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Virtual Reality as a Pedagogical Tool: Motivation and Perception in Teacher Training for Social Sciences and History in Primary Education

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Abstract: This study investigates the motivation of future primary education teachers when using virtual reality (VR) as a pedagogical tool for teaching Social Sciences and History. A total of 73 students participated, engaging with curricular content through an immersive experience designed to strengthen digital and methodological skills. Motivation was measured using a reduced version of the Instructional Material Motivational Survey (IMMS), assessing attention, relevance, confidence, and satisfaction. Additionally, an adaptation of the LOES-S questionnaire was used to analyze the perception of VR as a learning object in initial teacher training. On a Likert scale (1–5), the results showed a high overall motivation level ($M = 4.56$, $SD = 0.26$), with satisfaction ($M = 4.92$, $SD = 0.20$) being the most prominent factor. Relevance, however, received a lower score ($M = 4.36$, $SD = 0.44$), suggesting difficulty connecting immersive content with prior knowledge. In the LOES-S questionnaire, engagement ($M = 4.88$, $SD = 0.27$) was the highest-rated construct, indicating strong emotional and motivational involvement. No significant gender differences were found, emphasizing the inclusive nature of VR. This study highlights the potential of VR to enhance teacher training, motivation, digital competencies, and innovative methodologies, while underscoring the need for effective pedagogical design to optimize its educational impact.

Keywords: teacher motivation; virtual reality; initial teacher training; social sciences

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1. Introduction

Virtual reality (hereinafter, VR) has established itself as one of the most innovative technologies in 21st-century education. According to Pelletier et al. (2022), in the Horizon Report Teaching and Learning Edition, VR has reached a level of development so significant that an increasing number of educational institutions and research centers are focusing their efforts on exploring its pedagogical applications in teaching and learning processes. This progress is supported by the growing availability of accessible technological devices, which facilitates its implementation in classrooms and promotes immersive and meaningful learning experiences (Aznar-Díaz et al., 2018). These experiences and advancements not only enable the acquisition of knowledge but also foster active participation by students, thereby achieving deeper and more critical learning (Di Natale et al., 2020).

Several studies have highlighted that immersion is a key factor distinguishing VR from other computing technologies (Kalyvioti & Mikropoulos, 2014; Mikropoulos & Strouboulis, 2004; Webster, 2016). However, immersion does not manifest itself in a single way; it varies depending on the capabilities of the platform and the hardware used. In this sense, there is no single type of VR, as its manifestation depends on the devices and technical characteristics employed (Bowman & McMahan, 2007). This immersion not only improves the perception of realism, but also has the potential to increase student motivation and engagement, especially when offering experiences that cannot be easily recreated in a traditional classroom setting (Freina & Ott, 2015). In this regard, VR allows for the simulation of complex situations or contexts that are difficult to physically reproduce, significantly expanding teaching possibilities (Makransky et al., 2021; Makransky & Lilleholt, 2018). Thus, VR is presented in various forms that can enrich learning experiences, adapting to students' needs and the pedagogical objectives of the proposed activities.

Finally, we find non-immersive VR systems characterized by providing an experience in which users interact with the virtual environment by viewing it exclusively through the screen of a device, such as a desktop or laptop computer. This type of system creates the sensation of observing the virtual world through a window. These systems, also known as desktop virtual reality (VR) systems or 3D worlds, operate primarily with control mechanisms managed via a keyboard and/or mouse (Cabero & Fernández, 2018; Freina & Ott, 2015). Although these systems clearly do not achieve the same level of immersion as fully immersive or partially immersive systems, their accessibility and versatility in use enable enhanced content understanding and active student interaction within the educational context.

Concerning critical aspects, from a technical and pedagogical perspective, several authors have pointed out that the implementation of VR in educational contexts faces significant barriers. On one hand, the lack of interoperability between platforms and the absence of open standards hinders its efficient and scalable use in educational institutions, compromising its accessibility and sustainability (Bonnett, 2004; Caron, 2023; Harley et al., 2016). Moreover, the high cost of the necessary hardware and software remains a considerable limitation, especially in institutions with limited resources, creating inequalities in its adoption and making its integration into educational programs more difficult.

Another critical issue is the usability of VR tools. Various studies have highlighted that many of these platforms have unintuitive interfaces, making it difficult for both students and teachers without prior experience in virtual environments to use them (Allison, 2008; Bonnett, 2004). Additionally, the learning curve associated with using these devices requires specific teacher training, which poses an additional challenge for their effective implementation in pedagogical practice. Issues related to visualization and navigation in virtual environments have also been reported, potentially causing disorientation and frustration in users, which affects their learning experience (Christopoulos et al., 2024).

In this regard, the implementation of VR in education is not limited to enriching content comprehension; it also transforms teaching methodologies, making them more dynamic and tailored to students' needs. VR applications are used as tools to enhance student learning experiences, offering a more engaging and dynamic platform that facilitates the understanding of complex concepts, theories, and systems, as well as allowing the practice of skills (Fokides, 2023). Research, such as the meta-analysis by Villena-Taranilla et al. (2022b), gathers evidence on how VR transforms learning in traditional subjects such as science, mathematics, and history, demonstrating that the use of this technology can maximize educational benefits, fostering a more motivating and effective learning experience.

2. Literature Review

2.1. Virtual Reality and Motivation

Motivation in the educational context is a key factor in learning success, and its relationship with the use of virtual reality (VR) is becoming increasingly evident. The ability of this technology to generate immersive experiences not only enhances content comprehension but also directly influences student motivation. Sousa Ferreira et al. (2021) highlight that immersive virtual environments allow students to explore and manipulate three-dimensional resources, which promote both understanding and engagement in learning activities. In this regard, VR has the potential to transform teaching by making it more engaging and dynamic, increasing students' attention and willingness to participate. This is because such environments facilitate more meaningful learning by enabling active interaction with complex and dynamic scenarios.

In this regard, in the field of primary education, tools such as *CoSpaces* have proven effective in fostering intrinsic motivation by immersing students in three-dimensional environments that stimulate active learning (Córcoles-Charcos et al., 2023). These environments not only promote knowledge acquisition but also develop critical and collaborative skills, strengthening student engagement. Furthermore, it has been observed that the intrinsic motivation of students improves significantly when innovative methodologies supported by VR are used (Makransky & Lilleholt, 2018). This connection between motivation and learning has been corroborated by studies showing that immersive systems have a greater impact compared to semi-immersive and non-immersive systems (Villena-Taranilla et al., 2022a).

Motivation, understood as a key variable in the effective use of educational technologies, is deeply linked to the use of VR. According to Chen and Yeh (2009), motivation can be defined as "an internal state or condition that drives us to action, directs and sustains our behavior, and engages us in certain activities" (p. 597). In the educational context, this translates into the willingness of students to participate in learning activities, driven by specific reasons that directly influence their engagement (Brophy, 2004). Thus, designing educational materials with motivational elements is crucial to foster meaningful learning, as it allows students to enjoy the process while acquiring knowledge (Chen & Yeh, 2009).

Among the motivational models applied to instructional design, Keller's ARCS model (Keller, 1983, 1987, 2010) is particularly relevant in the use of VR. This model establishes four conditions to maintain motivation: attention, relevance, confidence, and satisfaction. VR meets these conditions by capturing students' curiosity through immersive experiences that directly connect to their prior knowledge and perceived learning needs (Keller, 1984). Furthermore, the interaction and personalization offered by VR enable students to develop a sense of confidence in their abilities, which contributes to their satisfaction and enhances their performance (Huett et al., 2008).

2.2. Impact of VR on the Training of Future Teachers

Future primary education teachers will be trained in the areas of Social Sciences and History, fields that have received less attention compared to their application in secondary or higher education Merchant et al. (2014); Villena-Taranilla et al. (2022b). While many previous studies have focused on the use of VR in STEM disciplines or on improving students' academic performance, few have examined how pre-service teachers perceive VR as a pedagogical tool and how it influences their motivation to integrate it into their future teaching practices. Recent research highlights that immersive virtual environments generate positive emotions and a high level of engagement among students. A meta-analysis on the effects of VR in K-6 education by Villena-Taranilla et al. (2022b) concluded that VR has a positive impact on learning across all areas of knowledge. However, the authors warn that most studies have been conducted in Mathematics and Science, while subjects such as History, Music, or Physical Education remain underrepresented in current research (Villena-Taranilla et al., 2022b). Other studies have pointed out that, despite its high potential in teaching Social Sciences, its implementation remains limited and requires further exploration. In this regard, Solano (2023) concluded that the integration of VR in Social Sciences and Humanities has been less explored compared to its application in scientific subjects and emphasizes the need for pre-service teachers to receive specific training to effectively incorporate it into the classroom.

In particular, regarding engagement, Villena-Taranilla et al. (2022a) demonstrated that the use of VR in activities such as exploring historical cities not only facilitates more meaningful learning but also increases intrinsic motivation, as students can make active decisions in interactive environments. This ability to personalize learning and integrate solid motivational principles makes VR a powerful pedagogical tool. In this regard, VR, when integrated with motivational principles such as those of the ARCS model, represents a powerful pedagogical strategy to capture and maintain student motivation, thus strengthening student confidence and satisfaction, key elements for deep and lasting learning. The successful integration of VR in education depends not only on the technology itself but also on teacher preparation. To address this gap, various authors recommend that teacher training programs include VR in their curriculum so that future teachers acquire basic competencies before graduating. Serin (2020) proposes integrating immersive virtual environments into pre-service teacher education to increase confidence and willingness to use VR in future classrooms.

In this sense, VR teacher training remains a key challenge for its educational implementation. Several studies have indicated that many pre-service teachers lack prior experience with this technology, which could limit its integration into educational practice (Khukalenko et al., 2022). The integration of VR not only benefits pre-service teachers but also plays a crucial role in the training of future educators. According to Cabero and Fernández (2018), future teachers who engage in VR-based activities develop greater confidence in their digital and pedagogical skills, which strengthens their ability to implement active methodologies in the classroom. Wadhera (2016) emphasizes the importance for educators to understand the learning needs of current students, who are part of the Experience Era. Since students spend much of their time online and are frequent users of technological devices, teachers must design and be familiar with instructional materials and activities that incorporate characteristics similar to those they use daily.

A crucial aspect is the preparation of teachers to manage the emotional responses that immersion in these environments can generate. García et al. (2021) argue that this comprehensive training should include not only technical skills but also strategies to handle the emotional impact that VR can have on users. However, despite the advantages, certain barriers should not be overlooked as they may limit the impact of VR on motivation and education. These barriers include the lack of specific training, the perception of technical complexity, and the need for adequate resources (Makransky & Lilleholt, 2018). These barriers not only affect future teachers' motivation but also their ability to design effective learning experiences. Contreras-Colmenares and Garcés-Díaz (2019) point out that insufficient training in the pedagogical use of VR can generate negative attitudes towards this technology, highlighting the need to design training programs that address both technical and pedagogical aspects. Furthermore, recent research suggests that teachers' confidence in their ability to use VR plays a crucial role in its adoption (Cabero & Fernández, 2018).

At this point, it is essential to include the use of emerging technologies, such as VR, in the training of future teachers. Exposure to this technology will not only enhance digital competencies but also motivate teachers to adopt innovative pedagogical approaches that align with the needs of today's students, whom they will encounter in their teaching practice. Furthermore, the integration of this immersive technology in university environments contributes to the creation of smart teaching spaces, characterized by accessibility, flexibility, and adaptability to students' needs, thus improving their interaction with educational content (González Aspera & Chávez Hernández, 2011). This pedagogical transformation enables future teachers to prepare for designing more dynamic and personalized learning experiences, benefiting both students and their own professional development.

In this regard, it is essential that these methodologies are designed with a pedagogical approach that links technology to content that is relevant and meaningful for students. Duque Vanegas (2018) and Miralles et al. (2019) emphasize that the integration of technologies in education must be connected to content that is relevant and meaningful for students. Only in this way can an effective transfer of learning to other contexts be ensured, thereby increasing its value and reinforcing student motivation in a sustainable manner. Therefore, it is crucial to investigate technologies that effectively integrate these motivational elements. One of the most prominent in this area is the technology addressed in this research, as the impact of VR on motivation has been widely documented in recent studies.

VR stands out as a technological tool capable of positively stimulating motivation, engagement, and interaction in learning. Previous studies have shown that its ability to generate immersive experiences contributes to greater enjoyment and the development of exciting experiences that capture students' attention, increasing their willingness to learn (Yildirim et al., 2018). Apostolellis and Bowman (2014) emphasize that interaction within virtual environments not only boosts intrinsic motivation but also fosters greater enjoyment in the learning process.

2.3. Need to Investigate the Perception of Future Teachers

In light of the above, it is essential to include emerging technologies, such as VR, in the initial training of future teachers. Exposure to this technology will not only enhance their digital competencies but also motivate them to adopt innovative pedagogical approaches that align with the needs of today's students. According to Cózar-Gutiérrez et al. (2019), VR facilitates immersive and meaningful experiences, such as virtual tours of historical contexts, which capture the attention and generate satisfaction among pre-service teachers. Analyzing and understanding the motivation of these future educators is crucial, as their willingness and confidence toward these technologies will largely determine their implementation in the classroom. Teacher motivation serves as a key factor in overcoming initial barriers, enabling the transformation of teaching through active methodologies and more engaging and effective learning experiences.

However, despite efforts to understand how VR can influence academic performance and student motivation, there is still a lack of knowledge regarding future teachers' perceptions of its use and the motivational impact this technology might generate. Several studies have used questionnaires to explore teachers' familiarity with VR (Tzima et al., 2019) and their willingness to adopt it in their classrooms (Serin, 2020), finding that many educators are unfamiliar with this technology and have rarely used it to foster student motivation. However, there is limited information on how direct exposure to a VR environment might affect future teachers' perceptions of its potential to increase motivation in the classroom. Therefore, it is essential to analyze how direct exposure to VR can influence the perceptions and motivations of future teachers.

The lack of knowledge about the impact of VR on student motivation highlights the urgent need to investigate future teachers' perceptions and their preparedness to integrate this technology into their future teaching practices. According to Marín-Díaz et al. (2022), secondary school students consider VR and augmented reality to be effective tools for enhancing their learning. These technologies enable a more engaging, dynamic, and experiential learning process, making them a key resource for increasing student motivation. For future teachers, this implies an urgent need to be prepared to effectively integrate these technologies into their pedagogical practices in order to motivate students and improve their educational outcomes.

Pre-service teachers' perception of VR not only influences their willingness to use it in the classroom but also affects its long-term effective implementation. The literature has identified that future teachers' technological self-efficacy is a key factor in the adoption of digital tools, including VR (Mercader & Duran-Bellonch, 2021). However, recent research has found that, although gender differences in digital skills are minimal or nonexistent, women tend to underestimate their competence in educational technology, which could impact their willingness to use VR in the classroom (Qazi et al., 2022).

This lack of confidence, along with the scarcity of VR training in teacher education programs, reinforces the need to design pedagogical strategies that promote the use of this technology from initial teacher training (Serin, 2020). Studies such as that of Solano (2023) have pointed out that VR remains underutilized in Social Sciences and Humanities compared to STEM disciplines, highlighting the importance of equipping future teachers with the tools and skills needed to leverage its potential in these fields.

3. Aims

Consequently, this study aims to explore the opinions of future teachers regarding the use of VR in education, with a particular focus on its impact on motivation. In particular, we aim to answer the following research question: "How does the use of VR in the teaching of Social Sciences and History impact the motivation of future primary education teachers, and what are the potential differences based on gender and specialization?". Hence, to answer this research question, this study is approached through the evaluation of VR as a learning tool and the exploration of any significant differences across gender and ICT interest of pre-service teachers. Specifically, this study aims to address the following objectives:

O1 To analyze the motivation of future primary education teachers regarding the use of VR in the teaching of Social Sciences and History.

O2 To evaluate VR as a learning tool for Social Sciences and History in the training of primary education teachers.

O3 To analyze whether significant differences exist in the results of O1 and O2 when data are grouped by students' gender and the specialization pursued by the students (specifically, those enrolled in the ICT specialization itinerary and those in the generalist group).

4. Materials and Methods

4.1. Participants

The sample was selected for convenience, as the objectives specifically aimed to analyze the perceptions of pre-service teachers using VR for the learning and teaching of Social Sciences and History content. Thus, this study was conducted with 73 students from the primary education degree program at the Faculty of Teacher Training at the Universitat de València. The research took place during the first semester of the 2024–25 academic year. Of the students, 24 were enrolled in the specialization in Information and Communication Technologies (ICT, 32.9%), while the remaining 49 (67.1%) were not enrolled in this specialization, being primary education students without a specialization. The ICT specialization is a special mention within the degree in primary education, which students can access after completing certain courses related to the use of ICT in education.

Additionally, of the total students, 53 were women (72.6%) and 20 were men (27.4%). On average, the participants were 21.6 years old, with a minimum age of 19 and a maximum of 36 years. A detailed distribution of the sample according to gender and specialization is presented in Table 1.

Table 1. Distribution of the sample by gender and specialization.

Group	Gender	Total	Average Age
No specialization	Female	44	22
	Male	5	22
Specialist in ICT	Female	9	21
	Male	15	22

4.2. Measurement Instruments

This research utilized two instruments. To address O1, a reduced version of the *Instructional Material Motivational Survey* (RIMMS) by Keller (2010), developed and validated by Loorbach et al. (2015), was used to measure the participants' motivation. This RIMMS questionnaire, based on Keller's ARCS motivational model, evaluates attention, relevance, confidence, and satisfaction in relation to the use of VR in educational contexts. The RIMMS consists of 12 items utilizing a Likert-type response scale. Each item offers five response options, ranging from "Strongly disagree" (1) to "Strongly agree" (5). The description of each item for the RIMMS questionnaire used can be found in Table A1.

To address O2, an adaptation of the *Learning Object Evaluation Scale for Students* (LOES-S) was used. This scale analyzes the constructs of learning, quality or instructional design, and engagement when students use learning objects. It was developed by Kay and Knaack (2009) after 10 years of research with a sample of over 1100 students. A description of each item used in the LOES-S questionnaire can be found in Table A2. The scale used in this study evaluates various aspects of students' perceptions regarding the use of VR. Due to time constraints, we exclude from the original LOES-S questionnaire the qualitative items, which would require more detailed responses from the students, as we describe in the following:

- Learning: This construct measures how much students learn. Due to time constraints, 3 out of the original 5 items were selected for evaluation.
- Quality: This construct examines the perceived quality of the learning object. In the adaptation, 3 out of the 4 original items were included.
- Engagement: This construct assesses the students' level of engagement with the learning object, regarding the emotional and cognitive involvement of students with the educational activity, which can translate into active participation observed during the activity. In the adaptation, the 3 quantitative items from the original scale were used, excluding the 2 qualitative items, to optimize measurement and fit within the available time. As in the previous instrument, a Likert-type response scale was used, where each item offered five response options, ordered in the same manner.

The combination of these two instruments provides a comprehensive understanding of the impact of VR on future teachers' training. This methodological approach enhances the rigor of the study, allowing for the analysis of not only motivation but also the perceived relevance of VR within the teaching process.

Finally, O3 is addressed by comparing the mean scores across different groups of participants, analyzing two main dimensions:

- Students without ICT specialization vs. ICT specialists: This examines whether prior experience with technology influences perception and motivation toward virtual reality in teaching.
- Women vs. men: This analyzes potential gender differences in the adoption and perception of VR as an educational tool, given that previous studies have suggested that self-efficacy in using digital tools may vary by gender.

This analysis not only helps identify the conditions under which VR is most motivating for future teachers but also provides insight into how the educational context and individual variables may shape their perception of this technology.

4.3. The VR Glasses and the VirTimePlace Application

The VR glasses used in this study were the *Netway Vita* model, which included an integrated processor and a 5.5-inch screen. Based on *Android* technology, these glasses allow access to various free applications through the official *Play Store*.

VirTimePlace is a free application by *Arketipo Multimedia*, available for iOS and Android. *VirTimePlace* is an educational tool that uses real-time 3D models to recreate historical environments, providing a much more dynamic and realistic experience than static images or videos. This tool offers a broad catalog of 3D recreations of historical cities and buildings, such as Carthago Nova, Roman Cordoba, Classical Athens, and the Mosque of Córdoba, among others. Users are able to freely navigate through these virtual environments interacting with various elements, such as monuments and historical objects, and access information as they moved through the virtual setting. In educational terms, the application has the potential to increase students' interest and motivation by providing a more interactive and immersive learning experience.

The process of using the glasses and the application was designed to integrate smoothly into the intervention. Therefore, it is worth noting that the *VirTimePlace* application had already been downloaded onto the glasses, allowing students to immediately access the experiences.

4.4. Methodology

The intervention with VR was conducted in a single one-hour session per group. The decision to have the intervention last a short duration (only 1 h) was based on previous research, which found that shorter interventions –less than 2 h– tend to be more effective compared to longer ones (Villena-Taranilla et al., 2022b). Specifically, interventions of less than 2 h showed an effect size of .72, while those lasting longer than 2 h had an effect size of .49.

This session began with an introduction to the VR device that the students would use. Specifically, the *Netway Vita* VR glasses described above were used. At the beginning of the activity, ten minutes were dedicated to explaining the basic instructions so that students could familiarize themselves with the virtual reality glasses and the *VirTimePlace* platform. During this time, they were taught how to properly adjust the glasses, ensuring comfort and clarity. They were also shown how to turn on the glasses and connect them to the *VirTimePlace* application. The controls for navigating the virtual environments were explained, allowing students to move and look around within the virtual recreations. Additionally, emphasis was placed on the importance of maintaining proper posture to avoid discomfort and ensure effective interaction with the virtual experiences.

Once the students were familiarized with the device, they were able to immerse themselves in the virtual recreation of the Hispano-Roman city of Augusta Emerita (Mérida, Badajoz in Spain), walking through its streets and exploring its buildings and significant artistic expressions, which facilitated the active and meaningful internalization of historical content. In our case, the Roman reconstruction of Mérida allowed students to view different types of housing and relevant structures, aligned with the curricular content and learning standards they will address in their future teaching practice.

At the end of the session, the students completed the items of the RIMMS questionnaire and the adapted LOES-S with paper and pencil (see the items in Tables A1 and A2, in Appendix A).

4.5. Data Analysis

In addition to the responses to the corresponding items to the RIMMS and LOES-S questionnaires, information was collected regarding gender, age, and whether the students were enrolled in the specialization in Information and Communication Technologies. All student data were anonymized. Data processing was conducted using the *R* software (R Core Team, 2021). The statistic calculations were processed with a pre-established significance level of 0.05. The normality of the data was tested using the Shapiro–Wilk test (Shapiro & Wilk, 1965). Non-parametric tests were used for comparing the scores obtained on the instruments, as the datasets compared did not follow a normal distribution. Therefore, the comparison of mean scores was carried out using the non-parametric Mann–Whitney U test (Mann & Whitney, 1947), which allowed for testing the significance of mean scores of participants under different conditions (specialists in ICT group vs. no specialization group and male vs. female). Additionally, effect sizes were evaluated using Rosenthal's explanatory r measure (Field et al., 2012), with the following thresholds:

- $r = .1$ (small effect): explains 1% of the total variance;
- $r = .3$ (medium effect): explains 9% of the total variance;
- $r = .5$ (large effect): explains 25% of the total variance.

Finally, to analyze the reliability of both questionnaires, their internal consistency was calculated using Cronbach's α for each of the constructs in the questionnaires.

5. Results and Discussion

5.1. Reliability of the Measurement Scores

The overall reliability of the RIMSS in terms of Cronbach's α was .72 ($n = 73$ for 12 items), which is an acceptable value. Table 2 presents Cronbach's α values for each construct of the RIMSS questionnaire, showing an acceptable value for the attention (.72) and confidence (.71) constructs. For the satisfaction construct, a questionable value was obtained (.63), below the acceptable standard value ($\geq$.70). However, as recognized by Cortina (1993) and Kline (1999), this is an expected and accepted value in research related to Social Sciences. Finally, the relevance construct shows a poor value (.45). Nevertheless, despite of the importance of the relevance construct in educational settings, studies such as that of Villena-Taranilla et al. (2022a) indicate that, compared to the other dimensions, relevance is the dimension that is least affected by the teaching methods used, which could explain the results obtained, as it provides a measure for the perception of the usefulness of the knowledge acquired by pre-service teachers (Huett et al., 2008).

Table 2. Cronbach's α results with reliability levels for each RIMMS construct.

Construct	Cronbach's α	Min. Reliability	Max. Reliability
Attention	.72	.79	.83
Relevance	.45	.61	.75
Confidence	.71	.73	.83
Satisfaction	.63	.79	.85
Total	.72		

The reliability of the data obtained with the LOES-S instrument proved to be acceptable, with a value of .73 ($n = 73$ in 12 items). Cronbach's α results for each of the subscales of this test are shown in Table 3. Thus, acceptable values were obtained for the constructs of quality (.71) and engagement (.71), and a value classified as questionable for the construct of learning (.66). However, as noted for the previous RIMMS questionnaire, this value would be accepted within the parameters established in Social Science studies (Cortina, 1993; Kline, 1999), despite their importance in an educational setting.

Table 3. Cronbach's α results with reliability levels for each construct of the LOES-S.

Construct	Cronbach's α	Min. Reliability	Max. Reliability
Learning	.66	.61	.69
Quality	.71	.54	.82
Engagement	.71	.78	.82
Total	.73		

5.2. Analysis of the Results of the RIMMS Motivational Test

In the analysis of the RIMMS questionnaire, an overall average motivation score of $M = 4.56$ was obtained, indicating a positive perception of the students towards the VR intervention. Among the four dimensions evaluated, satisfaction stood out as the most highly rated, with a mean of $M = 4.92$ ($SD = 0.20$) and minimal variance, reflecting a highly homogeneous perception among participants. In contrast, the relevance construct showed the lowest mean ($M = 4.36$, $SD = 0.44$), although still within positive levels. Table 4 presents the descriptive statistics for each item and construct of the RIMMS questionnaire.

As seen in Table 4, the lowest score corresponded to item A03 ("The variety of activities helps to maintain my attention in class"), with a rating of 2. Most participants gave high scores on the other items, reaching the maximum score (value 5) on many of them. This scoring pattern highlights a very positive overall evaluation of the experience. Although there was a somewhat more negative perception regarding the variety of activities, students expressed high satisfaction and motivation with the use of virtual reality as an educational tool, reinforcing the idea that this technology creates an engaging and stimulating learning experience. This finding reflects a widespread consensus that the virtual reality immersion experience was highly satisfying, contributing to high motivation and overall enjoyment among students.

When breaking down the dimensions, attention showed positive results, with an overall mean of $M = 4.55$ ($SD = 0.46$). Students particularly valued aspects related to the quality and organization of the activities, as reflected in items MA01 ("The quality of the Virtual Reality activities helps me maintain attention") and MA02 ("The way information is organized using these materials helps me maintain attention"), which received means of $M = 4.56$ and $M = 4.57$, respectively. However, item MA03 ("The variety of activities helps me maintain my attention in class") presented the lowest recorded score in the questionnaire (2), indicating that some students perceived less variety in the proposed activities.

Regarding relevance, this was the dimension with the lowest mean ($M = 4.36$, $SD = 0.44$). This result is mainly due to item MR04 ("It is clear to me how this class is related to things I already knew"), which received a mean of $M = 3.94$ ($SD = 0.78$), the lowest-rated item in the entire questionnaire. This suggests that, while students perceived the usefulness of the content worked with VR (as reflected in item MR06, $M = 4.58$), some had difficulty connecting the experience with their prior knowledge. The relatively low scores in the relevance dimension may be due to several factors. Although VR as an educational tool was generally well received, some students may have perceived the historical content presented as not sufficiently related to their previous experiences or expectations.

In this study, *Emérita Augusta* was used as the main setting for the virtual reality activity, which could have led to a perception of disconnection if students did not feel that the historical context had a direct connection to their current curriculum or personal interests. Additionally, the focus on exploring a single historical site may have limited the perception of relevance for students who would have preferred a more diverse approach or who do not feel as connected to the specific historical period. The lack of content diversity or the one-dimensional nature of the activity may have influenced the low rating in the relevance dimension.

The confidence dimension showed an overall mean of $M = 4.42$ ($SD = 0.47$), with participants expressing confidence in their ability to learn the content. Item MC07 ("While working in this class with Virtual Reality, I am confident I will learn the content") received a mean of $M = 4.43$, while MC08 ("After working in this class, I feel confident I would be able to pass a test on the topic") reached a mean score of $M = 4.31$, and MC09 ("The good organization of the class with Virtual Reality helps me feel confident I will learn the content") obtained $M = 4.52$. Although the scores were high, the results suggest that students have more confidence in the quality of the design and the activities proposed than in their own academic performance after the intervention.

Table 4. Descriptive statistics of data obtained with RIMMS.

Construct	Mean	SD	Minimum	Maximum
Attention	4.55	0.46	3.33	5.00
MA01	4.56	0.55	3.00	5.00
MA02	4.58	0.50	4.00	5.00
MA03	4.52	0.65	2.00	5.00
Relevance	4.36	0.44	3.33	5.00
MR04	3.95	0.78	3.00	5.00
MR05	4.53	0.55	3.00	5.00
MR06	4.59	0.52	3.00	5.00
Confidence	4.42	0.47	3.00	5.00
MC07	4.44	0.60	3.00	5.00
MC08	4.32	0.55	3.00	5.00
MC09	4.52	0.60	3.00	5.00
Satisfaction	4.92	0.20	4.00	5.00
MS10	4.82	0.39	4.00	5.00
MS11	4.97	0.16	4.00	5.00
MS12	4.97	0.16	4.00	5.00
Total	4.56	0.26	4.00	5.00

Finally, we categorized the results obtained from the 73 participants in each of the dimensions of the RIMMS instrument into three levels: low level (<3), medium level (between 3 and 3.49), medium–high level (between 3.5 and 3.99), and high level (between 4 and 5). The results are depicted in Table 5. In relation to the construct satisfaction, 100% of the participants reached a high level of satisfaction when using VR. The least beneficial dimension was relevance, where 83.56% reached a high level, while 15.07% remained at a medium–high level. Nevertheless, the motivational results show a high degree of satisfaction across all the dimensions measured by the instrument.

Table 5. Distribution of occurrences and percentages for the constructs of RIMMS.

	Attention		Relevance		Confidence		Satisfaction	
Level	**Occ.**	**Per.**	**Occ.**	**Per.**	**Occ.**	**Per.**	**Occ.**	**Per.**
High	69	94.52%	61	83.56%	68	93.15%	73	100%
Upper Middle	3	4.11%	11	15.07%	3	4.11%	0	0%
Middle	1	1.37%	1	1.37%	2	2.74%	0	0%
Low	0	0%	0	0%	0	0%	0	0%

5.3. Analysis of the LOES-S Test Results on VR as a Learning Object

Table 6 presents the descriptive statistics obtained with the LOES-S questionnaire, designed to assess the perception of VR as a learning object. The overall analysis shows a very positive evaluation, with a total average of $M = 4.57$ ($SD = 0.26$) out of 5 points, indicating high acceptance by the students.

Among the three dimensions evaluated, engagement received the highest score, with an average of $M = 4.88$ ($SD = 0.27$). Items related to this dimension, such as "I would like to use Virtual Reality again" ($M = 4.92$) and "Virtual Reality was motivating" ($M = 4.89$), stood out for their high rating. These results reflect that students perceived the activity as stimulating, engaging, and promoting their active participation. Additionally, this high level of engagement may be related to the satisfaction reported in the RIMMS questionnaire, as both dimensions appear to measure similar aspects related to enjoyment, interest, and emotional evaluation of the educational experience. This parallelism suggests that VR not only facilitates knowledge acquisition but also generates an immersive and motivating educational environment.

Regarding the quality dimension, the general average was $M = 4.59$ ($SD = 0.44$). While the scores were generally high, some specific items, such as "The aids in Virtual Reality were useful" ($M = 4.51$) and "The activity with Virtual Reality was well-organized" ($M = 4.72$), showed greater variability, indicating more diverse perceptions in certain aspects of the design. Nevertheless, the overall evaluation of the material quality was positive, reinforcing the acceptance of VR as a well-designed and functional tool.

Finally, the learning dimension received an average score of $M = 4.38$ ($SD = 0.36$), the lowest of the three dimensions. Despite this, students acknowledged the usefulness of VR in learning new concepts and facilitating content comprehension, as reflected in the items "Working with Virtual Reality helped me learn a new concept" ($M = 4.48$) and "The design of the Virtual Reality page helped me learn" ($M = 4.22$). However, these results suggest that adjustments in the activities or greater integration with traditional pedagogical strategies might be necessary to maximize VR's impact on learning.

In summary, the results from the LOES-S questionnaire highlight the high level of engagement and the positive perception of the quality of the designed materials. Moreover, the connection between the engagement observed in this questionnaire and the satisfaction reported in the RIMMS test reinforces the effectiveness of VR not only as an educational tool but also as an element that enhances interest and enjoyment in learning.

As with the data from the RIMMS instrument, we categorized the results obtained from the 73 participants into levels for each of the dimensions of the LOES-S instrument. The analysis of the clustering obtained in the LOES-S questionnaire reflects a very positive evaluation of VR as a learning object, as shown in Table 7. The results highlight high percentages of students in the high level across the three constructs evaluated, engagement, quality, and learning, as detailed in the corresponding tables.

Table 6. Descriptive statistics of data obtained with LOES-S.

Construct	Mean	SD	Minimum	Maximum
Learning	4.38	0.36	3.60	5.00
LA01	4.41	0.50	4.00	5.00
LA02	4.25	0.49	3.00	5.00
LA03	4.22	0.56	3.00	5.00
LA04	4.48	0.67	3.00	5.00
LA05	4.52	0.53	3.00	5.00
Quality	4.59	0.44	2.50	5.00
LC06	4.51	0.58	3.00	5.00
LC07	4.52	0.65	2.00	5.00
LC08	4.59	0.62	2.00	5.00
LC09	4.73	0.53	2.00	5.00
Engagement	4.88	0.27	3.67	5.00
LE10	4.84	0.37	4.00	5.00
LE11	4.89	0.31	4.00	5.00
LE12	4.92	0.32	3.00	5.00
Total	4.57	0.26	3.50	5.00

Table 7. Distribution of occurrences and percentages for the constructs of LOES-S.

	Learning		Quality		Engagement	
Level	**Occ.**	**Per.**	**Occ.**	**Per.**	**Occ.**	**Per.**
High	67	91.78%	71	97.26%	72	98.63%
Upper Middle	6	8.22%	1	1.37%	1	1.37%
Middle	0	0%	1	1.37%	0	0%
Low	0	0%	0	0%	0	0%

The engagement construct was the highest rated, with 98.63% of participants (72 students) reaching a high level and only 1.37% in the medium–high level. This result indicates that VR was not only perceived as a useful tool but also fostered active and motivating participation among students. Items like "I would like to use Virtual Reality again" and "Virtual Reality was motivating" reflect this high evaluation, indicating that students found the VR experience attractive and stimulating. This level of engagement may also be related to the enjoyment and satisfaction reported in the RIMMS test, reinforcing the idea that both questionnaires assess complementary emotional and motivational dimensions.

Regarding the quality construct, 97.26% of participants (71 students) reached a high level, while 1.37% were in the medium–high and low levels, respectively. This result reflects a very positive perception of the organization, design, and ease of use of the activities carried out with VR. Items such as "The activity with Virtual Reality was well-organized" and "Virtual Reality was easy to use" significantly contributed to this evaluation, highlighting that students found the materials clear and accessible. However, the fact that some participants were in lower levels could be related to occasional difficulties in interacting with the technology or the perception that certain aids could be improved.

Lastly, the learning construct showed that 91.78% of students were in the high level, followed by 8.22% in the medium–high level. Although these results are still very positive, it is notable that this construct shows the lowest percentage of the high level among the three dimensions evaluated. This result could be related to items like "The design of the Virtual Reality page helped me learn" and "Working with Virtual Reality helped me learn a new concept", which, while positively rated, reflect a lower perceived impact compared to the other constructs. This trend may be due to the fact that, although the VR experience is motivating and engaging, it does not always directly translate into a clear perception of learning. This suggests that work is needed in the pedagogical design of the activities and the integration of VR with traditional strategies to maximize its effectiveness in learning.

Overall, the results from the LOES-S questionnaire highlight VR's ability to motivate and engage students, as well as offer materials perceived as high-quality. However, the findings in the learning construct invite reflection on how to improve the connection between the immersive experience and the pedagogical objectives to ensure that VR's potential is translated into more meaningful learning outcomes.

5.4. Group Analysis: Specialization in ICT vs. No Specialization

In this study, students pursuing a degree in primary education were divided into two groups: those enrolled in a specialization in ICT and generalist students without a specialization. The third aim of this study was to analyze whether there were differences in the mean scores obtained in both questionnaires, RIMMS and LOES-S, based on the students' interest and academic profile. For each questionnaire, the null (H_0) and alternative (H_1) hypothesis would be as follows:

Hypothesis 0. *There is no significant difference in the mean scores between the ICT group and the generalist group in each questionnaire (RIMMS and LOES-S).*

Hypothesis 1. *There is a significant difference in the mean scores between the ICT group and the generalist group in each questionnaire (RIMMS and LOES-S).*

Table 8 shows that the mean scores of the ICT group are slightly higher than those of the generalist group in both questionnaires. For the RIMMS and LOES-S questionnaires, hypothesis tests were conducted to compare the mean scores of the ICT and generalist groups. In the case of the RIMMS questionnaire, the generalist group obtained a mean score of $M = 4.54$ ($SD = 0.26$), compared to $M = 4.61$ ($SD = 0.26$) for the ICT group. However, this difference is not statistically significant ($W = 490$, $p = .25$), with a small effect size ($r = -.13$). Similarly, in the LOES-S questionnaire, the ICT group obtained a mean score of $M = 4.60$ ($SD = 0.34$), slightly higher than that of the generalist group ($M = 4.56$, $SD = 0.34$). This difference also did not reach statistical significance ($W = 478.5$, $p = .198$), with a small effect size ($r = -.15$). The results indicate that, although the mean scores of the ICT group are slightly higher than those of the generalist group on both questionnaires, these differences are not statistically significant ($p > .05$ in both cases). Therefore, H_0 is not rejected in either case.

Table 8. Mean scores by specialization group in RIMMS and LOES-S instruments.

	RIMMS		LOES-S	
Group	**Mean**	**SD**	**Mean**	**SD**
No specialization	4.54	0.26	4.56	0.22
Specialist in ICT	4.61	0.26	4.60	0.34

A detailed analysis, focusing on the RIMMS instrument (Table 9), indicates that the mean scores of the ICT group were higher in all dimensions measured by the test, except in relevance, where they were lower. For each construct of the RIMMS questionnaire, hypothesis tests were conducted, with the corresponding hypotheses formulated as follows:

Hypothesis 0. *There is no significant difference in the mean scores between the ICT group and the generalist group in the respective dimension of the RIMMS instrument.*

Hypothesis 1. *There is a significant difference in the mean scores between the ICT group and the generalist group in the respective dimension of the RIMMS instrument.*

These differences were non-significant in all cases, except for the construct of confidence, where the difference between the mean score obtained by the ICT group ($M = 4.58$) was statistically significant compared to the mean score obtained by the generalist group ($M = 4.35$, $W = 419$, $p = .042$), though with a small effect size, $r = -.24$. Hence, the null hypothesis was rejected only for the confidence dimension ($p < .05$), indicating a statistically significant difference. However, the effect size was small, suggesting that while the difference is statistically significant, it may not be of practical importance.

Table 9. Mean scores by specialization group in RIMMS constructs.

Group	Attention	Relevance	Confidence	Satisfaction
No specialization	4.53	4.37	4.35	4.91
Specialist in ICT	4.60	4.32	4.58	4.94

Focusing on the test that evaluates VR as a learning object, we can see the mean scores of the test dimensions from the LOES-S, separated by groups, in Table 10. Here, we observe that the ICT group rates the dimensions of learning and engagement with higher mean scores, while the dimension of confidence is rated slightly lower. For the statistical test analysis, the null and alternative hypotheses can be formulated as follows for each of the dimensions measured using the LOES-S test (learning, engagement, and confidence):

Hypothesis 0. *There is no significant difference in the mean scores between the ICT group and the generalist group in the respective dimension of the LOES-S instrument.*

Hypothesis 1. *There is a significant difference in the mean scores between the ICT group and the generalist group in the respective dimension of the LOES-S instrument.*

However, these differences in mean scores were not statistically significant in any of the three constructs. In this case, we would fail to reject H_0 for the learning, engagement, or confidence dimensions.

Table 10. Mean scores by specialization group in LOES-S constructs.

Group	Learning	Quality	Engagement
No specialization	4.32	4.60	4.89
Specialist in ICT	4.49	4.55	4.86

5.5. Gender Analysis: Female vs. Male

Finally, to complete O3, a gender analysis was conducted to detect potential differences in the scores obtained by male and female participants on the RIMMS and LOES-S questionnaires. The overall results, presented in Table 11, show that, on average, male participants scored slightly higher on both tests. In order to test the significance of the obtained differences in the mean values, for each questionnaire, we state the following null (H_0) and alternative (H_1) hypotheses:

Hypothesis 0. *There is no significant difference in the mean scores between males and females in each questionnaire (RIMMS and LOES-S).*

Hypothesis 1. *There is a significant difference in the mean scores between males and females in each questionnaire (RIMMS and LOES-S).*

Table 11. Mean scores by gender in RIMMS and LOES-S instruments.

	RIMMS		LOES-S	
Gender	**Mean**	**SD**	**Mean**	**SD**
Female	4.54	0.28	4.57	0.24
Male	4.62	0.22	4.58	0.33

In the RIMMS questionnaire, male participants achieved a mean score of $M = 4.62$ ($SD = 0.22$), while female participants had a mean of $M = 4.54$ ($SD = 0.28$). However, this difference was not significant ($W = 439$, $p = .26$), and it exhibited a small effect size ($r = -.13$). Similarly, in the LOES-S questionnaire, males obtained a mean score of $M = 4.58$ ($SD = 0.33$), slightly higher than the mean of $M = 4.57$ ($SD = 0.24$) achieved by females. This difference was also not significant ($W = 483$, $p = .563$), and the effect size was small ($r = -.07$). Hence, for both tests, we could not reject the null hypothesis, as these differences were not statistically significant.

A more detailed analysis of the constructs in the RIMMS questionnaire (Table 12) reveals that males scored higher in the dimensions of attention, confidence, and satisfaction. However, females scored slightly higher in the relevance construct. In none of these cases were the differences statistically significant. Hence, we could not reject the null hypothesis (H_0: there is no significant difference in the mean scores between males and females in the respective dimension of the RIMMS instrument).

Table 12. Mean scores by gender in RIMMS constructs.

Group	Attention	Relevance	Confidence	Satisfaction
Female	4.53	4.36	4.37	4.91
Male	4.60	4.33	4.57	4.97

On the other hand, in the LOES-S questionnaire, males scored higher in the constructs of learning and quality, while females scored slightly higher in engagement. Again, these differences were not statistically significant for any of the evaluated constructs (results are shown in Table 13). As a consequence, we could not reject the null hypothesis (H_0: there is no significant difference in the mean scores between males and females in the respective construct of the LOES-S instrument).

Table 13. Mean scores by gender in LOES-S constructs.

Group	Learning	Quality	Engagement
Female	4.36	4.58	4.90
Male	4.41	4.60	4.83

Finally, it is essential to mention that the gender imbalance in the sample is a limitation of this study (with 72.6% women and only 27.4% men). The over-representation of women could skew the analysis, particularly when examining gender-based differences or perceptions. As such, future studies should aim to recruit a more balanced sample to ensure that the findings are more representative and that gender-related patterns can be more accurately assessed.

6. Conclusions

VR has established itself as an innovative educational tool, capable of motivating, engaging, and enriching the learning experience of future educators. The results obtained from the RIMMS and LOES-S questionnaires reflect how this immersive technology promotes a more interactive, engaging, and motivating learning environment, aligning with previous studies that emphasize its potential to enhance the teaching and learning process (Cabero & Fernández, 2018; Liu et al., 2020; Sousa Ferreira et al., 2021; Villena-Taranilla et al., 2023, 2022a, 2022b).

The results of this study reinforce the importance of considering teacher training as a key factor in the implementation of VR in education. The literature has highlighted that, although VR is a highly motivating and engaging tool for students, its effectiveness does not rely solely on its immersive capability but on its integration within a solid pedagogical design (Makransky & Lilleholt, 2018). Previous studies have identified that if VR is not clearly linked to learning objectives, it may be perceived more as an entertainment resource rather than an effective teaching strategy (Gómez-Trigueros, 2023). Regarding gender analysis, our findings align with research suggesting that VR can act as an equalizer in learning, reducing gender differences in the adoption of technology in the classroom (Onele, 2023). However, the fact that slight variations exist in the perception of VR based on gender suggests the need for further investigation to better understand the factors that may influence future teachers' technological self-efficacy (Qazi et al., 2022).

Concerning O1, the analysis of motivation of future primary education teachers regarding the use of VR in the teaching of Social Sciences and History was accomplished by means of the RIMMS questionnaire. The scores of the participants showed a high overall motivation level ($M = 4.56$, $SD = 0.26$), with particularly high ratings in the satisfaction dimension ($M = 4.92$, $SD = 0.20$), reflecting the high level of enjoyment generated by the experience. These results align with the meta-analysis by Villena-Taranilla et al. (2022b) and the research by Kavanagh et al. (2017), who emphasize that immersive technologies like VR enhance students' motivation and interest by providing more dynamic and engaging experiences. However, the attention dimension, while positive ($M = 4.55$, $SD = 0.46$), showed lower scores in the item related to the perception of variety in activities (A03). This may be due to the immersive activity, focused on exploring the city of Augusta Emerita, being perceived as a single thematic environment, lacking sufficient changes in the pedagogical approach or tasks carried out, which could have influenced the perception of monotony.

On the other hand, the relevance dimension received a relatively lower rating ($M = 4.36$, $SD = 0.44$), highlighting some difficulties participants had in connecting the content covered with their prior knowledge. This finding, consistent with the observations of Campos Soto et al. (2020), underscores the importance of designing activities that strengthen the connection between immersive content and the academic curriculum. This result can be explained by the fact that these immersive activities, focused on historical themes, although visually striking, may lack elements that help contextualize the relevance of the content in relation to the students' future professional practice. This finding reinforces the need to complement VR with pedagogical strategies that enhance its integration with prior learning and the students' specific competencies.

Regarding VR as a learning tool for Social Sciences and History in the training of primary education teachers (O2), the LOES-S questionnaire showed an overall rating that was also very positive ($M = 4.57$, $SD = 0.26$). Among the evaluated constructs, engagement stood out as the highest rated ($M = 4.88$, $SD = 0.27$), with 98.63% of participants achieving a high level, reinforcing the ability of VR to generate high emotional and motivational involvement in the classroom. Additionally, the quality dimension ($M = 4.59$, $SD = 0.44$)

reflected participants' positive perception of the design, organization, and usability of the VR-based activities, which are critical factors in ensuring technological acceptance in educational contexts (Riner et al., 2022). However, the learning dimension ($M = 4.38$, $SD = 0.36$) received a lower rating compared to the other dimensions, indicating the need to strengthen the pedagogical design to more clearly connect immersive experiences with learning objectives, in line with the findings of Kee et al. (2024).

Concerning O3, the uneven distribution of genders can affect the generalizability of our findings, as the results may not fully represent the perspectives or experiences of both genders. However, in the results, the gender analysis revealed no statistically significant differences in any of the questionnaires, which aligns with previous research such as that of Barroso et al. (2016), which dismissed a relationship between gender and technological acceptance. However, the literature has identified differences in technological self-efficacy between men and women, with studies indicating that women tend to underestimate their digital competence despite using ICTs in teaching as much or more than men (Mercader & Duran-Bellonch, 2021). Other studies like that of González-Calero et al. (2019) highlight that certain skills, such as spatial abilities, may develop differentially depending on gender and the design of technological activities. Although their research focused on the use of educational robotics, their findings underscore the importance of considering how different technologies, such as VR, can be designed to maximize their impact in an inclusive manner.

In this study, although men scored slightly higher in attention, confidence, and satisfaction, while women excelled in engagement, these differences were not significant, reflecting the inclusive ability of VR to motivate and engage students of both genders. Our results (although inconclusive) are aligned with the systematic review carried out by Qazi et al. (2022), which found that gender differences in digital skills are minimal or nonexistent in education, suggesting that the observed gap in some contexts may be more related to self-perception than actual competence. However, in the case of VR, studies addressing the gender variable are scarce and fragmented, representing a gap in the literature that our study helps to fill. Hence, our results reinforce the idea that VR, like other emerging technologies, can be used as an equitable tool when activities are designed to address the needs of all students. In particular, recent studies have identified the need to investigate how gender influences the perception of VR in educational settings, indicating that it is still not fully understood whether motivation and engagement with this technology vary between men and women Adeyele (2024).

On the other hand, the analysis by students' specialization showed that students in the ICT specialization tended to score slightly higher compared to the generalist group, particularly in confidence. This finding may be related to a greater technological familiarity, a factor identified as key for the effective adoption of emerging educational tools (Kee et al., 2024). According to Cózar-Gutiérrez et al. (2019), familiarity with technologies not only improves interaction with the tools but also enhances students' self-confidence in their use. As noted by Villena-Taranilla et al. (2023), this technological familiarity not only enhances interaction with the tools but also boosts the perception of utility and enjoyment, thereby reinforcing student engagement with these technologies.

Our study's findings highlight both the potential and the practical barriers of VR technology. Despite the typically high costs and technical complexities associated with VR, our experience demonstrates that its integration into teacher training can be achieved within a short timeframe. The high levels of motivation and satisfaction observed among participants suggest that even with minimal preparation time, VR can effectively enhance engagement and learning outcomes. However, our study also reinforces concerns about usability and accessibility. The lack of interoperability between platforms and the absence of open standards remain significant limitations, and while our implementation was successful, scaling VR to a broader educational context requires overcoming these barriers. Additionally, although participants showed strong emotional and motivational involvement, the learning curve associated with VR tools and the need for specific teacher training cannot be overlooked. These findings emphasize that, while VR holds great promise as a pedagogical tool, thoughtful planning, streamlined resources, and targeted training are essential to maximize its educational impact and ensure its sustainable integration into diverse learning environments.

Given the limitations of the present study, future research should expand the sample size and ensure a more balanced gender distribution, as the predominance of women in the current sample limited the depth of the gender-based analysis. Although no statistically significant differences were found, the low representation of male students restricts the generalizability of the results. Including students from different specializations within the primary education degree and with varying levels of prior experience in educational technologies could also provide a more nuanced understanding of motivational patterns.

Additionally, the use of longitudinal designs and mixed-method approaches would be valuable in examining whether the initial motivational impact of VR is sustained over time and translates into its practical application in real teaching contexts. Moreover, future research should delve into the challenges, limitations, and drawbacks associated with the use of these technologies in education, both from a technical perspective (accessibility, infrastructure, maintenance) and a pedagogical one (instructional design, classroom management, teacher training). Finally, it is recommended to continue investigating the use of VR in education by comparing different levels of immersion, as this study has focused exclusively on an immersive VR environment.

Overall, the results of this study confirm that VR is not only a motivating and engaging tool, but it also has the potential to transform the training of future educators. However, to maximize its effectiveness, it is essential to overcome technical challenges, ensure a solid pedagogical design, and provide specific training for the development of advanced digital competencies. As Riner et al. (2022) note, these measures are crucial for ensuring the effective and equitable integration of VR into the educational context, paving the way for more dynamic, inclusive learning environments tailored to the demands of the 21st century.

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Appendix A. Measurement Instruments Used in This Study

Instructions to complete the questionnaires given to the students: We want to know your opinion about the class you just had using Virtual Reality. Each questionnaire contains

12 statements. You must choose the option that best describes your experience for each statement, not the one you wish was true or what you think others would like to hear.

Scale response for each item:

1. Strongly Disagree
2. Quite Disagree
3. Neither Agree Nor Disagree
4. Quite Agree
5. Strongly Agree

Appendix A.1. RIMMS Questionnaire

Table A1. RIMMS questionnaire used in this study.

Construct	Item Description
Attention	
MA01	The quality of the activities with Virtual Reality helps me maintain attention.
MA02	The way information is organized using these materials (Virtual Reality) helps me maintain attention.
MA03	The variety of activities helps maintain my attention in class.
Relevance	
MR04	For me, it is clear how this class is related to things I already knew.
MR05	The content and activities with Virtual Reality give the impression that it is worth learning the content of the lesson.
MR06	The content of this class is useful to me.
Confidence	
MC07	While working in this class with Virtual Reality, I am confident that I will learn the content.
MC08	After working in this class, I feel confident that I would be able to pass an exam on the topic.
MC09	The good organization of the class with Virtual Reality helps me feel confident that I will learn the content.
Satisfaction	
MS10	I enjoyed the class with Virtual Reality so much that I would like to know more about this topic.
MS11	I liked this class (with Virtual Reality).
MS12	It has been a pleasure to work in such a well-designed class (with Virtual Reality).

Appendix A.2. LOES-S Questionnaire

Table A2. LOES-S questionnaire used in this study.

Construct	Item Description
Learning	
LA01	Working with Virtual Reality helped me learn.
LA02	The feedback from Virtual Reality helped me learn.
LA03	The design of the Virtual Reality page helped me learn.
LA04	Virtual Reality helped me learn a new concept.
LA05	Overall, Virtual Reality helped me learn.
Quality	
LC06	The aids in Virtual Reality were helpful.
LC07	The instructions in Virtual Reality were easy to follow.
LC08	Virtual Reality was easy to use.
LC09	The activity with Virtual Reality was well-organized.
Engagement	
LE10	I liked the overall theme of the Virtual Reality.
LE11	Virtual Reality was motivating.
LE12	I would like to use Virtual Reality again.

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