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Exploring the impact of virtual reality on presence: findings from a classroom experiment

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Introduction: This study examines the perception of presence among students using virtual reality (VR) compared to iPads. The research aimed to provide deeper insights into students' immersive experiences and identify factors influencing perceived presence.

Method and results: Using a comparative approach, we show a significant difference between the two groups, with students using VR reporting a heightened sense of immersion. Additionally, participant's previous experience with immersive VR affect the presence significantly, while we report no detectable effects of age and gender.

Discussion: These findings contribute to the discussion on innovative teaching methods, supporting the development of more effective and inclusive virtual learning environments.

KEYWORDS

virtual reality (VR), presence perception, immersion, learning environment, classroom experiment

1 Introduction

Using virtual reality (VR), students can now be interactively involved in the learning process in a captivating and immersive manner, which enables imparting complex topics in a completely new way. Technologies such as smartphones, tablets and laptops in the classroom have become commonplace in many schools. One technology that is attracting more and more attention in the educational context is VR (Marougkas et al., 2023). Unlike smartphones, tablets and laptops, which serve as mobile devices for accessing digital content, immersive VR is a technology that creates a completely new environment in which users can immerse themselves (Slater et al., 2022). VR uses special devices such as VR goggles or headsets to deliver visual and sometimes auditory stimuli that trick the user's senses and make them feel like they are in a different reality (Slater et al., 2022). This technology can be used to create realistic simulations, reconstruct historical events, enable virtual field trips or visualize complex concepts (Slater et al., 2022). By using VR, students can develop a deeper understanding of certain topics and experience an immersive learning experience (Chiquet et al., 2023).

Whether students truly learn more through VR, however, depends largely on their psychological sense of being present in the virtual environment, a phenomenon referred to as presence (Slater and Usoh, 1993). Mikropoulos (2006) states that presence, which results from various immersive environments can have a positive effect on learning performance. The prerequisite for this is to choose a teaching medium that creates a high level of immersion. Slater and Wilbur (1997) place the use of immersive technology in an educational theory context and consider various relationships that are important in the context of this article with regard to increased learning performance. To this end, Mikropoulos (2006) and Slater and Wilbur (1997) postulate that increased presence leads to an improvement in learning activities, and emphasize that the aim of using a virtual environment in an educational context should influence presence positively. Both objective and subjective influencing factors play a decisive role. The subjective influencing factors result from emotional, motivational and cognitive processes. The objective factors relate to the level of immersion, i.e., the extent to which the medium used is able to convey an illusion of reality to a human participant (Slater and Wilbur, 1997).

Recent studies align with this view, highlighting how integrating VR with AI and adaptive learning strategies can enhance both cognitive engagement and retention (Cao and Jian, 2024). Furthermore, differentiated learning strategies have been shown to be more effective when combined with immersive technologies, as they allow for personalized learning experiences tailored to students' needs (Frolovičeva, 2022). Studies also show that embodied learning in virtual environments can lead to deeper conceptual understanding (Smith, 2024). Additionally, research suggests that VR-based learning environments are particularly effective in language acquisition and historical education, where interactive and spatial learning play a crucial role (Naranjo et al., 2020; Tai et al., 2022; Zhang et al., 2023).

Based on this theoretical foundation, our study develops and conducts an experiment to investigate whether the use of VR fosters a greater sense of presence compared to traditional digital teaching media. By considering recent advancements in immersive education, this research aims to contribute to the growing discourse on the role of presence in digital learning environments.

The paper is structured as follows: First, the state of research regarding immersion and presence in the educational context is considered. Furthermore, the theoretical connections between immersion and presence are shown. A classroom experiment is presented which investigated whether VR leads to greater presence and whether the level of immersion has an effect. This experiment is certainly of an exploratory nature, but we can show fundamental differences in the usage of digital media regarding presence. This is followed by a discussion of results, their potential impacts and a conclusion.

2 Theoretical background

Presence on the one hand, is considered of as a psychological state of consciousness that describes being present in the virtual environment (Slater and Wilbur, 1997). Immersion, on the other hand, is considered as an objective description of a technology and describes the extent to which the computer display is able to convey an illusion of reality to the senses (Slater and Wilbur, 1997). Immersion is divided into the characteristics of liveliness and interactivity, which determine the degree of immersion and therefore the intensity of presence (Steuer, 1992).

2.1 Characteristics of immersion

Vibrancy refers to the ability of a technology to create a sensorial rich, mediated environment. The author divides sensory vividness into breadth and depth. Sensory breadth describes the number of sensory dimensions presented simultaneously. As a result, a VR system that appeals to several sensory senses at the same time intensifies the perception of the virtual environment and thus increases the level of immersion (Steuer, 1992). The vividness of a particular mediated representation also depends on the depth of sensory information available in the individual perception channels. This refers to the quality of the individual sensory dimensions. Depth refers to the spatial dimension of the immersive experience. Greater depth leads to a more realistic and higher quality experience, as it provides an impression of spatial perspective. This can be achieved through visual and auditory elements such as spatial sound (Steuer, 1992), and also referred to as the fidelity of a virtual environment (Yang et al., 2022). Fidelity refers to the accuracy and realism of the representation of images and scenes in a virtual environment. It includes various aspects, such as the detailed representation of 3D objects, the fluid and natural movement of objects and the realistic behavior of objects staged according to the concepts or ideas presented. A high level of fidelity means that the virtual environment resembles real life or the intended representation as closely as possible. This can help to create an immersive and convincing experience that reinforces the user's presence in the virtual environment (Chen et al., 2023; Dalgarno et al., 2002).

2.2 Interactivity and user control

In addition to liveliness, Steuer (1992) describes "interactivity as the extent to which users can participate in changing the form and content of a media environment in real time". According to Steuer (1992), interactivity could be divided into speed, reach and mapping. Speed refers to the reaction time of the medium to user interactions. A "real-time interaction represents the highest value in which the user's actions immediately change the virtual environment" (Steuer, 1992). In addition to the importance of fidelity for vividness, user control through interaction possibilities and capabilities in a virtual environment plays an important role for interactivity (Steuer, 1992; Yang et al., 2022). This includes the ability to change the position and direction of one's view within the environment to create a sense of fluid movement. If the user's movements in the virtual environment are continuous and precise, the likelihood of the individual perceiving increases the sense of presence and enhances the immersive experience (Han, 2020; Makransky and Lilleholt, 2018). However, if the movements are jerky or imprecise, this can lead to less immersion and reduce the sense of presence in the virtual environment (Yang et al., 2022). In addition, symptoms of discomfort and illness can arise from virtual environments, such as nausea, dizziness, headaches or fatigue, which is known in VR research as cyber sickness (Gonçalves et al., 2018; Lessiter et al., 2001; Mazloumi Gavgani et al., 2018).

The range of interaction options refers to the variety and scope of options available for interacting with the virtual environment. The more opportunities the user has to interact with the environment, the more diverse the options for action and the more extensive their engagement in the virtual world. Another immersive feature that can lead to an increasing presence is mapping (Steuer, 1992). Mapping refers to the way in which human actions are linked to actions within a media environment. An example of mapping in VR headsets is so-called "head tracking". Here, the user's movement is recorded with the help of sensors in the VR headset in order to adjust the visual perspective in the virtual environment accordingly (Wu et al., 2019). For example, if the user turns their head to the left, the virtual camera in the virtual environment is also moved to the left to reflect the user's line of vision. This creates a sense of immersion and presence, as the visual experience in the virtual environment is directly synchronized with the user's natural movements (Cummings and Bailenson, 2016). Through appropriate mapping, users can utilize their actions in the real world to perform certain actions or manipulations in the virtual environment. This increases immersion and the feeling of control and thus also the feeling of presence (Steuer, 1992). However, it cannot be assumed that there is a direct one-to-one relationship between immersion and presence. Cummings and Bailenson (2016) investigated the impact of the level of immersion on presence and show that one and the same medium leads to different levels of presence (Ochs and Sonderegger, 2022). This is consistent with the results of studies that assume a process of cognitive mediation and postulate an influence of immersion on presence solely through cognitive processes (Biocca, 2006; Parong and Mayer, 2021).

2.3 Research question and hypothesis

The relationship between immersion (objective) and presence (subjective) has been examined in more detail, as this is crucial for successful learning in virtual environments (Dengel and Magdefrau, 2018; Lui et al., 2023). The authors emphasize the importance of presence and indicate that the aim of using virtual reality in educational contexts should be to influence presence positively. This is against the background that subjective factors of immersive learning potential are responsible for the perception of objective stimuli (immersion) and that a feeling of presence can only arise through cognitive processes (e.g., Lessiter et al., 2001). Studies that show a positive relationship between VR and learning performance often refer to increased presence as an explanation of increasing performance (Alhalabi, 2016; Cadet and Chainay, 2020; Kozhevnikov et al., 2013; Rasheed et al., 2015; Ray and Deb, 2016). Cadet and Chainay (2020) show that presence and the retention of information were significantly higher in participants who used the immersive device (VR headset vs. computer screen). Similarly, Stevens and Kincaid (2015) reported a positive correlation between the extent of presence and learning performance. Interestingly, another study by Grassini et al. (2020) found that although the device used (screen vs. VR headset) had no influence on learning performance, there was a clear link between presence and performance. Participants who reported increased presence also achieved higher scores in a performance test. Bailey et al. (2012) investigated the effect of presence on memory and found no positive correlation. Accordingly, the reason is postulated to be cognitive fatigue caused by attention-grabbing and distracting features of the immersive virtual environment. The limited cognitive capacity is cited as a reason why a stronger presence hinders learning activities (Bailey et al., 2012). Lin et al. (2002) conducted another study that investigated the influence of presence on learning performance. They found that there is a positive correlation between presence and memory, but also a positive correlation between presence and cyber sickness. In addition, a combined assessment of engagement, enjoyment and presence had an even stronger influence on learning than presence alone (Lin et al., 2002). A distinction can be made between technologies with a high and a low degree of immersion. Technologies with a high degree of immersion, such as VR headsets and systems such as laptops, desktop PCs or tablets, are categorized as systems with a low degree of immersion.

Despite growing interest in the role of presence in virtual learning environments, there is still a lack of empirical research directly comparing students' perception of presence when using VR vs. traditional digital devices, such as tablets. While prior studies suggest that highly immersive technologies foster greater presence (Cummings and Bailenson, 2016), little is known about how different levels of immersion impact students' learning experiences in classroom settings. Furthermore, the extent to which individual factors, such as prior experience with VR, influence presence remains underexplored. To control the influence on presence, we include gender, age and prior experience with VR devices. Slater et al. (1998) consider gender as a potentially influential variable indicate that men and women do indeed report different levels of presence when immersed in virtual environments. However, very few studies have investigated the effects of age and gender on presence (Felnhofer et al., 2012; Sagnier et al., 2020). Previous studies have shown that cyber sickness (negative effects) is influenced by both gender and previous experience with VR (Knight and Arns, 2006; Munafo et al., 2017).

In order to address the research gaps the following research questions are considered, answered and discussed:

1. To what extent does VR enhance students' perceived presence compared to traditional digital learning tools such as iPads?
2. What individual factors, such as previous VR experience, influence the sense of presence in immersive learning environments?

Building upon theoretical and empirical findings, we hypothesize that students using VR experience a significantly higher sense of presence compared to students using iPads. Our study aims to contribute to the ongoing discourse on the role of immersive technologies in education by providing empirical evidence on the differences in perceived presence between VR and traditional digital devices.

3 Methods

3.1 Participants and measures

The experiment followed a 1×1 between subject experimental design, including the level of immersion (VR or iPad) as the independent variable and presence as the dependent variable. As a priori power analysis was conducted using G*Power to determine the required sample size for a multivariate analysis of covariance (MANCOVA) with two groups, four dependent variables, and the covariates gender, age and VR experience. Assuming a medium effect size [$f^2(V) = 0.0625$], a significance level of $\alpha = 0.05$, and a desired power of $1 - \beta = 0.80$, the analysis indicated a required sample size of ∼68 participants. With a total sample of 71 participants ($n = 37$ and $n = 34$ in each group), the study met this requirement, ensuring adequate statistical power to detect medium-sized effects while controlling for the specified covariates.

The experiment was conducted in the 9th grade biology class at a German comprehensive school (high school). Overall, 71 students aged between 14 and 15 participate in the experiment. Descriptive details are shown in Table 1. Participants were also asked about their level of use of media devices (TV, virtual reality headset, video games), as this could influence their experience of VR. Participants were asked by questionnaire to rate their level of knowledge in using a VR headset, on a four-point Likert-scale (1 = beginner and 4 = expert).

Additionally, we include personal characteristics (age, gender and experience in virtual environments) in the survey. Due to the classification of presence as a psychological perception, it cannot be measured directly, but rather indirectly through various items in a questionnaire (Slater, 2009). We use the ITC- Sense of Presence Inventory (ITC-SOPI) introduced by Lessiter et al. (2001) to measure presence, regardless of the type of device which is used and the environment in which it is used (TV, computer, VR headset, etc.). The questionnaire consists of 44 items,[1] which can be divided into four subjective factors, namely spatial presence, engagement, ecological validity and negative effects. Spatial presence represents how physically present users feel in the virtual environment (Khenak et al., 2018). Engagement shows how much users identify with the content of the virtual environment. Moreover, ecological validity reflects the degree of realism and naturalness of the environment, and negative effects measures the degree of cyber sickness[2] (Mazloumi Gavgani et al., 2018).

3.2 Procedure

In the experimental group we use the Oculus model (Quest 2). The HMD (head mounted display) has a total resolution of 3,664 × 1,920 pixels, for navigation and movement within the VR environment; the participants use battery-powered controllers. In control group, we present the same content using iPads (D-VR). The touch function allows browsing through the virtual space and zooming in. The multi-touch displays (10.2 inches) with LED backlighting and IPS technology have a resolution of 2,160 × 1,620 pixels. To create the virtual environment, we use the Mozilla Hubs program. Hubs can be used seamlessly on different devices, and supports important functions of virtual environments. This is a three-dimensional space in which content (photos, texts, videos, 3D models) can be uploaded. Participants can move through the virtual room and look at the virtual content by using controllers (VR) or touch function (iPad).

The virtual learning environment featured 3D models of cells, which participants could navigate around to closely examine individual compartments. Additionally, a gallery walk was implemented, where simpler models were presented as posters on virtual walls. This design choice aimed to maintain a lower level of interactivity to prevent motion sickness and avoid overwhelming participants with new technology. Moreover, creating a more interactive virtual environment would have required substantial financial resources for programming with advanced tools like Unity. Instead, we utilized Mozilla Spoke, which offers a user-friendly drag-and-drop system for virtual environment creation, making it an efficient choice for our study's objectives. The virtual room contains a 3D model of the human cell and DNA with additional information on cell structure and nucleus, which can be explored as illustrations on the walls of the virtual environment, which is shown in Figure 1. The subject content is based on the school curriculum on the contextual topic: "The cell is the basic unit of all living beings".

Participants were randomly assigned to the experimental group (VR; $n = 34$) and the control group (iPad; $n = 37$). Both groups were spatially separated. The participants were welcomed either in the classroom (iPad) or in the experimental room (I-VR) and informed about the course of the experiment. Followed by instructions on how to operate the device[3] (Oculus Quest 2 or iPad). In a warm-up phase, participants were asked to familiarize themselves with the respective device for 10 min, which is shown in Figure 2. The warm-up phase served to reduce excitement and distractions, in order to be able to start the learning phase in a concentrated and calm manner. This dispels the concerns expressed by Moreno and Mayer (2004) and Makransky et al. (2019) that participants do not perform well in VR due to excitement and distraction in the new and unfamiliar virtual environment, referred to as the "wow effect". Moreover, previous research indicates that the level of interactivity in immersive virtual environments can significantly affect learning performance. For instance, Hebbel-Seeger et al. (2019) explored the influence of immersion and presence on learning outcomes, highlighting the importance of balancing interactivity to optimize educational benefits. Similarly, Sapkaroski et al. (2022) found that immersive VR environments can enhance communication skills training, suggesting that appropriate levels of interactivity contribute to effective learning experiences (Hebbel-Seeger et al., 2019; Sapkaroski et al., 2022).

Subsequently, participants were instructed to concentrate on learning as much as possible in the virtual environment and to absorb as much of the teaching material as possible in the 15-min learning phase.

The parallel transfer of the presentation to tablets ensured guidance and assistance with navigation and movement within the I-VR. In this way, the research assistants could see what the students were seeing, and thus help with problems or questions, but behave passively apart from this. If the students became dizzy or had other problems while wearing the VR headset, they were allowed to take it off and take a break, or end the learning phase before the time expired. At the end, participants were asked in a further 15 min to answer the ITC-SOPI questionnaire in order to measure presence.

1 Please find the entire questionnaire in the Supplementary material.

2 All items are measured on a 5-point Likert scale.

3 Additional information is provided in Appendix.

TABLE 1 Descriptive analysis.

	Participants*	Previous VR use*	VR knowledge**	Video game use	
				Everyday*	Never*
Male	35	15	1.86 (0.692)	8	9
Female	36	15	1.94 (0.754)	7	5
Total	71	30	1.9 (0.720)	15	14

*Absolut number of participants.
**Mean and standard deviation in paratheses.

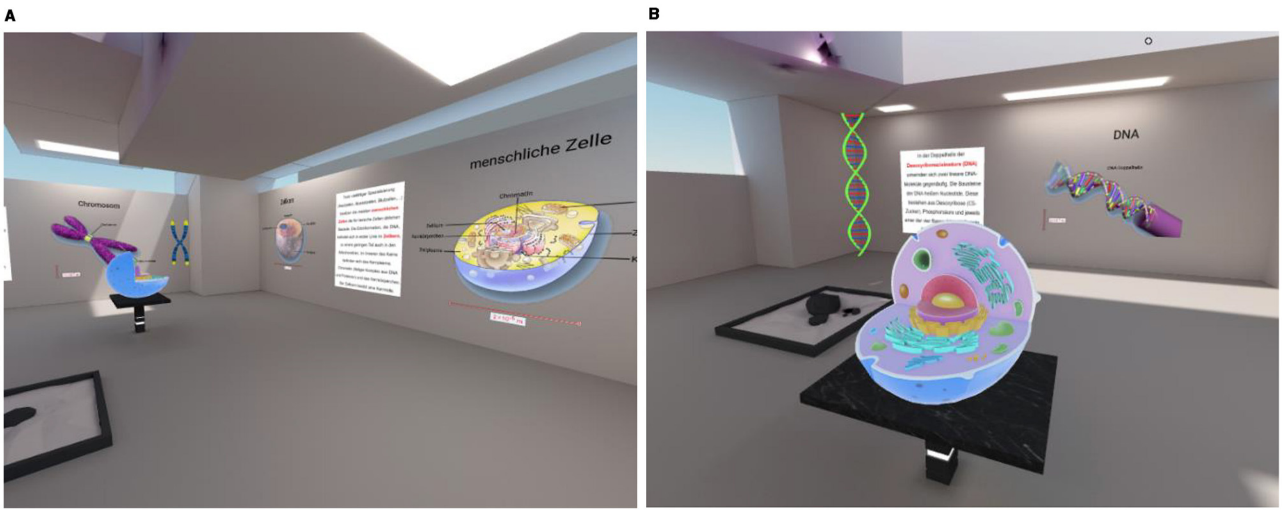

FIGURE 1
Virtual learning environment. Virtual learning environment **(A)** in biology lessons on the topic "Structure and function of the human cell" with 3D models **(B)**, information texts and labeled illustrations.

4 Results

Results show that the presence in the VR group (μ = 3.22, SD = 0.611) is higher than in the iPad group (μ = 2.43, SD = 0.6). For the determination presence, the aggregated values of spatial presence, engagement and ecological validity were averaged (see Table 2).

The significant difference in the groups (VR vs. iPad) is confirmed by MANCOVA (see Table 3). The examination of the individual target variables, taking into account the covariates of age, gender and previous experience was carried out using a MANCOVA. In summary, the multivariate analyses of covariance (MANCOVA) using Pillai's trace find no significant relationship between the covariates "gender", "VR experience", and "age" and the dependent variable "presence". None of the covariates showed a significant effect on the dependent variables.

5 Discussion

The central hypothesis of this study was that the perception of presence is more pronounced in students who use a VR headset is more pronounced than in the iPad group. The results reveal a significant difference between the two groups and go beyond the usually observed moderate effect of immersive technologies on the feeling of presence. The results are in line with current empirical findings (Çoban and Kayserili, 2021; Cummings and Bailenson, 2016; Han et al., 2022; Kang et al., 2022; Morélot et al., 2021). From a theoretical perspective, the experiment is consistent with the concepts of Slater and Wilbur (1997) on the effect of immersion on presence. The authors argue that a high degree of presence is related to the extent to which a person experiences a comprehensive, ambient and vivid representation. The results show that the characteristics of presence, engagement, spatial presence, ecological validity and negative effects reveal a significant difference between the VR group and the iPad group. Therefore, we answer the first research question by higher presence and engagement in the VR group.

In addition to previous experience with I-VR, no effects of gender and age on the feeling of presence could be shown using MANCOVA. As the age range was between 14 and 15 years ($M = 14.9$) and the feeling of presence was only examined in the ninth year, this low variance could be a reason for this effect. It would therefore be useful for future studies to compare the effect of I-VR in different age groups, e.g., between a 5th-year group and a 10th-year group. Studies that have investigated the influence of age on presence have shown that presence decreases with increasing age (Kober et al., 2012). As Kober's study compared people beyond school age, it is particularly important to consider age at school

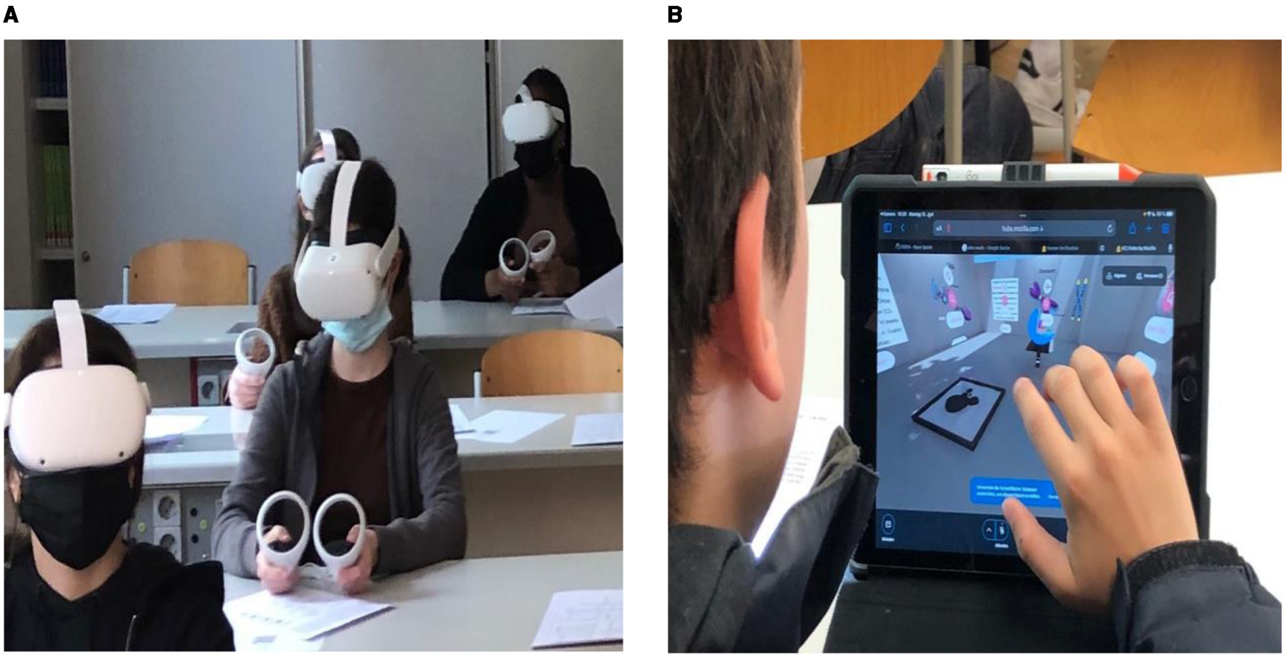

FIGURE 2
Exploring the virtual environment. Students exploring the virtual environment using VR headsets **(A)** and i-Pads **(B)** in biology lessons on the structure and function of the human cell.

TABLE 2 Mean values and standard deviations of main variables.

	Group	*n*	Mean	Median	Std. dev.	Percentile	
						25th	75th
Presence	iPad	37	2.43	2.44	0.6	2.03	2.86
	VR	34	3.22	3.21	0.611	2.81	3.46
Spatial presence	iPad	37	2.22	2.26	0.602	1.74	2.68
	VR	34	3.19	3.29	0.667	2.79	3.63
Engagement	iPad	37	2.45	2.38	0.616	2.08	3.00
	VR	34	3.43	3.44	0.663	2.87	3.87
Ecological validity	iPad	37	2.61	2.60	0.815	2.00	3.00
	VR	34	3.05	3.00	0.822	2.60	3.60
Negative effects	iPad	37	1.78	1.67	0.414	1.67	2.00
	VR	34	2.78	2.83	0.806	2.17	3.33

Mean values and standard deviations for the dependent variables of presence, spatial presence, engagement, ecological validity, and negative effects.

in relation to presence. A study investigating the influence of age on presence when using I-VR found that the older group had significantly higher ecological validity scores, which is explained by the fact that they have less experience with I-VR and virtual worlds in general (Lorenz et al., 2023).

In contrast, ecological validity indicates that younger people are more critical when it comes to the authenticity or realism of the virtual environment. This suggests that more effort should be devoted to creating an improved virtual scenario for students. This makes it clear that previous experience and age are important variables that should also be taken into account in future presence surveys. In contrast to studies that investigated the influence of gender on presence and found that women reported a lower spatial presence and ecological validity than men (Felnhofer et al., 2012), this study found no effect of gender on the variables investigated (spatial presence, ecological validity, engagement and negative effects). Therefore, no gender-specific aspects for the design of a virtual environment in the teaching-learning context can be derived. As this study focused on the influence of immersion level on student presence, future studies should investigate the relationship between gender differences and presence in more detail. This is important, as studies have indicated that there are

TABLE 3 Results of the MANCOVA (VR vs. iPad) and the covariate gender, VR experience and age.

		Sum of squares	*df*	*F*	*p*
Group (VR vs. iPad)	Spatial presence	16.7084	1	42.1160	<0.001
	Engagement	16.9361	1	42.0559	<0.001
	Ecological validity	3.3418	1	4.9769	0.029
	Negative effects	17.6536	1	43.8318	<0.001
Gender	Spatial presence	0.1418	1	0.3575	0.552
	Engagement	0.3646	1	0.9054	0.345
	Ecological validity	0.9365	1	1.3948	0.242
	Negative effects	0.1720	1	0.4271	0.516
VR experience	Spatial presence	0.6430	1	1.6208	0.207
	Engagement	0.7628	1	1.8942	0.173
	Ecological validity	0.9608	1	1.4309	0.236
	Negative effects	0.7690	1	1.9094	0.172
Age	Spatial presence	0.7404	1	1.8664	0.177
	Engagement	0.4581	1	1.1375	0.290
	Ecological validity	0.0108	1	0.0161	0.899
	Negative effects	0.1060	1	0.2633	0.610
Residuals	Spatial presence	26.1838	66		
	Engagement	26.5784	66		
	Ecological validity	44.3161	66		
	Negative effects	26.5820	66		

It is assumed that experiences with VR have an influence on presence, as found by Lombard and Ditton (2006).

gender-related differences in the perception of presence, and that the negative effects can also be different (Peck et al., 2020; Zibrek et al., 2020).

Beyond these direct findings, we consider broader implications of integrating VR into classroom settings. While VR offers significant potential for enhancing learning through immersive experiences, its large-scale implementation presents financial and logistical challenges. Schools may face substantial initial costs for acquiring VR hardware and software, as well as ongoing expenses related to maintenance, updates, and teacher training (Hellriegel and Cubela, 2018). Additionally, technical infrastructure, such as high-performance computers and stable internet connections, is required to ensure a seamless VR experience, which may not be universally available in all educational institutions (Bitkom, 2020). These factors underscore the need for strategic planning when considering the feasibility of VR adoption in formal education.

Furthermore, our findings contribute to the broader discourse on digital learning theories. The results align with constructivist principles, which emphasize active exploration and learner-centered engagement, as VR environments allow students to interact with content dynamically (Wiepke and Heinemann, 2021). However, in contrast to traditional digital learning models, VR may impose unique cognitive demands, such as increased cognitive load due to the complexity of virtual interactions. This distinction suggests that while VR can enhance learning outcomes, its effectiveness may depend on how well it is integrated into pedagogical frameworks. Future research should explore these nuances further to refine theoretical models of immersive learning.

Finally, the limitations section has been strengthened by acknowledging the potential influence of unmeasured factors on study outcomes. Variables such as socio-economic status may affect students' prior exposure to digital technologies, potentially shaping their adaptability to VR-based learning (Bitkom, 2020). Additionally, teacher engagement plays a critical role in facilitating the successful implementation of VR in classrooms, as varying levels of instructional support could affect student-learning experiences. Recognizing these factors provides a more nuanced interpretation of our findings and highlights areas for future research to address these gaps.

6 Conclusion

This study investigated the perception of presence in students utilizing virtual reality (VR) headsets, compared to those using iPads. The findings revealed a significant difference between the two groups, indicating that the VR group experienced a heightened sense of presence compared to the iPad group. These results extend beyond previous observations of moderate effects associated with immersive technologies, as suggested by Cummings and Bailenson (2016).

The experiment's outcomes align with Slater and Wilbur (1997) conceptualization of immersion's impact on presence, emphasizing the importance of a comprehensive, ambient, and vivid representation. Specifically, significant disparities were observed between the VR and iPad groups across various presence-related dimensions, including engagement, spatial presence, ecological validity, and negative effects.

Furthermore, while factors such as previous experience with immersive VR, age, and gender were examined (Campo et al., 2023), we do not find significant effects of those factors on presence. Although no age or gender effects were detected in this study, the literature suggests that age-related differences in presence may exist, particularly within educational contexts.

Future research endeavors could thus explore the influence of age across different age groups in order to better understand how age interacts with presence in immersive learning environments. Additionally, while gender differences were not evident in this study, previous research has highlighted potential gender-related variations in presence perception and associated negative effects, underscoring the need for more nuanced investigations in this area.

Overall, these findings add to the body of literature targeting the relevance of highly immersive technologies to perceiving presence in virtual environments.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required for the studies involving humans because this experiment which, according to the guidelines of the Ethics Committee, is not subject to an ethics vote so that this does not have to be obtained. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required from the participants or the participants' legal guardians/next of kin in accordance with the national legislation and institutional requirements because components of the experiment are part of the regular lessons (digital devices and content).

Author contributions

CA: Conceptualization, Visualization, Writing – original draft, Writing – review & editing. FB: Data curation, Formal analysis, Project administration, Software, Writing – review & editing. KB: Conceptualization, Project administration, Supervision, Writing – original draft. TU: Conceptualization, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1560626/full#supplementary-material

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