experimental sessions, participants were briefed on the objectives of the study, the research process, and their expected roles. Technical training was provided on the use of the Meta Quest 2 headset and controllers. Following group information sessions, individual trial sessions were conducted to increase familiarity with the equipment. These preliminary practices aimed to minimize technical difficulties during the actual sessions.

Phase 3: Planning of Educational Content and Virtual Environments

The VR-supported educational content was designed to include theoretical knowledge on the relationship between technology and architecture. The experimental sessions were conducted on four VR platforms (Mozilla Hubs, Meta Horizon, Engage, and MeetinVR). Each session lasted 10 minutes, enabling participants to engage with diverse environments. The sessions were carried out in university offices and studios, individually scheduled to ensure distraction-free conditions. Each participant experienced VR for approximately 120–150 minutes in total.

Phase 4: Application of Data Collection Instruments

After each session, data were collected through two instruments:

- **Form A (Structured Experience Form):** Included demographic information (e.g., age, academic title, department, year of study, prior VR experience) and Likert-scale evaluations of spatial perception components (material, texture, lighting, form, color, size, and scale).
- **Form B (Open-Ended Questionnaire):** Consisted of ten questions, the first five focusing on perceptions of physical environmental components in virtual classrooms and the remaining five addressing overall experience and pedagogical reflections. This form enabled participants to articulate their design-oriented thinking and provided deeper insights into their VR experiences.

Phase 5: Preparation of Technical Infrastructure

Two Oculus Meta Quest 2 headsets, controllers, and charging units were used during the experiment. High-performance laptops ensured seamless platform integration and smooth operation. User accounts were created for each participant, and the VR devices were synchronized for platform compatibility and internet connectivity.

Phase 6: Data Analysis

Collected data were analyzed through both quantitative and qualitative methods:

- **Appendix A Data:** Quantitative data were analyzed using SPSS software. The normal distribution was tested with the Kolmogorov-Smirnov and Shapiro-Wilk tests. Independent Samples t-tests and One-Way ANOVA were conducted to examine group differences. Results were reported according to participant type (student/faculty), VR platform, and spatial perception parameters.
- **Appendix B Data:** Open-ended responses were imported into MAXQDA Analytics Pro 24. Word clouds, keyword trends, and frequency analyses were performed, identifying dominant themes in participants' experiences of VR-supported educational environments. These analyses provided valuable insights into design-related criteria.

ANALYSIS AND FINDINGS

Analysis of the Likert Scale-Based Interview Questionnaire (Appendix Form A)

Analysis of Physical Environment Criteria in VR Educational Settings from the Perspective of Students (Appendix A Form)

Table 1. Likert Scale-Based Survey on the Hubs Mozilla, Engage, MeetinVR, and Meta Horizon VR Platforms

Likert Scale (1-Strongly Disagree 2-Disagree 3-Neutral 4-Agree 5-Strongly Agree)			
VR PLATFORM	**CATEGORY**	**Categorized Statements Answered on a Likert Scale Regarding Online VR Platforms**	**LIKERT SCALE (1-5)**
HUBS MOZILLA, ENGAGE, MEETINVR, META HORİZON	MATERIAL-TEXTURE	1) The selection of textures and materials of interior furnishings and objects in the virtual learning space is similar to the real world.	
		2) The textures and materials of the virtual learning space are readable and perceptible.	
		3) The materials in the virtual learning space support the perceptibility of the shapes and forms of interior elements.	
		4) The material selections of the virtual learning space are compatible with each other.	
	LIGHT	1) The lighting of the virtual learning space is similar to the real world.	
		2) The light level in the virtual learning space illuminates the space sufficiently and ensures clear readability of materials, textures, and colours.	
		3) The contribution of lighting in the virtual learning space to the perception of depth and scale is sufficient.	
		4) Different light sources in the virtual learning space provide a natural and realistic atmosphere.	
	FORM	1) The furnishings in the virtual learning space are similar in form and shape to the real world.	
		2) The objects and furnishings in the virtual learning space are compatible in terms of form and shape.	
		3) All forms and shapes in the virtual learning space are clearly perceptible.	
		4) Different forms and shapes in the virtual learning space provide a natural and realistic atmosphere.	
	COLOUR	1) The colours in the virtual learning space are similar to the real world.	
		2) The effect of colours in the virtual learning space on depth and scale perception is positive.	
		3) The colour selections in the virtual learning space are compatible with each other.	
		4) The colours of the virtual learning space are readable and perceptible.	
	DIMENSION-SCALE	1) The dimensions of furnishings and objects in the virtual learning space are similar to the real world.	
		2) All elements in the virtual learning space are perceptible in terms of dimension and scale.	
		3) The size of the virtual learning space is suitable for the processability of the lesson and the efficiency of the space.	
		4) The elements in the virtual learning space are compatible in terms of dimension and scale.	

Overall, student participants demonstrated a positive tendency in their evaluations of the physical environment components across the four different VR platforms (Hubs, Meta Horizon, Engage, and MeetinVR).

On the Hubs VR platform, students particularly rated the *form* and *lighting* categories with average scores of 4.00 and above, indicating that the spatial elements were perceived as harmonious and the lighting as sufficient. However, in the *material-texture* component, some participants expressed partial uncertainty regarding the clarity of materials.

In the Meta Horizon VR platform, the mean scores were higher across all categories. Notably, the *scale/dimension* and *lighting* factors were strongly supported at the "Strongly Agree" level. This indicates that Meta Horizon was perceived as highly effective in terms of realism and perceptibility.

In the Engage VR platform, *form*, *color*, and *scale* components stood out. Participants particularly emphasized the clear perceptibility of the size and proportions of objects within the space. The overall average scores for the *material-texture* component were also found to be high.

In the MeetinVR platform, participant responses were more varied compared to the other platforms. While high averages were observed in components such as *material*, *lighting*, and *form*, the similarity of interior objects to real-world counterparts received a significant number of "Neutral" responses. This suggests a degree of hesitation regarding the compatibility of certain physical elements in MeetinVR with real-world characteristics.

In conclusion, when comparing all four VR platforms, students reported the highest levels of satisfaction with Meta Horizon and Engage. The components of *material*, *lighting*, *form*, *color*, and *scale* were generally found to be perceptible, realistic, and supportive of instructional effectiveness.

Analysis of Physical Environment Criteria in VR Educational Settings from the Perspective of Academics (Appendix A Form)

Academic participants evaluated the four different VR educational platforms (Hubs, Meta Horizon, Engage, and MeetinVR) generally positively, though with occasional hesitation, in terms of material-texture, lighting, form, color, and scale/dimension components.

In the Hubs VR platform, academics predominantly selected "Neutral" in the material and lighting categories, indicating uncertainty regarding the clarity of physical elements and their resemblance to real-world features. Only in the form and scale/dimension components were the averages closer to 4.0, suggesting a generally favorable perception of spatial harmony.

In the Meta Horizon VR platform, the mean scores were higher across all categories. Elements such as material consistency, lighting level, and form recognizability were rated at the "Agree" and "Strongly Agree" levels. Particularly, the scale/dimension component received the highest averages, indicating that virtual elements were perceived as having realistic proportions.

In the Engage VR platform, academics provided positive feedback on material consistency, form, and scale components. However, some reservations were noted regarding the lighting component, where participants adopted a more cautious stance on the influence of different light sources on the spatial atmosphere.

In the MeetinVR VR platform, evaluations were more varied. While material and lighting categories yielded high average scores, ratings related to the resemblance of interior objects to real-world counterparts were lower, with "Neutral" responses being more prominent. This suggests that some elements, especially related to form and scale perception, did not fully meet expectations.

Overall, academic participants found the Meta Horizon and Engage platforms more successful in terms of physical environment components. In contrast, the Hubs and MeetinVR platforms were perceived as needing improvement in aspects such as material realism and lighting design.

Category-Based Comparative Analyses and Visualizations Across Platforms and Participant Groups

The categories were compared across platforms based on the response averages of students, academics, and all participants. "Student Avg" represents the average responses of student participants, "Academic Avg" indicates the average responses of academic participants, and "Overall Avg" refers to the overall response average of all participants.

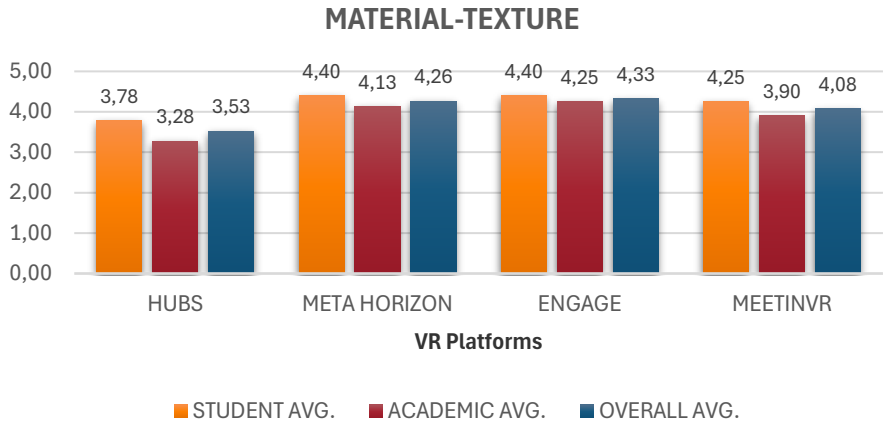


Figure 1. Platform Averages in Terms of Material-Texture Dimension

When the findings related to the material-texture dimension are examined, it is observed that student participants assigned the highest average scores to the Meta Horizon and Engage VR platforms, while the lowest average was reported for the Hubs VR platform. A similar trend was observed among academic participants; the highest average score was recorded for the Engage VR platform, and the lowest for the Hubs VR platform. Considering the overall averages, all participants evaluated the Engage VR platform more favorably than the others in terms of the perceptibility of material and texture components, whereas the Hubs VR platform received the lowest average in this dimension (Figure 1).

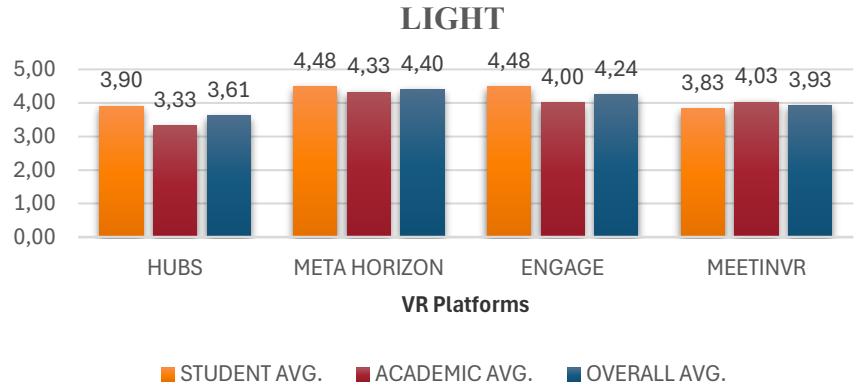


Figure 2. Platform Averages in Terms of Lighting Dimension

In the evaluations regarding the lighting dimension, student participants assigned the highest average scores to the Meta Horizon and Engage VR platforms, while the lowest average was given to the MeetinVR platform. From the perspective of academic participants, the highest average score was recorded for the Meta Horizon VR platform, and the lowest for the Hubs VR platform. Considering the overall averages, all participants evaluated the lighting component most positively in the Meta Horizon VR platform, whereas the Hubs VR platform received the lowest average in this dimension (Figure 2).

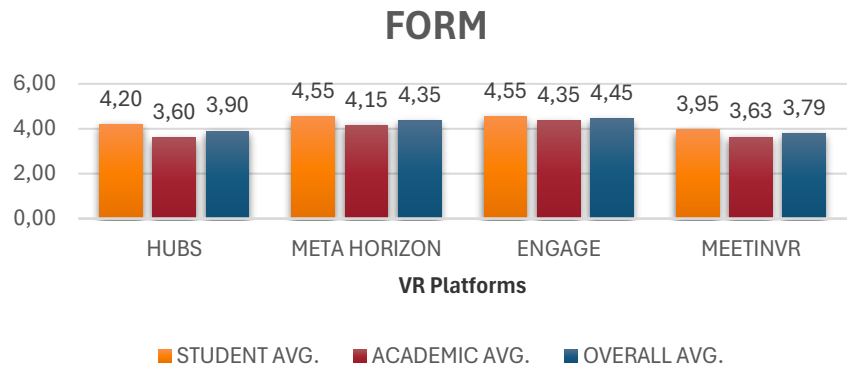


Figure 3. Platform Averages in Terms of Form Dimension

When the evaluations regarding the form dimension are examined, student participants reported the highest average scores for the Meta Horizon and Engage VR platforms, while the lowest average was observed for the MeetinVR platform. For academic participants, the highest average was recorded for the Engage VR platform, and the lowest for the Hubs VR platform. In general, all participants evaluated the form component most positively in the Engage VR platform, whereas the MeetinVR platform received the lowest average in this dimension (Figure 3).

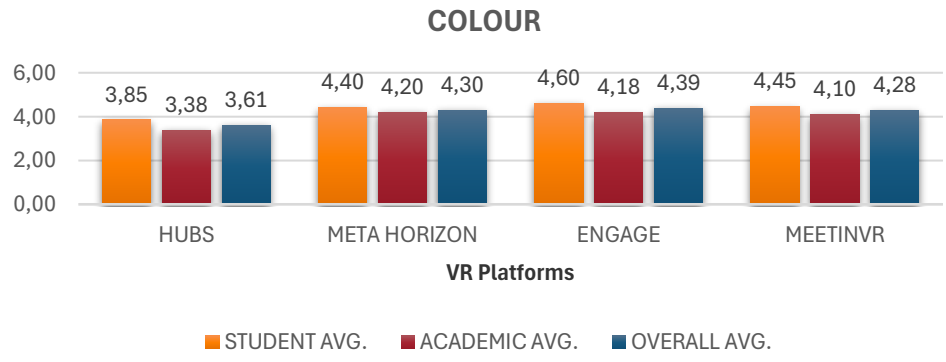


Figure 4. Platform Averages in Terms of Color Dimension

In the evaluations regarding the color dimension, student participants assigned the highest average score to the Engage VR platform, while the lowest average was given to the Hubs VR platform. For academic participants, the highest average was recorded for the Meta Horizon VR platform, and the lowest for the Hubs VR platform. Considering the overall averages, all participants evaluated the color component most positively in the Engage VR platform, whereas the Hubs VR platform received the lowest average in this dimension (Figure 4).

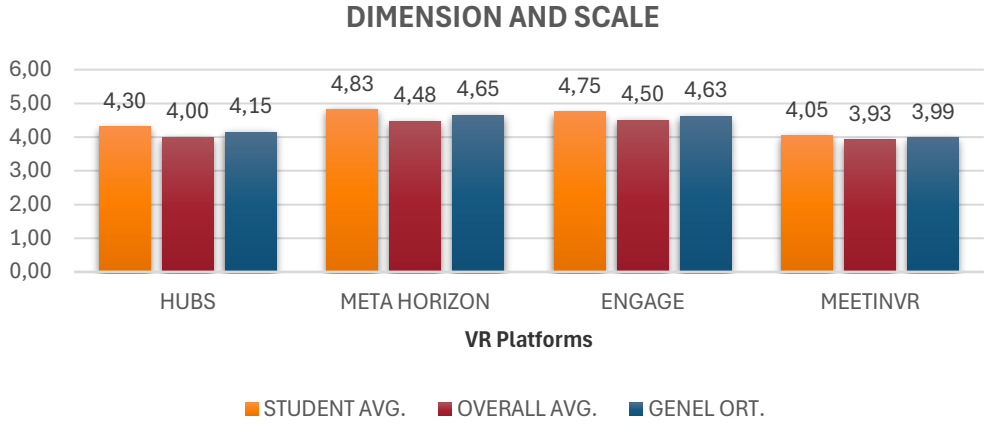


Figure 5. Platform Averages in Terms of Scale-Dimension

In the evaluations regarding the scale-dimension, student participants reported the highest average score for the Meta Horizon VR platform, while the lowest average was observed for the MeetinVR platform. For academic participants, the highest average was recorded for the Engage VR platform, and the lowest again for the MeetinVR platform. Considering the overall averages, all participants evaluated the scale component most positively in the Meta Horizon VR platform, whereas the MeetinVR platform received the lowest average in this dimension (Figure 5).

Comparison of Dimensions from the Perspectives of Students and Academics

In terms of participant type, no significant differences were found across the dimensions of material-texture, lighting, form, color, and scale ($p > 0.05$). Both student and academic participants shared similar perceptions across all five dimensions, indicating no variation in their evaluations. Based on the mean response values, it was determined that both groups generally responded with "4 = agree." (Table 2).

Table 2. Comparison of the Dimensions in Terms of Student and Academic Participants

Dimensions	Group	n	$\bar{X}$	Ss.	t-ist	p
MATERIAL-TEXTURE	Student	10	4,21	0,54	1,410	0,176
	Academic	10	3,89	0,49		
LIGHT	Student	10	4,16	0,67	0,815	0,426
	Academic	10	3,92	0,67		
FORM	Student	10	4,31	0,62	1,435	0,168
	Academic	10	3,93	0,56		
COLOUR	Student	10	4,33	0,75	1,163	0,260
	Academic	10	3,97	0,64		
DIMENSION-SCALE	Student	10	4,48	0,38	1,185	0,251
	Academic	10	4,23	0,57		

Comparison of Dimensions Across Platforms for Student Participants

Significant differences were found across platforms in terms of the lighting, color, and scale dimensions ($p < 0.05$). The lighting dimension was significantly higher in the "Meta Horizon" (4.48±0.33) and "Engage" (4.48±0.13) VR platforms. The color dimension was significantly higher in the "Engage" (4.60±0.22) VR platform, while the scale dimension was significantly higher in the "Meta Horizon" (4.83±0.17) VR platform (Table 3).

Table 3. Comparison of Dimensions Across Platforms for Student Participants

Dimension	Group	n	$\bar{X}$	Ss.	F	p	Post-hoc (Tukey)
MATERIAL-TEXTURE	(1) Hubs	4	3,78	0,28	1,880	0,187	
	(2) Meta Horizon	4	4,43	0,43			
	(3) Engage	4	4,40	0,16			
	(4) MeetinVR	4	4,25	0,70			
LIGHT	(1) Hubs	4	3,90	0,18	3,552	0,038*	2>1,3>1 2>4,3>4
	(2) Meta Horizon	**4**	**4,48**	**0,33**			
	(3) Engage	**4**	**4,48**	**0,13**			
	(4) MeetinVR	4	3,83	0,64			
FORM	(1) Hubs	4	4,20	0,27	2,175	0,144	
	(2) Meta Horizon	4	4,55	0,24			
	(3) Engage	4	4,55	0,25			
	(4) MeetinVR	4	3,95	0,66			
COLOUR	(1) Hubs	4	3,85	0,21	7,818	0,004*	3>1, 3>2, 3>4, 4>1,2>1
	(2) Meta Horizon	4	4,40	0,18			
	(3) Engage	**4**	**4,60**	**0,22**			
	(4) MeetinVR	4	4,45	0,31			
DIMENSION-SCALE	(1) Hubs	4	4,30	0,26	3,974	0,035*	2>1, 2>3, 2>4, 3>1,3>4
	(2) Meta Horizon	**4**	**4,83**	**0,17**			
	(3) Engage	4	4,75	0,21			
	(4) MeetinVR	4	4,05	0,64			

*Significant difference at $p<0.05$

Comparison of Dimensions Across Platforms for Academic Participants

Significant differences were found across platforms in terms of the material-texture, lighting, color, and scale dimensions ($p < 0.05$). The material-texture dimension was significantly higher for the "Engage" (4.25±0.13) VR platform. The lighting (4.33±0.15) and color (4.20±0.20) dimensions were significantly higher for the "Meta Horizon" VR platform. The scale dimension was also significantly higher for the "Engage" (4.50±0.08) VR platform (Table 4).

Table 4. Comparison of Dimensions Across Platforms for Academic Participants

Dimension	Group	n	$\bar{X}$	Ss.	F	p	Post-hoc (Tukey)
MATERIAL-TEXTURE	(1) Hubs	4	3,28	0,05	5,908	0,010*	3>1, 3>2, 3>4, 2>1,2>4
	(2) Meta Horizon	4	4,13	0,43			
	(3) Engage	**4**	**4,25**	**0,13**			
	(4) MeetinVR	4	3,90	0,55			
LIGHT	(1) Hubs	4	3,33	0,15	6,288	0,008*	2>1, 2>3, 2>4, 4>1,3>1
	(2) Meta Horizon	**4**	**4,33**	**0,15**			
	(3) Engage	4	4,00	0,29			
	(4) MeetinVR	4	4,03	0,57			
FORM	(1) Hubs	4	3,60	0,26	3,470	0,067	
	(2) Meta Horizon	4	4,15	0,40			
	(3) Engage	4	4,35	0,13			
	(4) MeetinVR	4	3,63	0,64			
COLOUR	(1) Hubs	4	3,38	0,36	9,868	0,001*	2>1, 2>3, 2>4, 4>1,3>1
	(2) Meta Horizon	**4**	**4,20**	**0,20**			
	(3) Engage	4	4,18	0,13			
	(4) MeetinVR	4	4,10	0,26			
DIMENSION-SCALE	(1) Hubs	4	4,00	0,08	7,252	0,005*	3>1, 3>2, 3>4, 2>1,2>4
	(2) Meta Horizon	4	4,48	0,28			
	(3) Engage	**4**	**4,50**	**0,08**			
	(4) MeetinVR	4	3,93	0,34			

*Significant difference at $p<0.05$

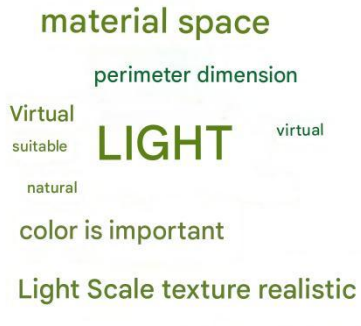
Analyses of Open-Ended Interview Questions (Appendix B)

Responses provided by academic and student groups regarding their virtual classroom experiences across four different VR platforms were analyzed. This analysis aimed to evaluate participants' perceptions of physical environmental components such as material realism, textural perception, color and lighting quality, and spatial scaling. Using MAXQDA Analytics Pro 24 software, separate word cloud and word frequency analyses were conducted for each group. These methods enabled the identification of prominent concepts and trends within the texts, offering both content-based and statistical insights into the design of virtual learning environments. The results are expected to contribute to the more effective structuring of VR-supported educational spaces (Table 5).

Table 5. Appendix B – Open-Ended Interview Questions Form

QUESTIONS
This form includes questions designed to gather your opinions about the overall structure and content of the VR-based virtual learning environments you have experienced. You are expected to write your answers in the spaces provided under each question. The impartiality and sincerity of your responses are of great importance. Therefore, please make sure to complete this form with utmost attention and care. Thank you for your participation in this study
1. Which physical environmental components (material, light, form, texture, colour, size, scale, etc.) make the virtual reality experience feel more realistic? Among these components, which one is the most important for you and why?
2. What types of materials or textures in a virtual learning environment motivate or disturb you the most?
3. What are your thoughts on the impact of colour choices in a virtual learning environment on learning and concentration? In your opinion, what colours should a virtual learning space consist of?
4. How do you think the dimensions and scales of a virtual learning space affect your learning process?
5. How could the lighting design of a virtual learning environment contribute to making the space more usable or efficient for you? Do you have any suggestions regarding the lighting system, light colour, or light intensity?
6. To what extent do you think geometric forms influence learning comfort in a virtual learning environment? What types of forms attract you more or contribute to your learning comfort?
7. How did you initially feel during your experiences with VR platforms? Please explain.
8. What aspects did you find lacking in the virtual reality environment you experienced? Please elaborate.
9. Could you describe the realistic and unrealistic aspects of your virtual reality experience, along with the reasons?
10. How did the emotions or experiences you had during the VR learning session affect your learning motivation?

Open-Ended Question 1 Analysis for Students and Academics



Word	Word Length	Frequency	%	Degree
Light	4	**15**	3,13	1
Realistic	8	**11**	2,3	2
Environment	5	**9**	1,88	3
Texture	4	**9**	1,88	3
Important	4	**9**	1,88	3
Material	5	**7**	1,46	6
Dimension	6	**6**	1,25	7
Colour	5	**5**	1,04	9
Virtual	4	**5**	1,04	9
Light	4	**4**	0,84	9
Space	5	**4**	0,84	10
Suitable	4	**4**	0,84	10

Figure 6. Word cloud and word frequency analysis for the first open-ended question conducted separately for academic staff and students.

Word Frequency Analysis: This analysis reveals the most frequently emphasized physical environment components in the virtual reality experience according to students and academics. The highest frequency is associated with the word "light", indicating that lighting is perceived as a critical element in virtual environments. The words "environment", "texture", and "important" also stand out prominently (Figure 6).

Word Cloud Analysis: The word cloud shows that the primary elements enhancing realism in the virtual reality experience are "light" and "realistic". These are followed by terms such as "texture", "material", "virtual", "appropriate", "natural", "scale", and "space". The findings support the notion that lighting is the most defining factor from the participants' perspective (Figure 6).

Open-Ended Question 2 Analysis for Students and Academics



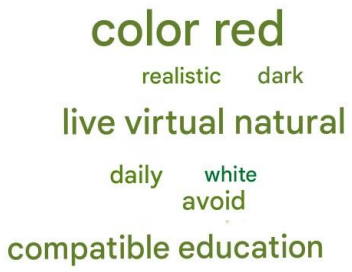
Word	Word Length	Frequency	%	Degree
Motive	6	**14**	4,81	1
Material	7	**10**	3,44	2
Uncomfortable	8	**9**	3,09	3
Education	6	**7**	2,41	4
Wood	5	**6**	2,06	5
Virtual	5	**6**	2,06	5
Natural	5	**4**	1,37	7
Textures	7	**4**	1,37	7
Space	5	**4**	1,37	7
Artificial	5	**4**	1,37	7

Figure 7. Word Cloud and Word Frequency Analysis for the Second Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: In terms of materials, the word *"wood"* has the highest frequency, indicating its prominence in the participants' feedback (Figure 7).

Word Cloud Analysis: According to the data, wood material is perceived as the most significant element in the context of virtual reality experiences related to materials. The words *"motivate"* and *"materials"*, highlighted in the largest font in the word cloud, indicate that wood is considered a material that enhances motivation within the virtual space (Figure 7).

Open-Ended Question 3 Analysis for Students and Academics



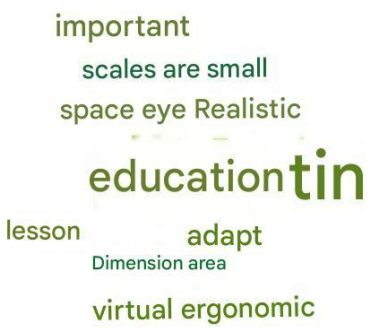
Word	Word Length	Frequency	%	Degree
Education	6	**12**	3,29	1
Suitable	6	**11**	3,01	2
Virtual	5	**10**	2,74	3
Live	5	**6**	1,64	4
Colour	4	**6**	1,64	4
Appropriate	5	**6**	1,64	4
Carefull	6	**4**	1,1	7
Natural	5	**4**	1,1	7
Distraction	8	**3**	0,82	9
Dark	4	**3**	0,82	9
Focus	11	**3**	0,82	9
Tone	7	**3**	0,82	9

Figure 8. Word Cloud and Word Frequency Analysis for the Third Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: The word with the highest frequency describing the color category is *"compatible"*, indicating that both academics and students consider *color compatibility* to be the most important aspect in their virtual reality experience (Figure 8).

Word Cloud Analysis: Academics and students primarily emphasized that colors should be *compatible*, also highlighting the words *"vivid"* and *"natural"*, while pointing out the use of *red* and *white* colors (Figure 8).

Open-Ended Question 4 Analysis for Students and Academics



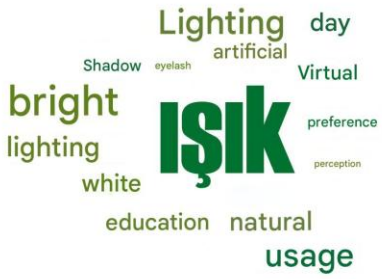
Word	Word Length	Frequency	%	Degree
Education	6	**7**	1,94	1
Important	6	**5**	1,39	2
Lesson	4	**4**	1,11	3
Virtual	5	**4**	1,11	3
Adapt	6	**3**	0,83	5
Space	4	**3**	0,83	5
Dimension	5	**3**	0,83	5
Ergonomic	9	**3**	0,83	5
Realistic	8	**3**	0,83	5
Eyes	3	**3**	0,83	5
Easy	5	**3**	0,83	5
Small	5	**3**	0,83	5
Learning	7	**3**	0,83	5

Figure 9. Word Cloud and Word Frequency Analysis for the Fourth Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: This analysis shows that "important" and "education" are the most frequent words, highlighting that scale and size are key factors in the virtual learning environment (Figure 9).

Word Cloud Analysis: The words "important" and "education" appear most often, followed by "lesson," "space," "size," and "scale," indicating that the design and dimensions of virtual classrooms are strongly emphasized. Terms like "realistic," "adapt," and "ergonomic" also underline the importance of realistic and user-friendly VR spaces (Figure 9).

Open-Ended Question 5 Analysis for Students and Academics



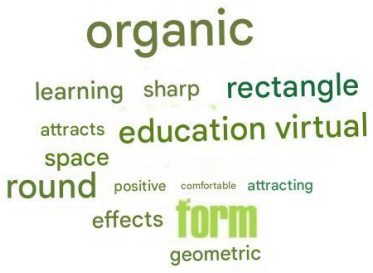
Word	Word Length	Frequency	%	Degree
Light	4	**24**	6	1
Education	6	**9**	2,25	2
Natural	5	**8**	2	3
Bright	8	**7**	1,75	4
Usage	9	**5**	1,25	5
Virtual	5	**5**	1,25	5
Preference	6	**5**	1,25	5
Artificial	5	**5**	1,25	5
Lighting	10	**4**	1	9
Shadow	5	**4**	1	9
Eyes	3	**4**	1	9
Day	3	**4**	1	9
Eyeflash	12	**4**	1	9

Figure 10. Word Cloud and Word Frequency Analysis for the Fifth Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: The table shows students' and academics' views and suggestions about the lighting of virtual learning spaces. The words "bright" and "natural" have the highest frequency, indicating that these lighting aspects are seen as most important in VR environments (Figure 10).

Word Cloud Analysis: Both groups emphasize "light" as the key factor. The impact of lighting on usability and efficiency is frequently noted. Words like "education" and "natural" highlight the value of natural light in supporting learning. Proper lighting is seen to minimize shadows and improve effectiveness. "Artificial," "virtual," "white," and "preference" reflect the types of light suggested for VR classrooms (Figure 10).

Open-Ended Question 6 Analysis for Students and Academics



Word	Word Length	Frequency	%	Degree
Education	6	**10**	3,14	1
Organik	7	**10**	3,14	1
Virtual	5	**9**	2,83	3
Form	4	**7**	2,2	4
Rectangle	10	**5**	1,57	5
Attracting	7	**4**	1,26	6
Learning	7	**4**	1,26	6
Comfortable	5	**4**	1,26	6
Round	8	**4**	1,26	6

Figure 11. Word Cloud and Word Frequency Analysis for the Sixth Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: The table shows that both students and academics emphasized the impact of geometric forms on learning comfort in virtual education spaces. The words *"rectangle"* and *"organic"* have the highest frequencies, indicating that these shapes are considered the most significant form-related elements in the VR experience (Figure 11).

Word Cloud Analysis: The prominence of the words *"education"* and *"form"* highlights the importance of geometric forms in virtual learning environments. The frequent mention of *"organic"* and *"rectangle"* suggests that both shapes are preferred and contribute positively to learning comfort. The words *"comfortable"* and *"attractive"* further indicate that certain forms create a pleasant and engaging effect for participants (Figure 11).

Open-Ended Question 7 Analysis for Students and Academics



Word	Word Length	Frequency	%	Degree
Virtual	5	**9**	2,75	1
I felt	9	**9**	2,48	2
First	3	**9**	2,48	2
I lived	7	**7**	1,93	4
Adapt	6	**6**	1,65	5
Sometimes	5	**5**	1,38	6
It was enjoyable	9	**6**	1,38	6
Im excited	13	**4**	1,1	8
It was fun	10	**4**	1,1	8
I was scared	7	**4**	1,1	8
Nausea	4	**4**	1,1	8
VR	2	**4**	1,1	8

Figure 12. Word Cloud and Word Frequency Analysis for the Seventh Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: The table shows the results of participants' experiences and feelings in virtual learning environments. The words "fun" and "excited" had the highest frequency, highlighting the emotional responses of both students and academics (Figure 12).

Word Cloud Analysis: The most prominent words describing participants' emotions were "fun," "excited," and "scared," followed by "adapted," and "felt." These findings indicate that VR experiences evoke complex and varied emotional reactions among users (Figure 12).

Open-Ended Question 8 Analysis for Students and Academics



Word	Word Length	Frequency	%	Degree
If	4	**6**	2,51	1
Lack	8	**5**	2,09	2
I would like	8	**5**	2,09	2
Touch	7	**4**	1,67	4
Movement	7	**4**	1,67	4
Virtual	5	**4**	1,67	4
Less	5	**3**	1,26	7
Sometimes	5	**3**	1,26	7
Material	7	**3**	1,26	7
Space	5	**3**	1,26	7
No space	5	**3**	1,26	7

Figure 13. Word Cloud and Word Frequency Analysis for the Eighth Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: The table shows how students and academics describe the shortcomings they identified in virtual learning spaces. The highest-frequency words were *"touch"* and *"movement,"* highlighting key areas perceived as lacking (Figure 13).

Word Cloud Analysis: Participants often mentioned *"lack," "movement," "material," "touch,"* and *"space,"* indicating that virtual environments need improvements in physical interaction, material variety, and haptic feedback (Figure 13).

Open-Ended Question 9 Analysis for Students and Academics



Word	Word Length	Frequency	%	Degree
Some	4	**7**	1,92	1
Could be some	10	**7**	1,92	1
Virtual	5	**7**	1,92	1
Space	5	**6**	1,65	4
Texture	4	**5**	1,37	5
Realistic	7	**5**	1,37	5
Light	11	**5**	1,37	5
Material	4	**5**	1,37	5
Colour	7	**5**	1,37	5

Figure 14. Word Cloud and Word Frequency Analysis for the Ninth Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: The table shows how students described the realistic and unrealistic aspects of virtual learning spaces. The highest-frequency words were *"texture/textures"* and *"light,"* highlighting key elements (Figure 14).

Word Cloud Analysis: Participants used words like *"virtual," "could be," "some," "textures," "realistic," "space," "material," "color,"* and *"light"* to describe strengths and weaknesses, emphasizing areas that need improvement and elements considered most important (Figure 14).

Open-Ended Question 10 Analysis for Students and Academics



Word	Word Length	Frequency	%	Degree
My motivation	13	**10**	2,89	1
Positive	12	**10**	2,89	1
Motive	6	**8**	2,31	3
Influenced	8	**8**	2,31	4
Education	6	**8**	2,31	5
Curiosity	5	**4**	2,31	6

Figure 15. Word Cloud and Word Frequency Analysis for the Tenth Open-Ended Question Directed at Academics and Students

Word Frequency Analysis: The table shows how students and academics describe the impact of their VR learning environment experiences on learning motivation. The word with the highest frequency is *"positive,"* indicating that the VR experience had a motivating effect overall (Figure 15).

Word Cloud Analysis: Key words such as *"affected," "motivate," "positive," "education," "motivation," "experience," "spaces," "curiosity," "excitement,"* and *"virtual"* highlight how emotions and experiences during VR training influenced motivation. The results indicate that VR education provided an overall positive and motivating experience, enhancing learning motivation for both students and academics (Figure 15).

FINDINGS

Findings on the Analysis of Physical Data Metrics in the Context of VR-Based Learning Environments (Appendix-A Form Results)

Findings on the Comparison of Spatial Perceptions by Participant Type; No statistically significant differences were identified between student and academic participants regarding spatial perception dimensions such as material-texture, lighting, form, color, and size-scale ($p > 0.05$). The similarity in attitudes across both groups indicates that the VR classroom designs addressed the expectations of both user types equally and effectively.

Findings on the Dimensional Differences Between VR Platforms According to Student Participants; Among the VR platforms evaluated by student participants, significant differences were observed in the dimensions of lighting, color, and size-scale ($p < 0.05$). The "Meta Horizon" and "Engage" platforms received more favorable feedback, particularly in terms of lighting quality and spatial arrangement. While the "Engage" platform stood out in terms of color perception, the "Meta Horizon" platform demonstrated higher satisfaction in terms of scale and spatial compatibility.

Findings on the Dimensional Evaluation of VR Platforms by Academic Participants; Statistically significant differences were found among VR platforms in terms of material-texture, lighting, color, and size-scale according to evaluations made by academic participants ($p < 0.05$). The "Engage" platform was rated more positively for material-texture and size-scale dimensions, whereas "Meta Horizon" received higher ratings for lighting and color. These findings highlight that each VR platform exhibits varying design performances across different spatial dimensions.

Findings on the Impact of Design Differences in Virtual Learning Environments on User Experience; Overall, both the "Meta Horizon" and "Engage" VR platforms were evaluated more positively by users in terms of lighting, color selection, material realism, and spatial organization. These results suggest that, for a successful virtual learning experience, the visual, tactile, and spatial elements of design should be addressed in a holistic manner that aligns with user expectations.

Qualitative Results Derived from the Analysis of Open-Ended Questions (Appendix-B Form Results)

The results of the word frequency and word cloud analyses revealed that "lighting" was the most frequently emphasized physical environmental element by both students and academics in VR-based educational environments. This finding highlights the critical role of lighting arrangements in shaping perceived realism and spatial awareness within virtual spaces. In addition to lighting, concepts such as "environment," "texture," "appropriateness," and "realism" also came to the forefront, indicating the strong influence of physical design components on user experience.

In analyses focused on material preferences, "wood" emerged as the most frequently mentioned material by participants. The warm and natural atmosphere created by wooden elements is interpreted as a factor that positively influences learning motivation. This suggests that the use of visuals evoking natural materials may enhance user experience in virtual environments.

Regarding the color category, the word "harmonious" had the highest frequency, indicating that color harmony is a key aesthetic and perceptual factor for users. Moreover, expressions related to specific colors such as "vivid," "natural," "red," and "white" suggest that certain color palettes are perceived as both attention-grabbing and pedagogically effective.

Analyses related to scale and size perception showed that the words "important" and "education" were frequently used, implying that designing virtual classroom elements at realistic scales contributes positively to users' learning experiences. Terms such as "ergonomic," "adaptive," and "realistic" further indicate that spatial arrangements are directly linked to user comfort.

In opinions related to lighting, the prominence of the words "bright" and "natural" reflects the participants' evaluation of lighting not only as a technical aspect but also as a pedagogical component. The contribution of natural light to the learning process, as well as the color and intensity of artificial light sources, significantly affect users' evaluations of virtual environments.

In terms of geometric form perception, a preference for "organic" and "rectangular" shapes indicates that participants responded positively to both traditional and naturally inspired forms. The characterization of these forms as "comfortable" and "appealing" emphasizes the importance of visual design elements in shaping spatial comfort and the sense of place.

Analyses involving participants' emotional responses revealed expressions such as "fun," "excited," and "scared," showing that VR experiences have a strong emotional impact. Statements like "it was enjoyable" and "I adapted" suggest that users easily adjusted to VR environments and generally had positive experiences during their time in these spaces.

Regarding perceptions of limitations, the high frequency of the words "touch" and "movement" suggests that participants perceived VR environments as physically restricted and lacking. This indicates that VR technologies still require further development in terms of sensory feedback and interaction capabilities.

In the context of realism evaluations, the prominence of "texture" and "lighting" as key factors determining perceived realism demonstrates that detailing and visual quality play a significant role in users' perceptions. These findings show that while virtual environments are considered sufficient in certain areas, there is still room for improvement in others.

Finally, when evaluating the impact on learning motivation, expressions such as "positive," "motivating," and "influential" suggest that VR experiences enhance intrinsic motivation for learning. Concepts like "curiosity," "exploration," and "excitement" indicate that the learning process is nourished not only cognitively but also emotionally. This highlights the potential of VR-based educational environments to enhance both pedagogical effectiveness and user engagement.

DISCUSSION

This study aimed to examine user experience in virtual reality (VR)-supported educational environments through the lens of physical environmental components—namely lighting, texture, color, form, size, and scale—in order to identify key design criteria for effective learning spaces. The findings revealed that **lighting** is the most influential factor in shaping users' spatial perception and sense of realism within VR environments. This aligns with the findings of Schwienhorst (2002) and Graetz (2006), who emphasized the critical role of lighting in perceptual comfort and learning motivation.

The absence of significant differences between student and academic participants suggests that users with different profiles responded similarly to the physical dimensions of VR environments. This indicates that **user-centered VR designs have universal applicability**, capable of addressing the expectations of diverse demographic groups. Additionally, the strong preference for natural materials such as *wood* supports the perspectives of Aiello (2012) and Jamieson (2000), who noted that natural elements contribute positively to emotional engagement and learning motivation in educational spaces.

Qualitative data highlighted the significance of concepts such as "harmonious colors," "ergonomic forms," and "realistic scale," suggesting that **perceptual consistency** enhances the learning experience in VR settings. These findings are in line with Dede (2009) and Mikropoulos & Natsis (2011), who argued that VR technologies have the potential to deepen learning by concretizing abstract knowledge.

However, some platforms—particularly Hubs and MeetinVR—were found lacking in terms of **material realism and lighting quality**, which made it difficult for users to establish perceptual connection with the virtual spaces. Frequently reported limitations such as the absence of **touch and movement** indicate that current VR environments remain restricted in terms of sensory feedback, thereby reducing the depth of experience. Among academic participants, issues such as **insufficient lighting intensity and inadequate color contrast** led to uncertainty in spatial perception. These critical evaluations suggest that VR technologies must be improved not only in terms of **aesthetic coherence** but also **functional accessibility**.

Pedagogically, the study underscores the importance of designing VR environments that are not only visually compelling but also satisfying at **experiential, emotional, and cognitive levels**. The frequent mention of emotional responses such as "curiosity," "fun," and "excitement" indicates that VR-supported education has the potential to **enhance intrinsic motivation** and foster deeper engagement.

In conclusion, this study demonstrates that the **design of physical environmental components** in virtual learning environments directly influences user satisfaction, perceived realism, and learning motivation. Therefore, achieving **visual, sensory, and emotional integration** in VR design is essential. The findings offer practical guidance for future VR-based educational designs and emphasize the need for **user-centered, interdisciplinary solutions** that support both learning efficacy and technological accessibility.

CONCLUSION

This study explored the user experience and satisfaction levels in VR-supported educational environments through both quantitative and qualitative analyses. By evaluating four different VR platforms — Mozilla Hubs, Engage, Meta Horizon, and MeetinVR —

across a range of physical environmental components such as material, texture, light, form, color, size, and scale, the study offers in-depth insights into how these variables influence the perceived quality and usability of virtual learning spaces.

The quantitative findings revealed that Meta Horizon and Engage platforms consistently scored higher in categories such as light quality, spatial scale, and material realism, indicating a stronger alignment with real-world spatial cues. Participants, both students and academics, emphasized lighting, material realism, and spatial proportions as critical factors enhancing the perceived authenticity of VR environments. The absence of significant perceptual differences between the two participant groups suggests that effective VR space design can cater to a wide range of users, regardless of their academic role.

Qualitative data further emphasized the importance of natural and bright lighting, material compatibility (with wood as a preferred element), and organic or rectangular forms in enhancing learning comfort and user motivation. Emotional responses such as curiosity, excitement, and positive motivation were frequently reported, underlining the immersive and emotionally engaging nature of VR-based education. However, participants also highlighted current limitations of VR environments, particularly in terms of haptic feedback and movement constraints, signaling the need for continued technological enhancement.

In conclusion, this research underscores that the integration of perceptually rich and contextually appropriate physical environment components in VR design significantly enhances user experience and learning motivation. For virtual learning spaces to be more effective, they must move beyond basic visual simulation and engage users through multi-sensory and ergonomically grounded design strategies. These findings offer practical guidance for educators, designers, and developers aiming to create more user-centered, pedagogically effective, and emotionally engaging VR-supported educational environments.

RECOMMENDATIONS

Based on the findings of this study, several key recommendations have been developed to improve the effectiveness of virtual reality-supported learning environments. First, to enhance the perceived realism in virtual spaces, lighting arrangements should be designed in a natural and balanced manner. The use of materials and textures should closely resemble those in the physical world, with a preference for materials like wood that evoke a sense of warmth and comfort for users.

In terms of color selection, harmonious and non-distracting tones should be prioritized, supported by vivid yet non-straining color palettes to maintain visual comfort. The perception of size and scale in virtual environments should align with real-world dimensions to strengthen spatial awareness. Geometric forms should be simple, familiar, and ergonomic, and spatial layouts should be designed in a way that does not compromise user comfort.

Technologies that enhance physical interaction, such as haptic feedback systems, should be developed to make virtual experiences more tangible. In addition to these design elements, users' emotional responses should also be taken into account. VR environments should be not only visually compelling but also experientially satisfying.

Design processes must be shaped according to the needs of diverse user profiles, and the content used within these environments should be tailored to the specific requirements of each discipline. Finally, robust technical infrastructure must be ensured, and users should be provided with basic training to help them easily adapt to the platforms.

Ethics and Consent: Ethical approval for this study was obtained from the Executive Board of the Graduate School of Science at Mimar Sinan Fine Arts University with the decision dated 26.01.2024 and numbered 3/5-c, based on the Scientific Research Ethics Declaration Form registered under number 148835.

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REFERENCES

Aiello, P. (2012). A constructivist approach to virtual reality for experiential learning. E-learning and Digital Media, 9(3), 317-324.

Arlı, Z. K., & Nazik, İ. (2001). Eğitimde ve psikolojide ölçme ve değerlendirme. Anı Yayıncılık.

Ashby A., Richardson J. T., Woodley A. (2011). National student feedback surveys in distance education: an investigation at the UK Open University. Open Learn.

Baber H. (2020). Determinants of students' perceived learning outcome and satisfaction in online learning during the pandemic of COVID-19. J. Educ. E-Learn. Res. 7 285–292. 10.20448/journal.509.2020.73.285.292

Byrne, M. B. (1996). Virtual environments for teaching and learning. Interactive Learning Environments, 4(3), 223-241.

Dede, C. (2009). Immersive interfaces for engagement and learning. Science, 323(5910), 66-69.

Graetz, K. A. (2006). Chapter 6. The Psychology of Learning Environments. Learning Spaces.

Jamieson, P., Fisher, K., Guilding, T., Taylor, PG ve Trevitt, ACF (2000). Yeni öğrenme ortamlarının tasarımında yer ve mekan. Yüksek. Eğitim. Araştırma. Dev. 19, 221–236. doi: 10.1080/072943600445664

Kaya, S. (2011). Sanal sınıf yönetimi sürecinde görev alacak öğretim elemanlarının eğitim gereksinimlerinin belirlenmesi. (Doktora Tezi). Anadolu Üniversitesi Eğitim Bilimleri Enstitüsü, Eskişehir.

Mcgonigle, D., & Eggers, R. (1998). Stages of virtually: Instructor and student. Interactive Learning Connection-University Space Network Pilot Project.

Mikropoulos, T. A., & Natsis, A. (2011). Educational virtual environments: A tenyear review of empirical research (1999–2009). Computers & Education, 56, 769- 780. http://dx.doi.org/10.1016/j.compedu.2010.10.020

Saxena, N., Kyaw, B. M., Vseteckova, J., Dev, P., Paul, P., Lim, K. T. K., Kononowicz, A., Masiello, I., Tudor Car, L., Nikolaou, C. K., Zary, N., & Car, J. (2016). Virtual reality environments for health professional education. Cochrane Database of Systematic Review, 2, CD012090.

Schwienhorst, K. (2002). Why virtual, why environments? Implementing virtual reality concepts in computer-assisted language learning. Simulation & Gaming, 33(2), 196-209.

Von Horn, R.(1997). The Virtual School. Phi Delta Kappan, 78(6), 481-482.