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Article

Perceived Presence, Fidelity, Immersion and Usability in an Immersive Virtual Reality Learning Object: A Cross-Sectional Study with Higher-Education Students in a Future Classroom Environment

Julio Cabero-Almenara [1], Antonio Palacios-Rodríguez [1,*], Julio Barroso-Osuna [1] and Mª Victoria Fernández-Scagliusi [2]

[1] Department of Didactics and Educational Organization, Faculty of Educational Sciences, University of Seville, 41013 Seville, Spain; cabero@us.es (J.C.-A.); jbarroso@us.es (J.B.-O.)
[2] Faculty of Educational Sciences and Humanities, International University of La Rioja, 26006 Logroño, Spain; mariavictoria.fscagliusi@unir.net
* Correspondence: aprodriguez@us.es

Abstract

Immersive virtual reality (VR) is increasingly used in higher education, yet evidence on how perceived presence, fidelity, immersion and usability co-occur in authentic learning objects—and how they relate to prior experience and gender—remains limited. This cross-sectional study examines these four perceptual dimensions in 250 undergraduate students of Early Childhood and Primary Education at the University of Seville immediately after interacting with an immersive VR learning object built around the Future Classroom model. All variables are self-reported perceptions collected at a single post-experience time point; no learning outcomes were assessed. Data were collected with the Igroup Presence Questionnaire (IPQ), a fidelity–immersion scale and the System Usability Scale (SUS). Reliability was high across instruments (α = 0.881–0.931). Students reported moderate-to-high presence, realism, fidelity and immersion, and a notable usability score (SUS = 71.18). Presence, fidelity and immersion correlated strongly and positively, although their conceptual proximity and the shared measurement method preclude treating these associations as evidence of empirically distinct constructs. Associations with usability were weak and heterogeneous. Gender differences were absent except for involvement, an isolated result reported as exploratory. Prior experience with VR and with head-mounted displays was associated with differences in the ratings, with small effect sizes and a non-monotonic pattern: the intermediate-experience group scored lowest, whereas the low- and high-experience groups did not differ significantly from one another. The study characterises students' perceived experience of an immersive VR learning object; it does not test its effects on learning.

Keywords: virtual reality; presence; immersion; fidelity; usability; perceived experience; self-report measures; cross-sectional study; higher education; IPQ; SUS

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1. Introduction

Virtual reality (VR) is one of the emerging technologies with the strongest presence across education, business, tourism and healthcare, including therapeutic uses such as phobia treatment [1]. Its integration is no longer limited to face-to-face instruction: it

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is progressively being incorporated into pure e-learning and blended designs that combine online and in-person activities [2,3]. VR is also being combined with 360° video and artificial intelligence (AI) to generate more interactive, personalised, realistic and immersive environments [4,5].

Recordings in 360° are a more intuitive, realistic and cost-effective alternative to other VR production modalities: they deliver an immersive experience with less complex technology while sustaining high engagement in educational settings [6]. Regarding AI, the meta-analysis by Chimbo et al. [7] shows that integrating VR and agentic AI increases engagement, cognitive accuracy, affective safety and socio-emotional development, enabling adaptive learning, emotional regulation and personalised pacing.

Definitions of VR are diverse [8]. One of the broadest characterises it as an environment—real-looking or otherwise—that gives the user the sensation of being inside it, generated by a computer system and visualised through devices such as head-mounted displays (HMDs), and optionally combined with position and motion sensors, gloves, spatial audio and hand controllers to move around and manipulate objects [9].

Three broad categories are usually distinguished based on how integrated the user is with the digital environment: fully immersive, semi-immersive and non-immersive (desktop) systems. In fully immersive VR, the user is completely integrated in a computer-generated environment with no perceptual reference to the physical context; this is achieved through HMDs. Semi-immersive VR combines physical space with virtual elements projected on high-resolution surfaces, supporting interaction via sensors, physical interfaces or gestural recognition. Non-immersive VR delivers digital content through conventional devices such as computers or tablets, keeping a clear boundary between physical and virtual space; interaction relies on traditional peripherals [10–12].

Across historical [13] and contemporary [14–16] definitions, there is broad agreement that immersion, presence and interactivity are the defining features of VR. VR has also renewed debates on realism. Hao [17] frames this as a tension between realists—for whom VR is a special form of objective material existence—and antirealists, who see it as an artificial reality that is only perceptible on a technological basis. The author concludes that VR is best understood as a technology that creates a multidimensional digital environment allowing users to experience and interact with a simulated world through the integrated stimulation of multiple sensory modalities, framed around interactivity, immersion and imagination [17].

The relationships between the virtual and the real always unfold through interfaces, which not only negotiate the boundaries between the tangible and the intangible but also reconfigure the modes of representation, interaction and perception [17]. Within this reconfigured digital reality, presence and immersion become critical constructs for understanding the connections, sensations, learning processes and interactions that occur in the user. Framed within the growing conversation on embodied cognition and spatial computing in education, they are the axes on which the affordances of immersive VR for teaching and learning ultimately rest.

Two clarifications frame the present study. First, presence, immersion and fidelity are perceptual and experiential constructs: they describe how users experience an environment, not what they learn from it. Second, the affordances attributed to them in the educational literature are hypotheses about conditions that may support learning rather than demonstrations of learning itself. Accordingly, this study is deliberately confined to the first link in that chain—the quality of the experience students report after using an authentic immersive VR learning object—and does not attempt to establish effects on knowledge acquisition, academic performance or transfer.

2. Theoretical Background

2.1. Presence and Immersion in Virtual Reality

In an early and widely cited work, Witmer and Singer [18] argued that the effectiveness of virtual environments—regardless of type—is frequently linked to the sense of presence users report. They defined presence as the subjective experience of being in a place or environment even when one is physically located elsewhere, describing it as a phenomenon of normal consciousness that requires directed attention and arises from the interaction between sensory stimulation, environmental factors that foster involvement and enable immersion, and internal engagement behaviours.

As Krassmann et al. [19] note, different terms have been used to designate that subjective experience: virtual presence, collaborative virtual presence, and others. In line with several authors [20], we use the term presence to refer to a state of consciousness and the psychological sense of being in the virtual place that leads the individual to accept the virtual reality as natural. For this to happen, Scavarelli et al. [21] argue, the person must accept two illusions: the place illusion (that the place they are in is real) and the plausibility illusion (that what is happening is really happening). Steuer [22] adds that whereas presence is natural in a real environment, in a virtual one it requires a technological medium and rests on a dual mechanism: credibility (sensory information) and interactivity (real-time modification of the environment by the user).

Different types of presence have been proposed: spatial, sensory, social realism, personal, social, environmental and engagement [23]. Other authors identify social, spatial (physical) and self-presence as the core dimensions in VR [24]. Social presence emerges when users interact naturally with virtual agents or other users' avatars; self-presence involves a sense of belonging to the avatar; and spatial presence occurs when users feel transported from the real world into the virtual environment through their interactions with it. From a psychological standpoint, Waterworth and Waterworth [25] proposed a model in which presence is influenced by three factors: locus (whether the user's attention is focused on the virtual or the real world), focus (a continuous scale between absence and presence) and sensus (activation, ranging from unconsciousness to consciousness).

Recent meta-analyses show a sharp increase in VR research focused on presence [26], although work has tended to concentrate on the technical aspects of immersion and experience design rather than on educational relationships. Krassmann et al. [19] therefore highlight the importance of empirical educational studies, since presence and learning are strongly related.

As for immersion, Valdés and Rueda [27] describe it as a way of being—a state of forming part of something rather than merely being in it, akin to being dissolved in a digital, immaterial surface. Espinoza-Castro et al. [28] define it more operationally as the system's capacity to stimulate the user's senses, facilitating interaction and generating the sensation of physical presence in the virtual environment. As already noted, immersion is commonly graded into non-immersive, semi-immersive and fully immersive levels [28]. Stracke et al. [29] specify that non-immersive VR keeps a visible boundary between the virtual and the real (conventional screens), semi-immersive VR uses large projection surfaces, so the boundary becomes less evident, and fully immersive VR eliminates visible boundaries through devices such as CAVE environments and HMDs.

The relationship between presence and immersion is close but not identical. The perceived level of immersion allows the user to temporarily disengage from the physical environment and experience the virtual one as the most immediate reality, thereby increasing realism: the greater the detachment from the real environment, the higher the credibility and sense of presence. Williams et al. [30] make the distinction clearer: immersion refers to the objective technical specifications required to deliver the virtual experience of being there, while presence is the subjective psychological experience. Immersive VR delivered through HMDs, enabling 360° viewing via head movement and object manipulation through hand controllers, heightens the user's sense of presence in the virtual environment. Slater and Wilbur [31] anchor this distinction: immersion as an objective property of the technological system and presence as the psychological state or experience of being there.

Several factors can enhance the sense of presence. One is the level of immersion afforded by the technology [32]: their classroom experiment showed that immersive VR significantly increased students' presence compared with desktop versions on an iPad. Chang and Suh [33] found that in VR art-viewing experiences, dimensions such as entertainment, escapism and aesthetic experience positively shape user interaction and contribute to presence, immersion and satisfaction. Presence is also affected by the realism of the object, which reduces the user's cognitive load [34], and by the incorporation of 360° video [35,36]. A related strand of work has shown that the usability of the objects favours both student acceptance and increased presence [37,38].

Related to usability is plausibility, which refers to the importance of generating virtual scenes whose dynamic behaviour is congruent with what happens in the real environment the VR system is recreating [26,39]. This calls for the construction of VR learning objects that are realistic and faithful in reproducing real-world phenomena, and here 360° recordings are particularly helpful.

2.2. Presence and Immersion in Educational Settings

How do presence and immersion influence the quality of user interaction and the outcomes achieved? Empirical work relating these constructs to strictly educational dimensions is still scarce but growing.

An earlier study [20] indicated that the sense of presence reduces the social distance between learners and improves skill acquisition and knowledge transfer by enabling multiple perspectives and situated performance. Presence in virtual learning environments was also found to foster motivation, learning engagement and potential learning outcomes by enabling focused, naturalistic interactions with learning materials and activities.

Wiepke and Heinemann [24] argue that, in learning contexts, experiencing presence can enhance students' capacity to transfer acquired knowledge and skills to real-life situations, correlating positively with learning outcomes. In this respect, VR is gaining traction in higher education because it enables complex simulated scenarios that support practical training, especially in medicine, engineering and the natural sciences [40].

The value of achieving a sense of presence with VR was clearly evidenced during the COVID-19 period, when its combination with e-learning delivered highly effective digital learning environments in terms of satisfaction, achievement and technical skill development, compensating for the lack of physical presence [41]. Increased presence also expands the motivation students bring to VR experiences [42], and immersion quality further increases the person's engagement and acceptance [43]. Presence has been reported as especially beneficial for the health sciences [40,44].

Two limitations frame the interpretation of this body of evidence. First, a substantial part of it rests on post-experience self-reports of presence, immersion and satisfaction rather than on objective indicators of knowledge acquisition, performance or transfer; associations between perceived presence and perceived learning are not equivalent to demonstrated learning gains [26,28]. Second, presence, realism, fidelity and immersion are conceptually adjacent and are typically captured with questionnaires administered at the same moment and in the same format, so part of the covariation they display may reflect overlapping item content and common-method variance rather than relations among independent constructs [27]. High internal-consistency coefficients speak to reliability, not to discriminant validity. None of this diminishes the relevance of perceptual measures, which remain the standard way of characterising the experiential quality of immersive environments, but it does set the boundary within which findings of this kind can be interpreted.

Although the influence of gender on VR experiences remains inconclusive, previous studies have reported mixed findings regarding presence, immersion, technology acceptance and interaction within virtual environments [28]. Some studies suggest that men and women may differ in their perceptions of immersion, engagement or technology adoption, whereas others have found no significant gender-related effects, particularly in higher education contexts [19,20]. Given these inconsistent findings, examining gender differences remains relevant to determine whether immersive VR learning experiences are perceived similarly across groups and to contribute additional evidence to an area where results remain contradictory.

3. Materials and Methods

3.1. Objectives

This study follows a cross-sectional, single-group, post-experience survey design. All variables are students' self-reported perceptions of a single immersive VR learning object, gathered at one time point immediately after use. The design includes no pretest, no control group and no non-immersive comparison condition. It therefore supports descriptive and associative claims about the perceived experience, but it does not support causal claims about the effects of immersion, fidelity or usability, and it does not address learning outcomes.

The educational question behind the study is a design question rather than an effectiveness question: whether a learning object produced with accessible 360° authoring technology and embedded in ordinary university practical sessions is perceived by students as delivering the experiential conditions—presence, fidelity, and immersion—that the literature identifies as prerequisites for the pedagogical affordances attributed to immersive VR, and whether perceived usability behaves as the enabler of those conditions that is frequently assumed. Documenting how that experience is perceived, and how it is distributed across students, is a precondition for the outcome studies that must follow; it is not a substitute for them.

The study addresses the following objectives:

- To describe the levels of presence, fidelity and immersion that students report after interacting with an immersive VR learning object representing an authentic professional setting.
- To examine how perceived usability relates to reported presence, fidelity and immersion, and whether that relationship is uniform across their dimensions.
- To examine whether the reported experience differs by gender.
- To examine whether the reported experience differs as a function of students' prior experience with VR objects and with VR head-mounted displays.

3.2. Sample

The sample comprised 250 undergraduate students of Early Childhood and Primary Education at the Faculty of Education Sciences of the University of Seville, enrolled in the course "ICT applied to Education". Sampling was non-probabilistic (convenience), and most students on those degrees participated, since the activity was embedded in the course's practical sessions. The sample included 203 women (81.2%) and 47 men (18.8%).

This distribution reflects the gender composition typically found in Early Childhood and Primary Education degree programmes in Spain.

3.3. Instruments

Three instruments were used. Presence was assessed with the Igroup Presence Questionnaire (IPQ), originally developed by Schubert et al. [45]; the Spanish version validated by Castro et al. [46] was administered. Fidelity and immersion were assessed with the instrument developed by McEwan et al. [39], and usability was assessed with the System Usability Scale (SUS) proposed by Brooke [47,48].

The IPQ comprised 13 items across three dimensions: involvement (3 items), realism (4 items) and spatial presence (6 items). Spatial presence refers to the sensation of being located within the virtual environment (VE)—the feeling of being there; involvement refers to the attention and concentration devoted to the VE, such that the user forgets the surrounding real context; and realism refers to the perceived capture of the VE, or judgements about its comparability to reality [46]. The IPQ is one of the most widely used subjective assessment instruments for measuring presence in virtual environments, with strong reliability indices [49], and its international consolidation has been reinforced by the Igroup Project Consortium through adaptation, translation and validation in different cultural and linguistic contexts.

The instrument originally developed by McEwan et al. [39] assessed three dimensions: fidelity, immersion and spatial presence. Because spatial presence was already assessed with the IPQ, only the fidelity and immersion dimensions were used here, comprising 10 items (6 for fidelity and 4 for immersion). Both scales used a Likert response format ranging from 0 (nothing) to 10 (a great deal). For usability, several models are available [50], but the SUS is among the most widely used tools for diagnosing perceived usability of an object or technological system [51,52], and its usefulness for AR and VR objects has been shown in multiple studies [53–56].

All questionnaires were administered in digital format immediately after completion of the VR experience. Participants responded by selecting the option that best represented their perceptions and experiences during the activity.

For the IPQ, items were rated on an 11-point scale ranging from 0 to 10, where higher scores indicated a stronger sense of presence in the virtual environment. The fidelity–immersion instrument also used an 11-point Likert-type scale ranging from 0 (nothing) to 10 (a great deal) [39]. For the SUS, participants responded to the 10 items using the standard five-point response scale ranging from 1 (strongly disagree) to 5 (strongly agree) [47,48]. Higher SUS scores indicate greater perceived usability of the system.

Reliability was analysed with Cronbach's alpha (α) and McDonald's omega (ω) [57,58]. Table 1 reports the values obtained for each instrument, both as a whole and by dimension.

Table 1. Reliability indices of the instruments used.

Instrument	Dimension	Cronbach's α	McDonald's ω
IPQ (Presence)	Involvement	0.842	0.857
	Realism	0.814	0.829
	Spatial presence	0.883	0.891
	IPQ (total)	0.912	0.924
Fidelity	Fidelity	0.851	0.867
	Immersion	0.889	0.903
	Total fidelity and immersion	0.931	0.944
SUS	—	0.881	0.894

Reliability coefficients show high internal consistency across all scales, exceeding the values recommended in the literature [59–64].

Two features of the measurement design bear on how the results should be read. The three instruments were administered in the same digital format and at the same moment, and the constructs they capture—presence, realism, fidelity and immersion—are conceptually adjacent, so part of the covariation reported in Section 4 may stem from overlapping item content and common-method variance. The coefficients in Table 1, moreover, index internal consistency and do not by themselves establish that the dimensions are empirically distinct: no confirmatory factor analysis or formal test of discriminant validity was conducted on the present sample.

Prior experience was measured with two single self-rating items, one referring to VR learning objects and one to Meta Quest-type head-mounted displays, each on the same 0–10 scale used by the other instruments. For the group comparisons, ratings were collapsed into three bands—low (0–3), medium (4–6) and high (7–10)—which divide the 0–10 range into approximately equal intervals corresponding to the lower, middle and upper thirds of the response scale. The cut-offs are thus scale-based rather than sample-based: they were fixed a priori on the response metric rather than derived from the observed distribution, which avoids capitalising on sample-specific variation but produces markedly unequal group sizes, since most students rated themselves in the upper band. This imbalance constrains the group comparisons reported in Section 4 and is revisited in Section 6.

3.4. Learning Object

The VR experience was implemented during scheduled practical sessions of the course. Prior to the activity, students received a brief orientation regarding the objectives of the experience and the use of the immersive equipment. Students worked individually or in pairs, exploring the learning object using Meta Quest 3 (Meta Platforms, Inc., Menlo Park, CA, USA.) head-mounted displays (Figures 1–3).

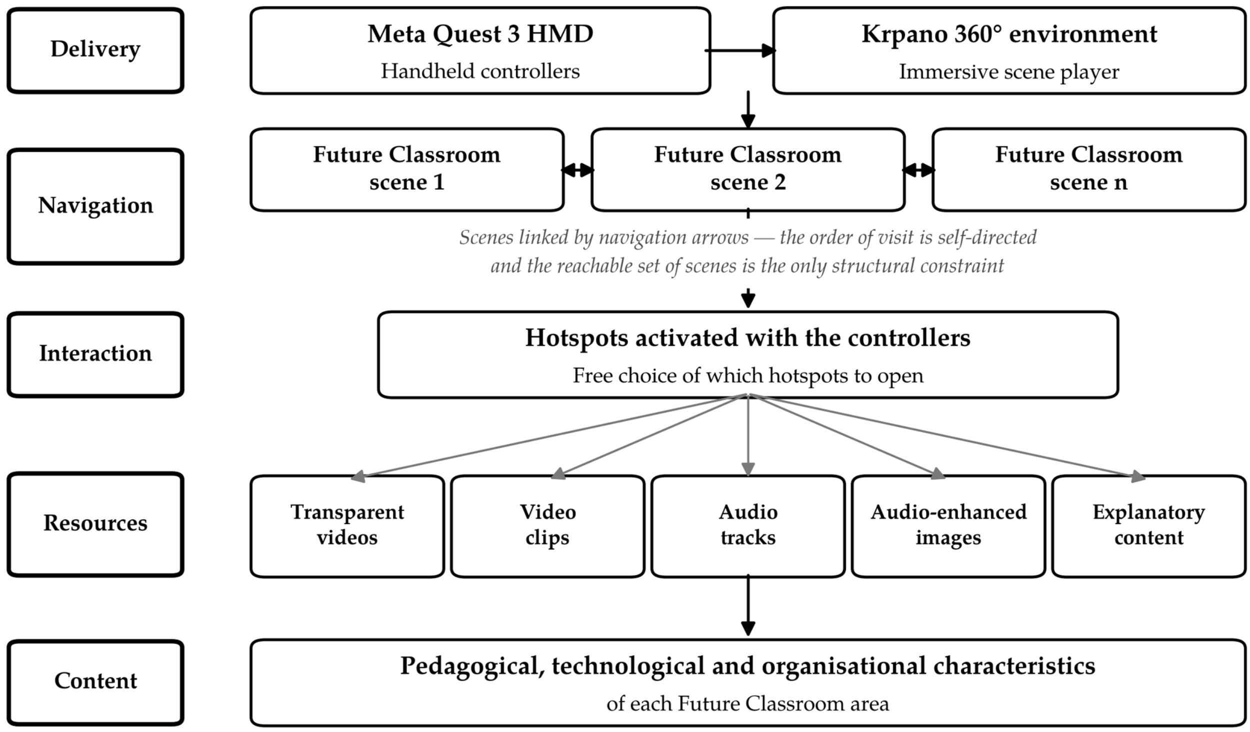

Figure 1. Structure of the VR learning object: delivery, navigation between 360° scenes, in-scene interaction, types of embedded resources, and the content addressed in each Future Classroom area.

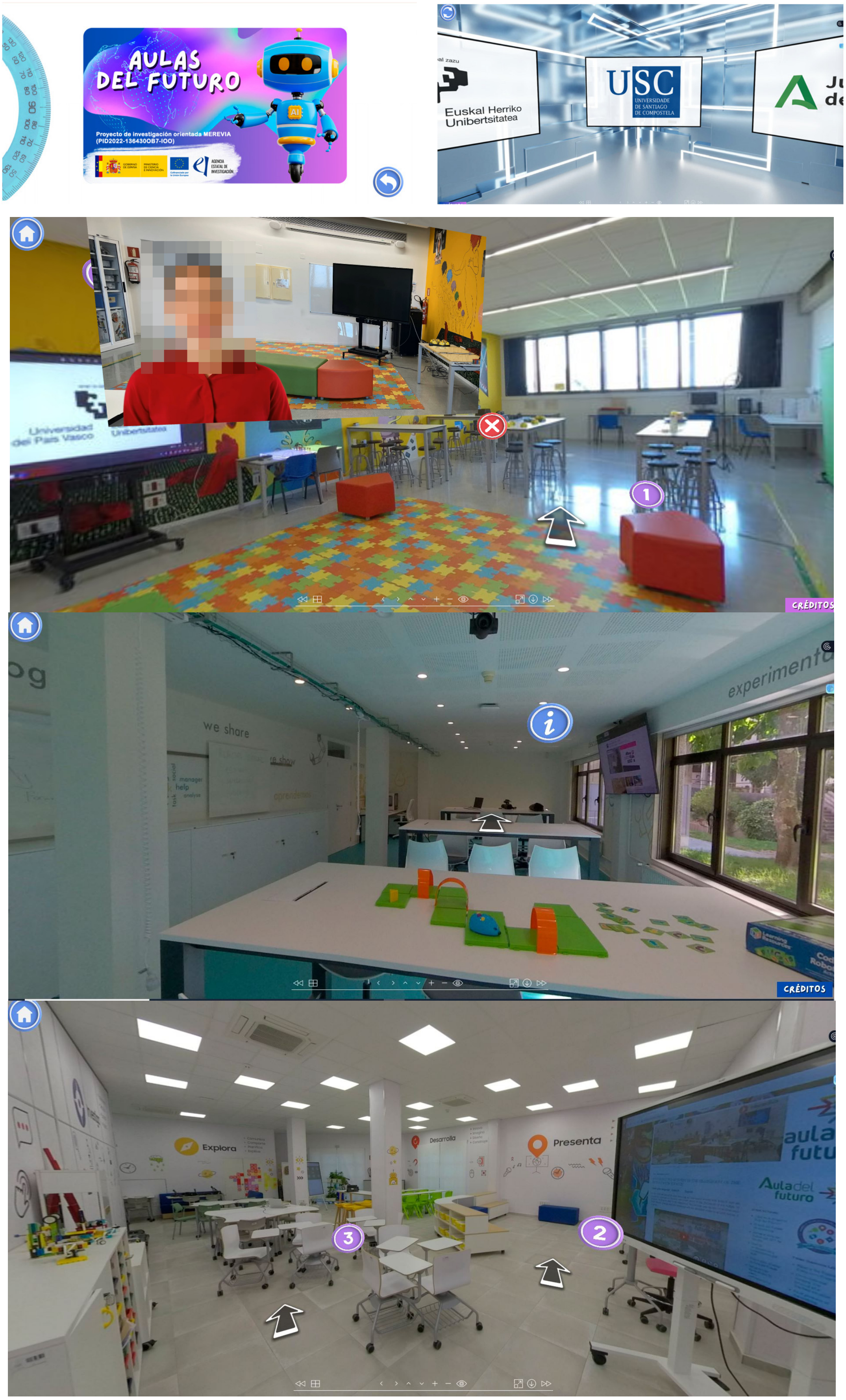

Figure 2. Images from the VR object "Future Classroom". The face of the person appearing in the transparent video resource has been pixelated to protect the identity of the individual portrayed.

Figure 3. Students during the VR experience.

The learning object was developed using Krpano software 1.24, which enabled the creation of immersive 360° virtual environments integrating interactive multimedia elements. The environment included navigable scenes representing different Future Classroom settings and incorporated a variety of educational resources, such as videos, audio recordings, images, hotspots, and explanatory content embedded within the virtual space [62–67]. Navigation arrows were also incorporated to guide movement between scenes and facilitate orientation within the environment [65].

Interaction with the learning object was carried out through the Meta Quest 3 handheld controllers. Participants could freely navigate through the different virtual spaces, activate hotspots, access supplementary multimedia information, and explore the pedagogical, technological, and organisational characteristics associated with each Future Classroom area.

The learning object combined immersive observation with interactive access to multimedia resources, including transparent videos, audio tracks, video clips, hotspots, and audio-enhanced images. These elements were incorporated to promote engagement, facilitate orientation, and support the understanding of the educational functions associated with each classroom space [6,65,68–70].

Figure 1 summarises this architecture, showing how the delivery hardware, the navigation layer, the hotspot interaction layer and the embedded resource types relate to the content addressed in each Future Classroom area.

Upon completion of the VR experience, participants completed the three instruments used in the study: the Igroup Presence Questionnaire (IPQ), the fidelity–immersion scale, and the System Usability Scale (SUS).

Beyond its technological configuration, the activity was framed by three open guiding questions posed to students before they entered the environment: what they understood virtual reality to be, whether they had previous experience with it, and how VR might be integrated into a learning situation. These questions were designed to activate prior knowledge and to orient students towards the educational potential of the medium; they did not prescribe content to be located within the environment. Exploration was accordingly self-directed: students chose the order in which they visited the scenes and which hotspots to activate, and the only structural constraint was the set of scenes reachable through the navigation arrows.

It should be noted that the guiding questions concerned virtual reality as a technology rather than the pedagogical organisation of the Future Classroom depicted in the object.

This framing is relevant to the interpretation of the involvement scores reported in Section 4 and is taken up in Section 5.

No graded task, worksheet submission or knowledge test was attached to the experience; the only post-activity requirement was completion of the three questionnaires.

3.5. Procedure and Equipment

Students interacted with the object using Meta Quest 3 headsets (Figure 3) during the course's scheduled practical sessions, which were run with reduced group sizes. Ten headsets were available, so students worked individually or in pairs rather than in extended rotating turns. Each practical session lasted 1 h and 20 min in total, of which approximately 1 h was spent interacting with the virtual environment; the remaining time covered the initial orientation, the guiding questions, the fitting and calibration of the devices and the completion of the questionnaires. The initial orientation covered how to fit the headset and how to navigate within the environment. Beyond this, teaching staff provided technical assistance with the equipment but no content-related guidance during the exploration itself. Immediately after removing the headset, each student completed the IPQ, the fidelity–immersion scale and the SUS in digital format, in that order. All students enrolled in the sessions took part in the activity.

Because a proportion of students worked in pairs, some participants experienced the environment alongside a peer rather than in isolation. Each student completed the three instruments individually, but this shared setting may have introduced a degree of social framing that the design does not isolate. This is noted as a further constraint in Section 6.

4. Results

Students' self-reported prior experience with VR objects and with immersive headsets is summarised in Table 2.

Table 2. Means and standard deviations of self-reported prior experience.

	Prior Experience with VR Objects	Prior Experience with Meta Quest–Type Headsets
M	7.41	6.93
SD	2.823	3.261

Self-rated prior experience was relatively high overall (M = 7.41 for VR objects and M = 6.93 for headsets on a 0–10 scale), with somewhat lower values for headset-based (immersive) interaction than for desktop-type use. High standard deviations indicate substantial dispersion, which is clearer when students are grouped into three levels—low (0–3), medium (4–6), high (7–10)—as shown in Table 3.

Table 3. Distribution of students by self-rated experience level.

	Level	f	%	Cumulative %
Experience with VR	Low	31	12.4	12.4
	Medium	39	15.6	28.0
	High	180	72.0	100.0
Experience with VR headsets	Low	50	20.0	20.0
	Medium	28	11.2	31.2
	High	172	68.8	100.0

Item-level, dimension-level and overall means and standard deviations for the IPQ are reported in Table 4.

Table 4. Means and standard deviations for the IPQ.

Item/Dimension	M	SD
How aware were you of the real world surrounding you while navigating the virtual world? (I)	6.03	2.498
I was not aware of my real environment (I)	5.17	2.718
I still paid attention to the real environment (I)	4.32	2.984
Did the virtual world seem real to you? (R)	7.62	2.131
How much did your experience in the virtual environment seem consistent with your experience in the real world? (R)	7.40	1.943
How real did the virtual world seem to you? (R)	7.90	1.858
The virtual world seemed more realistic than the real world (R)	4.22	3.082
I had the sense of being in the virtual space, rather than operating something from outside (SP)	6.87	2.119
I did not feel present in the virtual space (SP)	4.67	2.919
In the computer-generated world I had the sense of "being there" (SP)	7.14	2.251
Somehow I felt the virtual world surrounded me (SP)	7.46	2.054
I felt present in the virtual space (SP)	7.56	1.913
I felt as though I was merely looking at images (SP)	4.19	3.046
Involvement (I)	5.17	1.943
Realism (R)	6.79	1.871
Spatial presence (SP)	6.31	1.341
IPQ (total)	6.09	1.296

Overall, a moderate level of presence was obtained, with relatively low standard deviations suggesting some homogeneity across responses. Ratings are slightly above the mid-point of the scale for the total score and for realism and spatial presence, and close to the mid-point for involvement. This pattern is reflected in specific items: "Did the virtual world seem real to you?" (7.62), "How much did your experience in the virtual environment seem consistent with your experience in the real world?" (7.40) and "How real did the virtual world seem to you?" (7.90), as well as "Somehow I felt the virtual world surrounded me" (7.46) and "I felt present in the virtual space" (7.56).

Item-level and dimension-level results for the fidelity–immersion instrument are shown in Table 5.

Table 5. Item, dimension and total scores for the fidelity–immersion instrument.

Item/Dimension	M	SD
I believe this environment is a duplicate of a classroom (F)	6.82	2.293
This virtual environment matches experiences I have had in a physical world (F)	6.45	2.554
This environment does not reproduce familiar places (F)	4.63	2.965
The environment looks like a place I could encounter in the real world (F)	7.90	2.128
Overall, to what extent did things in the virtual environment look as they would if you had experienced them directly? (F)	7.41	2.018
This environment seems a representation of something real (F)	7.90	1.862
I felt fully immersed (I)	7.22	2.143
I felt disconnected from the outside world (I)	6.44	2.482
I felt I could interact with the place as if I were in the real world (I)	6.84	2.396
I forgot my daily worries (I)	6.15	3.155
Fidelity (F)	6.85	1.548
Immersion (I)	6.66	2.079
Total fidelity and immersion	6.76	1.642

Scores on the fidelity–immersion instrument were above the scale midpoint: perceived fidelity averaged 6.85 and immersion averaged 6.66, while the total fidelity–immersion score was 6.76, with relatively low dispersion.

Following standard SUS scoring [71], the overall SUS score was 71.18. Under Gimeno's interpretation [72], this places usability at the notable band (65–80), and above the 68-point threshold proposed by Pedrosa [73] for desirable usability. Under these interpretive benchmarks, the SUS score corresponds to a notable or desirable level of perceived usability.

Relationships between presence and fidelity, and their dimensions, were examined with Spearman rank correlations (Table 6).

Table 6. Spearman rank correlations between presence and fidelity dimensions.

	Involvement	Realism	Sp. Presence	Fidelity	Immersion	Total F&I
Involvement	—			0.246 <0.001	0.032 0.617	0.124 0.051
Realism	0.095 0.134	—		0.630 <0.001	0.691 <0.001	0.728 <0.001
Spatial presence	0.337 <0.001	0.607 <0.001	—	0.548 <0.001	0.603 <0.001	0.645 <0.001
IPQ	0.642 <0.001	0.737 <0.001	0.797 <0.001	0.614 <0.001	0.533 <0.001	0.618 <0.001
Fidelity				—	0.604 <0.001	0.842 <0.001
Immersion					—	0.927 <0.001

Correlations across dimensions of the two instruments are positive and significant, indicating that scores co-vary. Overall correlations tend to be high or very high (generally above 0.70). Across dimensions, except for the IPQ involvement dimension, relationships are positive and significant, ranging from moderate to high.

Interval estimates were computed for these coefficients using the Fisher transformation with the standard error appropriate to Spearman's rho [74,75]. The intervals for the strong associations are narrow and remote from zero—for example, immersion with the fidelity–immersion total, 95% CI [0.903, 0.945]; spatial presence with the IPQ total, 95% CI [0.739, 0.844]; realism with the fidelity–immersion total, 95% CI [0.655, 0.787]; and fidelity with immersion, 95% CI [0.511, 0.683]. The precision of these estimates is therefore high, although, as noted in Section 3.3, their magnitude reflects conceptual proximity and shared measurement method as well as any substantive relationship.

Table 7 reports correlations between usability (SUS) and presence and fidelity.

Table 7. Spearman rank correlations between SUS and presence and fidelity.

	Involvement	Realism	Sp. Presence	IPQ	Fidelity	Immersion	Total F&I
SUS	−0.162	0.148	0.111	0.064	0.173	0.169	0.186
p	0.010	0.019	0.079	0.314	0.006	0.007	0.003

The pattern for perceived usability is weak and heterogeneous rather than uniformly positive. Usability correlates positively but weakly with fidelity (ρ = 0.173), immersion (ρ = 0.169), the fidelity–immersion total (ρ = 0.186) and the realism dimension of the IPQ (ρ = 0.148); it correlates negatively with involvement (ρ = −0.162); and it shows no significant association with spatial presence (ρ = 0.111, p = 0.079) or with the IPQ total score (ρ = 0.064, p = 0.314). All coefficients fall below 0.20, so even the significant associations account for less than 4% of shared variance. Perceived usability therefore cannot be characterised in these data as a general facilitator of presence.

The interval estimates make the contrast with Table 6 explicit. The confidence intervals for the usability coefficients are wide relative to their magnitude and lie close to zero throughout: involvement, 95% CI [−0.281, −0.038]; realism, [0.024, 0.268]; fidelity, [0.049, 0.292]; immersion, [0.045, 0.288]; and fidelity–immersion total, [0.062, 0.304]. For spatial presence, [−0.014, 0.232], and for the IPQ total, [−0.061, 0.187], the intervals include zero. Even at the upper bound of the intervals, none of these associations would reach the magnitude of the weakest relationship reported in Table 6. The data are thus compatible with a very small positive association between usability and some experiential dimensions, and with no association at all for others.

For the gender analyses, the following hypotheses were tested for each dependent variable. H0: no significant gender differences at $p \leq 0.05$; H1: significant gender differences at $p \leq 0.05$. The Mann–Whitney U test was used. Results for prior experience with VR and headsets are shown in Table 8.

Table 8. Mann–Whitney U for gender and prior experience with VR and VR headsets.

	Experience with VR	**Experience with VR Headsets**
Mann–Whitney U	4251.000	4691.500
Wilcoxon W	24,957.000	5819.500
Z	−1.476	−0.217
Asymp. sig. (2-tailed)	0.140	0.828

H0 cannot be rejected in either case: no gender differences in prior experience with VR or with VR headsets at $p \leq 0.05$.

Table 9 shows the corresponding tests for IPQ, fidelity–immersion and SUS scores by gender.

Table 9. Mann–Whitney U for gender across IPQ, fidelity–immersion and SUS.

	Mann–Whitney U	**Wilcoxon W**	**Z**	**Asymp. Sig. (2-Tailed)**
Involvement	3731.000	24,437.000	−2.331	0.020
Realism	4113.500	5241.500	−1.472	0.141
Spatial presence	4501.000	5629.000	−0.604	0.546
IPQ	4646.000	5774.000	−0.279	0.780
Fidelity	4639.500	5767.500	−0.293	0.769
Immersion	4496.500	5624.500	−0.614	0.539
Total fidelity and immersion	4485.500	5613.500	−0.638	0.523
SUS	4635.500	5763.500	−0.303	0.762

H0 could only be rejected for the involvement dimension of the IPQ ($p \leq 0.05$). Neither the three instruments overall nor most dimensions produced significant gender differences. For the involvement dimension, mean ranks (Table 10) show that men reported higher involvement than women.

Table 10. Mean ranks for the involvement dimension by gender.

	Gender	N	Mean rank	Sum of Ranks
Involvement	Male	47	147.62	6938.00
	Female	203	120.38	24,437.00

This is the only significant result among the nine gender comparisons reported in Tables 8 and 9, and no correction for multiple testing was applied. With a nominal α of 0.05 across nine tests and a markedly unbalanced design (47 men, 203 women), the probability of at least one spurious significant result is substantial. This difference is therefore reported as exploratory and is not interpreted as a stable gender effect.

Finally, the effect of prior experience with VR objects and with VR headsets on the ratings of presence, fidelity and usability was tested. The following hypotheses were tested. H0: no significant differences at $p \leq 0.05$ as a function of prior experience; H1: significant differences at $p \leq 0.05$. The Kruskal–Wallis H test was applied, grouping students into low, medium and high experience. Results for prior experience with VR objects are shown in Table 11.

Table 11. Kruskal–Wallis H for prior experience with VR objects across IPQ, fidelity–immersion and SUS.

	Kruskal–Wallis H	df	Asymp. Sig.	Cohen's d
Involvement	7.708	2	0.021	0.31
Realism	17.563	2	<0.001	0.52
Spatial presence	13.204	2	0.001	0.43
IPQ	10.542	2	0.005	0.38
Fidelity	14.188	2	<0.001	0.45
Immersion	11.914	2	0.003	0.41
Total fidelity and immersion	14.213	2	<0.001	0.45
SUS	12.776	2	0.002	0.43

All H0 are rejected at $p \leq 0.05$: significant differences exist as a function of prior experience with VR objects in the presence and fidelity ratings and in the perceived usability of the object. Effect sizes are reported as Cohen's d derived from η^2H [76]; the underlying η^2H values range from 0.023 (involvement) to 0.063 (realism), all below the conventional threshold for a moderate effect. Prior experience is therefore a statistically detectable but small source of variation, accounting for roughly 2–6% of the variance in the rank distributions.

Because the Kruskal–Wallis test indicates only whether the groups differ somewhere, without identifying which pairs, pairwise comparisons were computed following Dunn's procedure from the reported mean ranks and group sizes, with Bonferroni adjustment for the three contrasts performed on each variable.

For prior experience with VR objects, no contrast between the low- and high-experience groups reached significance on any variable (IPQ: z = −2.02, p adj. = 0.129; total fidelity and immersion: z = −0.46, p adj. = 1.000; SUS: z = 1.16, p adj. = 0.744). Every significant contrast involved the medium-experience group: it scored below the high-experience group on the IPQ (z = −2.83, p adj. = 0.014), on the fidelity–immersion total (z = −3.77, p adj. < 0.001), on the SUS (z = −3.15, p adj. = 0.005), below the low-experience group on the fidelity–immersion total (z = 2.40, p adj. = 0.050) and on the SUS (z = 3.24, p adj. = 0.004).

The pattern for prior experience with head-mounted displays is the same. No low-versus-high contrast was significant on any variable, whereas the medium-experience group scored below the high-experience group on the fidelity–immersion total ($z = -3.41$, p adj. = 0.002) and on the SUS ($z = -2.58$, p adj. = 0.030), and below the low-experience group on the SUS ($z = 3.05$, p adj. = 0.007). For the IPQ, no pairwise contrast survived adjustment (smallest p adj. = 0.072), indicating that the omnibus effect for this instrument is distributed across levels rather than localised in a single pair.

These comparisons answer the question of which groups differ: the differences detected by the omnibus tests are not the expression of a gradient running from less to more experienced students, since students at the two extremes of the experience scale are statistically indistinguishable from one another throughout. They are driven entirely by the intermediate group, which scores below both.

Mean ranks (Table 12) show that the relationship is not monotonic. For the IPQ and for the fidelity–immersion total, the highest ranks correspond to the high-experience group and the lowest to the medium-experience group, with the low-experience group in an intermediate position. For the SUS, the ordering differs again: the highest mean rank corresponds to the low-experience group (146.00), followed by the high-experience group (129.75), with the medium group lowest (89.58). The differences detected by the omnibus test are therefore driven mainly by the medium-experience group scoring below the other two, and not by a linear gain with increasing familiarity. Because dimension-level patterns mirror the overall pattern, only totals are reported.

Table 12. Mean-rank test for prior VR experience across IPQ, fidelity–immersion and SUS totals.

	VR Experience Level	N	Mean Rank
IPQ	Low	31	106.23
	Medium	39	98.49
	High	180	134.67
Total fidelity and immersion	Low	31	127.40
	Medium	39	85.69
	High	180	133.80
SUS	Low	31	146.00
	Medium	39	89.58
	High	180	129.75

Kruskal–Wallis results for prior experience with VR headsets are shown in Table 13.

Table 13. Kruskal–Wallis H for prior experience with VR headsets across IPQ, fidelity–immersion and SUS.

	Kruskal–Wallis H	df	Asymp. Sig.	Cohen's d
Involvement	2.535	2	0.282	—
Realism	15.165	2	<0.001	0.47
Spatial presence	11.297	2	0.004	0.40
IPQ	8.270	2	0.016	0.32
Fidelity	9.331	2	0.009	0.35
Immersion	12.010	2	0.002	0.41
Total fidelity and immersion	12.472	2	0.002	0.42
SUS	9.557	2	0.008	0.36

All H0 are rejected at $p \leq 0.05$ except for the IPQ involvement dimension, although the IPQ as a whole does show significant differences. Prior experience with VR headsets is thus associated with differences in presence and fidelity ratings and in perceived usability. Effect sizes are again small ($\eta^2H = 0.025$–0.053).

Mean ranks for headset experience (Table 14) reproduce the same non-monotonic pattern: the medium-experience group again records the lowest ranks for the fidelity–immersion total (84.36) and for the SUS (88.96), while the low-experience group obtains the highest usability rank (141.06). Given the very unequal group sizes—28 students in the medium band against 172 in the high band—these orderings are unstable and should be interpreted with caution.

Table 14. Mean-rank test for prior VR-headset experience across IPQ, fidelity–immersion and SUS totals.

	VR-Headset Experience Level	N	Mean Rank
IPQ	Low	50	109.22
	Medium	28	100.95
	High	172	134.23
Total fidelity and immersion	Low	50	117.15
	Medium	28	84.36
	High	172	134.63
SUS	Low	50	141.06
	Medium	28	88.96
	High	172	126.92

5. Discussion

The three instruments used—IPQ [46], fidelity–immersion [39] and SUS [47,48]—showed high internal consistency in this sample and were completed without difficulty. Their construct validity was not tested here. The discussion that follows is therefore organised around what perceptual data of this kind can and cannot establish.

Students rated their prior experience with VR and with VR headsets as relatively high (M = 7.41 and M = 6.93 on a 0–10 scale), with 72.0% and 68.8% respectively falling in the high-experience band. Dispersion was nevertheless substantial (SD = 2.82 and 3.26), and a minority reported little previous contact with the technology, particularly with head-mounted displays (20.0% in the low band). These figures are self-ratings of familiarity rather than objective records of exposure, and they may reflect acquaintance with virtual reality in a broad sense—including desktop and mobile formats—rather than sustained use of immersive equipment; the consistently lower values for headset-based use are compatible with that reading. Independently of how familiar students consider themselves to be, the integration of immersive VR in the classroom continues to face documented obstacles related to novelty, cost and the scarcity of learning objects [77]. When VR is adopted, students often interact with it more playfully than instructionally [78], which requires careful pedagogical design of the activities in which it is embedded.

After interacting with the object through Meta Quest 3-type HMDs, students reported moderate-to-high levels of presence and fidelity, describing themselves as located within the virtual environment. Because the design includes no comparison condition, these ratings cannot be attributed to the head-mounted display or to immersion as such: they characterise the experience reported for this particular combination of device, content and instructional setting. Meta-analyses [40,79] suggest that experiences of this kind may be useful for learning, a link that the present study did not test. Presence, however, is not created by the hardware alone: design principles that support fidelity to the real context matter. These principles have been shown to improve academic performance [56,80], perceived usability of VR objects [12], and student acceptance of VR experiences [81,82]. Sosa [83] argues for the need to establish a design protocol for these objects that is systematically informed by ongoing empirical evidence.

At the same time, involvement—the attention and concentration devoted to the experience—was the lowest-rated IPQ dimension, suggesting that students may perceive the activity as recreational rather than educational. This mirrors findings from other researchers [84,85]. A practical implication is that when embedding VR in a course, the instructor should signal ex ante that a test or task will follow the experience, which is likely to raise cognitive investment and involvement, since, as Sandoval et al. [86] argue, the pleasurable component must be integrated into clear educational objectives to avoid a purely recreational experience. This also opens a future line of research: administering objective knowledge measures in a pretest–post-test design to assess both learning gains and their impact on involvement.

This is, however, only one of several possible readings, and the study collected no direct measure of motivation, cognitive engagement or learning orientation that would allow them to be distinguished. Lower involvement may equally reflect a novelty effect, with attention directed to the device rather than to the content [85]; the cognitive load imposed by operating an unfamiliar interface while processing the material [34]; the absence of any task or assessment attached to the activity, which gave students no reason to invest effort beyond exploration; the wording of the involvement items themselves, which are framed in terms of awareness of the real environment and may be read as questions about attention control rather than about engagement; or the framing of the activity itself, since the guiding questions posed beforehand concerned virtual reality as a technology rather than the pedagogical organisation of the classroom depicted, which may have oriented attention towards the medium rather than towards the educational content it carried. Distinguishing among these explanations requires designs that measure engagement directly.

Design decisions were reflected in the notable usability rating obtained. The relationship between usability and the experiential dimensions, however, does not replicate the facilitating role reported in earlier work [37,84]: the associations observed here are weak, absent for spatial presence and for the IPQ total, and negative for involvement. One reading of that negative association is that an interface which is effortless to operate leaves the environment less cognitively demanding, and that the students who navigated most fluently were also those who remained most aware of the physical classroom around them. This is a post hoc interpretation that the present data cannot test, and it is offered as a hypothesis for designs that manipulate interface demand directly. What the data support is the weaker claim that usability did not obstruct the experience; they do not support the claim that usability produced it.

Gender was not a systematic differentiating factor: no significant differences emerged in the totals for presence, fidelity–immersion or usability, nor in self-reported prior experience with VR objects or Meta Quest-type headsets. The single exception was the involvement dimension, where men reported higher scores. Since this is one significant result out of nine comparisons, no adjustment for multiple testing was applied, and the male subsample comprises 47 of 250 participants, the finding is treated as exploratory. The overall pattern is consistent with recent work reporting that gender does not substantively differentiate students' perceptions of AR and VR technologies in higher education [32,87]; the present design, however, is underpowered to detect small gender effects and should not be read as positive evidence of their absence.

In contrast, prior experience with VR and with VR headsets was associated with significant differences in presence, fidelity and usability. The direction of those differences is not a simple gradient: the medium-experience group consistently recorded the lowest ranks, and for usability the low-experience group rated the object most favourably. Rather than a linear benefit of familiarity, the data suggest that students new to the technology and those most accustomed to it both responded more positively than the intermediate group—a pattern that might reflect novelty in the first case and fluency in the second, but which rests on a medium band of only 28–39 participants and requires replication before any substantive interpretation is placed on it. What can be said is that prior familiarity is a source of heterogeneity in how the same object is experienced, and that reporting it should be standard practice in studies of this kind.

One methodological recommendation from the study is to revise the wording of some items in the presence and fidelity questionnaires: heterogeneous formulations may confuse interpretation and be coded differently by respondents, affecting mean scores.

Several practical implications follow for educators and designers of immersive VR learning objects, although each is bounded by what the present design can establish. Delivering the object through head-mounted displays and 360° scenes proved viable in ordinary practical sessions: students reported moderate-to-high presence, realism and fidelity using accessible authoring software and consumer hardware. What the data do not show is that this presence translates into knowledge acquisition, performance or transfer. Modelling an authentic professional setting appears worthwhile, since fidelity was the highest-rated experiential dimension (M = 6.85) and covaries strongly with presence; the direction of that relationship, however, cannot be established, because both were measured simultaneously by self-report. Providing navigation aids and a structured hotspot layout yielded a notable usability score (SUS = 71.18) without extensive prior training in the device, but the results do not support the inference that greater usability produces greater presence: the associations were weak, absent for some dimensions and negative for involvement.

Three further implications concern the framing of the activity and the composition of the sample. Involvement was the lowest-rated dimension in an experience to which no task or assessment was attached, which suggests that coupling immersive activities to explicit learning demands deserves attention—though the present data cannot estimate how much such a task would raise involvement. Students' prior VR experience should be recorded and reported, since ratings differed significantly by experience level; the data do not, however, support a linear benefit of familiarity or a stable direction for the effect, given that the intermediate group was consistently the least favourable. Finally, gender-balanced samples remain desirable for evaluation work of this kind: no systematic gender differences emerged in the instrument totals, but this cannot be read as evidence of their absence, since the design is underpowered and the comparisons were uncorrected for multiplicity.

6. Limitations and Future Work

The study has limitations. All instruments used, while widely adopted and reliable, capture self-perception, which has known constraints [88,89]. Convenience sampling also entails trade-offs relative to random sampling [74]. A useful next step would be to replicate the study with random stratified sampling on the prior-experience variables, and to add objective pre/post learning measures to relate presence and immersion to actual learning outcomes.

Three main limitations constrain how these findings can be interpreted. First, and most importantly, the study measures no learning. Knowledge acquisition, academic performance, skill transfer, retention and cognitive change were not assessed, and nothing in the data speaks to them. The literature on embodied and situated learning is cited here as the theoretical context that motivated the study, not as a body of claims that the study substantiates.

Second, the single-group, post-use design cannot attribute the reported perceptions to immersive VR as such. In the absence of a pretest, a control group, a desktop or on-screen 360° comparison condition, or a contrast with conventional learning materials, the ratings obtained are equally compatible with the specific content of the Future Classroom object, the novelty of wearing a head-mounted display for the first time, the framing provided by the teaching staff, or a generally favourable disposition towards VR among education students. No causal claim about the effects of immersion, fidelity or usability is warranted.

Third, the constructs measured are conceptually adjacent and were captured through self-report questionnaires completed at the same moment and in the same format. The strong correlations among presence, fidelity and immersion may therefore partly reflect overlapping item content and common-method variance [89]. The reliability coefficients in Table 1 do not address this concern; establishing that these dimensions are empirically distinct would require confirmatory factor analysis and formal tests of discriminant validity, for which the present study was not designed.

Further constraints concern the group comparisons. The prior-experience bands are markedly unequal, with 28–39 participants in the medium band against 172–180 in the high band, which makes the mean-rank orderings unstable. No correction for multiple testing was applied across the gender comparisons. Interval estimates are reported for the correlation coefficients but not for the effect sizes of the group comparisons, for which the reported point estimates should be read as indicative rather than precise. Exposure was substantial in duration—approximately one hour inside the environment—but confined to a single session, so nothing can be said about how these perceptions evolve once the novelty of the device recedes. A session of this length also raises the possibility of visual fatigue or simulator discomfort towards the end of the experience, which was not measured. Finally, since part of the sample worked in pairs, the assumption that observations are fully independent of one another is only approximately met.

The clearest priority for future work is a design that measures learning directly: a pretest–post-test study with an objective knowledge or performance measure, a comparison condition (desktop or on-screen 360° video) and a delayed post-test that separates immediate impressions from retention. Complementing self-reports with behavioural or physiological indicators—dwell time within scenes, hotspot activation logs, eye tracking—would reduce reliance on a single method. Replication with a gender-balanced sample and with stratified random sampling on prior experience would address the two sampling constraints identified above. Finally, the item wording of the presence and fidelity instruments deserves attention: several items are negatively phrased or framed in terms of awareness of the real environment, and cognitive interviewing would help establish whether respondents interpret them as intended.

An additional limitation concerns the gender distribution of the sample, which reflects the demographic structure typically found in Early Childhood and Primary Education degree programmes. Although non-parametric statistical procedures were used and the male subgroup remained large enough for comparative analyses, the imbalance between female and male participants may have reduced statistical power for detecting gender differences. Therefore, gender-related findings should be interpreted with caution and replicated in more balanced samples.

7. Conclusions

This study characterises the experience that 250 higher-education students reported after using an immersive VR learning object built around the Future Classroom model. Students reported moderate-to-high presence, fidelity and immersion and rated the object's usability as notable (SUS = 71.18). These ratings were obtained under ordinary teaching conditions and without prior training in the device, which indicates that an environment authored with accessible 360° technology and delivered on consumer headsets can be implemented in routine practical sessions and be perceived favourably by students; in the absence of a comparison condition, no claim is made as to whether it produces the experiential conditions the literature associates with immersive VR. Presence, fidelity and immersion covary strongly, although their conceptual proximity and shared measurement method mean this covariation cannot be read as evidence of a mechanism linking distinct constructs. Perceived usability plays a smaller and less uniform role than is often assumed: its associations with the experiential dimensions are weak, absent for spatial presence and for the IPQ total, and negative for involvement. Gender did not systematically differentiate the reported experience, whereas prior familiarity with the technology did, though not in a linear fashion.

The lowest-rated dimension was involvement, in an activity to which no task or assessment was attached. Whether coupling the experience to explicit learning demands raises involvement is an empirical question that the present design cannot answer, and it is among the most immediately testable implications of these results.

These conclusions concern perceived experience only. The study did not measure knowledge acquisition, performance or transfer, and it includes no comparison condition; it therefore cannot establish that immersive VR produced these perceptions, nor that they translate into learning. What it offers is a description of the perceptual outcomes reported for this object—the levels of presence, fidelity, immersion and usability that students reported, and how these are distributed across the sample. Whether they correspond to the experiential preconditions posited by theories of embodied and situated learning is a question that the present data cannot settle. That description is a necessary starting point for the outcome studies that must follow, and not a substitute for them.

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