e-ISSN 1135-9250

EDUTEC - Revista Electrónica de Tecnología Educativa.

Issue 93 – September 2025

Students as evaluators of learning objects in virtual reality: usability and technical and aesthetic valuation

Los estudiantes como evaluadores de objetos de aprendizaje en realidad virtual: usabilidad y valoración técnica y estética

Julio Cabero-Almenara (J.C.-A.). Universidad de Sevilla (España)

Carmen Llorente-Cejudo (C.L.-C.). Universidad de Sevilla (España)

Verónica Basilotta-Gómez-Pablos (V.B.-G.-P.). Universidad del Atlántico Medio (España)

Antonio Palacios-Rodríguez (A.P.-R.). Universidad del Atlántico Medio (España)

ABSTRACT

Virtual Reality (VR) is emerging as a key tool in education, transforming both teaching methods and learning experiences. This study examines its impact through an experimental investigation involving 554 university students who interacted with VR-based learning objects. Usability, technical quality, aesthetics, and effectiveness in information acquisition were assessed. The results indicate high usability levels, with scores exceeding those reported in previous studies, as measured by the System Usability Scale (SUS). Version 1 of the VR objects, which included additional elements such as music and stimulus variation, received higher ratings than Version 2, particularly in terms of educational and social utility. While both versions were positively evaluated, Version 1 demonstrated a significantly greater impact on academic performance and student attitudes. Interaction with the VR objects substantially facilitated knowledge acquisition, highlighting the transformative potential of this technology. In conclusion, VR significantly enhances the educational experience and fosters a positive attitude toward learning, thus supporting its integration into academic curricula. These findings endorse the use of VR as an innovative and effective resource to enrich traditional teaching methods.

RESUMEN

La Realidad Virtual (RV) emerge como una herramienta clave en la educación, transformando el modo de enseñar y aprender. Este estudio analiza su impacto mediante una investigación experimental con 554 estudiantes universitarios, utilizando objetos de aprendizaje en RV. Se evaluaron aspectos de usabilidad, calidad técnica, estética y eficacia para la adquisición de información. Los resultados revelan una alta usabilidad, con puntuaciones superiores a estudios anteriores según la Escala de Usabilidad del Sistema (SUS). La versión 1 de los objetos, que incluía música y variación de estímulos, fue mejor valorada que la versión 2, especialmente en utilidad educativa y social. Ambas versiones fueron calificadas positivamente, pero la versión 1 mostró un impacto más significativo en el rendimiento académico y en la actitud de los estudiantes. La interacción con los objetos de RV facilitó de forma notable la adquisición de conocimientos, evidenciando el potencial transformador de esta tecnología. En conclusión, la RV mejora significativamente la experiencia educativa y promueve una actitud positiva hacia el aprendizaje, por lo que se recomienda su integración en los programas formativos. Estos hallazgos apoyan el uso de la RV como un recurso innovador y eficaz para enriquecer los métodos de enseñanza tradicionales.

KEYWORDS - *PALABRAS CLAVE*

Virtual Reality, System Usability Scale, Performance, Higher Education, Academic Performance

Realidad Virtual, Escala de Usabilidad del Sistema, Rendimiento, Educación Superior, Rendimiento Académico

DOI: https://doi.org/10.21556/edutec.2025.93.4069

Received: 05-05-2025
Accepted: 09-07-2025

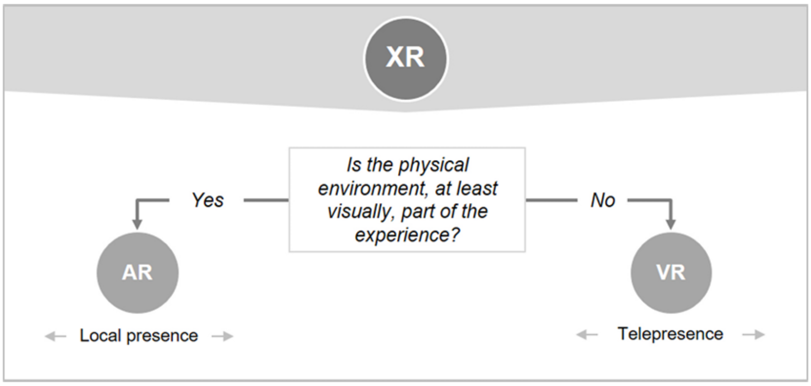
1. INTRODUCTION

Emerging technologies, which are being increasingly used in education, include Extended Reality (XR), Virtual Reality (VR) and Augmented Reality (AR) (Wang & Li, 2024). These resources are becoming key technologies in education, and they are radically transforming the way in which knowledge is taught and how learning is experienced, through immersive environments and interactive simulations (Dyer et al., 2018; Panerai et al., 2018; Wang & Yanping, 2024).

In conceptualizing these concepts, Rauschnabel et al. (2022) noted that these terms often lead to conceptual confusion, and clarifying and distinguishing them necessitates considering the framework presented in Figure 1.

Figure 1

Framework of mixed or extended reality, as well as augmented and virtual reality. Source: Rauschnabel et al. (2022, p.6).



By clarifying the meaning of each technology, it can be stated that augmented reality (AR) superimposes virtual elements onto the real world, thereby enriching the perception of the environment without isolating the user from their physical context (Barroso-Osuna & Cabero-Almenara, 2016). In contrast, virtual reality (VR) can be understood as the combination of hardware and software systems designed to create a complete sensory illusion of being present within a digital environment. One of the key benefits of VR is its ability to promote an immersive experience, wherein the user is fully immersed in a virtual and digital setting (Lai & Cheong, 2022).

Within VR, three categories can be distinguished (Lai & Cheong, 2022): Non-immersive VR, which is often overlooked as a VR experience, involves sensors that detect the user's movements and translate them to actions on a screen within a virtual environment. Semi-immersive VR provides a partially virtual setting and is commonly used for training and educational applications, such as flight simulators. Fully immersive VR offers the most realistic immersive experience and requires special headsets to deliver sensory content with a wide field of view; it can also be programmed to provide full-body haptic feedback.

Other authors distinguish between non-immersive or desktop VR, which relies on conventional devices like a mouse and keyboard, and highly immersive VR, which generally requires specialized headsets (Caballero et al., 2020; Mulders et al., 2020; Cigdem & Oncu, 2024). Highly immersive VR includes various models with differing levels of immersion quality (Swidrak, 2023). These two types of VR each have distinct characteristics: non-immersive VR is more affordable, easier to use, quickly accepted by users, provides a lower sense of reality, and offers only partial immersion. In contrast, highly immersive VR involves higher costs, is more complex to use, can cause disorientation, but delivers a strong sense of realism and full immersion.

Finally, in a wider context, there is XR, which encompasses both AR and VR, offering an integration between the physical and digital worlds, and providing new possibilities in fields such as education, medicine and industry (Cabero-Almenara et al., 2023a, 2023b).

These technologies are acquiring increasing prominence in training, which is clearly observed in the number of studies that are carried out on them. The results of these studies have been shown in different meta-analyses (Radianti et al., 2020; AlGerafi et al., 2023; Chen et al., 2023; Marougkas et al., 2023; Mogrovejo et al., 2024; Geovana, 2024; Llorente-Cejudo, 2024; Rico & Fernández, 2024), which underline the growing interest of education for these technologies, highlighting a series of findings in this scope: they facilitate the interaction of the student with experience; favour the acquisition of learnings, thereby enabling the simulation of complex actions in safe and controlled environments; both students and teachers present favourable attitudes for their use and incorporation in the classroom; they can be used in a variety of contents and disciplines; and they favour the use of different active methodologies. On their part, previous meta-analyses show a series of limitations in the use of these technologies and in the research associated with their use, which can be summarised in the following inconveniences: the cognitive load that their utilisation poses to the user in some cases; the lack of teacher training in the employment of these resources; the mental fatigue caused in the individual, especially with immersive VR; the limited studies that have analysed their impact on performance; the lack of studies on the design and development of these learning objects; the fact that learning performance is not considered as a study variable; and the need to favour an egalitarian access to this technology.

1.1. The design of learning objects in Virtual Reality

The design of learning objects is a fundamental research line, since, as was pointed out by research in the field of Educational Technology, the way technological resources are design has a clear impact on learning, and it has become a constant line of research (Reeves & Lin, 2020; Cabero & Valencia, 2021; Wang et al., 2022; Baeza González et al., 2024). However, as was previously mentioned, there are very few relevant studies on the design and development of learning objects in AR, VR and XR.

Since the design of learning objects in the format of AR, VR and XR is an important research line in the educational context, it is worth formulating the following questions: "what principles should guide the design of these objects?" and "what elements should be taken into account in their development?"

Moreover, the design of these resources for individuals with specific needs and characteristics gains a fundamental relevance in the field of education (Ausín Villaverde et al., 2023; López-Belmonte et al., 2024).

In this scope, some authors have underlined that the principles that could guide the design of learning objects with XR and VR are those that intervene in the cognitive theory of multimedia learning (Kartiko, Kavakli & Cheng, 2010). This theory was proposed by Mayer (2002 & 2021) and, according to Mulders et al. (2020), it is based on different principles: reducing superficial processing, thereby dispensing with the aspects that may distract the student; contemplating principles such as information redundancy; the use of signs to guide the attention of the student; and the principle of modality, which establishes that it is better to present images with spoken text rather than written text, posing a presentation format that leads to a more effective learning.

Furthermore, it is important to consider the principle of segmentation, which recommends the distribution of complex material in smaller learning units, or designing the material from a perspective that involves the participation of the student (Alpizar et al., 2020; Mulders et al., 2020; Mayer et al., 2023).

The abovementioned principles for the design of learning objects in VR and XR format must be contemplated with caution, since, according to Parong and Mayer (2021), this type of material tends to generate emotional arousal, thereby leading the student to perform ludic actions rather than formal actions (Makransky et al., 2019; Parong & Mayer, 2021; Mayer et al., 2023).

In XR objects, signs and guides can be favoured, on the one hand, by incorporating “hot points” that provide additional information to the student in different formats: stationary images, video clips, animations, and audio podcasts (Alpizar et al., 2020). On the other hand, sings and guides can be supported by placing arrows that suggest movement.

It is important to highlight that 360º videos have proved effective (Cabero-Almenara et al., 2023; Christopoulos et al., 2023; Chen & Cukurova, 2024), and they are being incorporated increasingly frequently in VR objects (Herranz et al., 2019; Marín et al., 2022). Zilles (2020, p. 6) stated that: “360º content is not VR in itself. While VR is an interface (the device, the platform, the medium), the content formats framed in this medium are the videos and 3D images that are developed in 360º spaces.”

Nevertheless, for the creation of 360º videos, new audiovisual narratives are being sought to guide the attention of the viewer (Tecnic, 2018; Benítez & Herrera, 2021), through the incorporation of arrows, graphs, hot points…, etc.

In conclusion, there are different principles and elements that can be taken into account in the development of XR and VR materials: information presentation (text, audio, visual, and audiovisual); the intervention possibilities of the user; the freedom or guidance of movement; the incorporation of evaluations; the contextualisation of information through schemes and maps; the role of the information presenter; the use of “hot points”; and the use of summaries.

This study is a continuation of a previous investigation in which a pilot project was conducted (Cabero-Almenara et al., 2025). In line with the recommendations derived from that earlier work, this research now involves a more contextually grounded sample, with the aim of providing reliable data for the analysis of usability, as well as technical and aesthetic aspects, as evaluated by students.

2. METHODOLOGY

2.1. Objectives

The following objectives were set in this study:

1. To determine the valuation of the students about the usability and different technical and aesthetic aspects of learning objects in VR, analysing whether said aspects depend on the version they interact with.
2. To analyse whether the interaction with learning objects developed in VR facilitates the acquisition of information and whether said acquisition is influenced by the different versions of learning objects.

To attain these objectives, an experimental design was carried out with two experimental groups using a pre-post-test analysis.

2.2. Evaluation procedure and instrument

Different information gathering instruments were used in this study, and they were administered in a pre- post-test version. The pre-test, in addition to collecting biographic data of the student, integrates 15 multiple-choice questions with a single response option about the contents that are offered in the learning objects. The post-test, in addition to the questions about the information presented (similar to that of the pre-test, but changing the order and response options), incorporates the System Usability Scale (SUS), as well as a set of questions for the valuation of the developed objects from a technical and aesthetic perspective, which have been used in previous studies to assess learning objects in the AR format (Barroso & Cabero, 2016; Cabero-Almenara et al., 2017).

To evaluate the usability of these technologies, different instruments were employed, including surveys, interviews and the analysis of the metrics of technology use (Lewis, 2018; Gronier & Baudet, 2021; Schrepp et al., 2023). One of the most used scales in the last years is SUS, which was developed by Brooke in 1996 and revised in 2013. This scale has emerged as one of the most prominent instruments for the diagnosis of perceived usability, presenting adequate validity and reliability in the scope of technologies (Vlachogianni & Tselios, 2022).

Its use in this study can be justified by different aspects:

a) In a search conducted in Google Scholar, under the terms "System Usability Scale (SUS)" and "Escala de Usabilidad del Sistema" (in Spanish), a total of 1,600,000 (0.08 s) and 39,800 (0.09 s) references were found, respectively. All this indicates its frequent use.
b) It has been used to analyse the usability of different tools: portable catheters (Mota & Turrini, 2022), hydraulic platforms (Montiel et al., 2020), e-commerce (Mata & Hernández-Ruíz, 2019), COVID-19 monitoring tools (Alvian et al., 2022) and financial systems (Díaz & Guzmán, 2023).
c) It has been employed to evaluate the use of different technologies: virtual training platforms such as Moodle and Google Classroom (Lirola Sabater & Pérez, 2020; Setiawan & Langgeng, 2020; Rodríguez & Del Valle, 2021), websites (Welda et al., 2020;

Derisma, 2021; Galuh et al., 2021), evaluation of Google tools (Gamarra et al., 2021), objects in AR and immersive VR (Fernandes et al., 2021; Campo-Prieto et al., 2021), simulators (Preciado et al., 2021), social media (Purwandani et al., 2023), and artificial intelligence (Artiles-Rodríguez et al., 2021; Patience et al., 2023).

d) It has been translated and adapted to different languages: French (Gronier & Baudet, 2021), Chinese (Wang et al., 2020), Spanish (Castilla et al., 2023), Portuguese (Silva & Turrini, 2019), Dutch (Ensink et al., 2024), and Malayan (Marzuki et al., 2018), with all these studies obtaining high reliability levels.

e) Several studies have used it in combination with other instruments, such as the TAM and UTAUT2 scales, to measure the degree of acceptance of a technology and the scale of emotions (Pincay et al., 2021; Cheah et al., 2022; Ong et al., 2023).

f) Different meta-analyses and systematic reviews highlight that this instrument has high reliability levels (Lewis, 2018; Vlachogianni & Tselios, 2022), with most of them reporting Cronbach's alpha values above 0.80.

The SUS scale integrates 10 Likert items, with five response options, ranging from 1 (very negative / strongly disagree) to 5 (very positive / strongly agree).

The items of the instrument are as follows:

3. I think I would like to use this system frequently.
4. I think the system is unnecessarily complex.
5. I think the system is easy to use.
6. I think I would need help from a person with technical knowledge in order to be able to use this system.
7. I found that the different functions of this system were well integrated.
8. I believe that the system is very inconsistent.
9. I presume that most people would learn to use this system very quickly.
10. I found that the system was very difficult to use.
11. I felt very safe using the system.
12. I needed to learn many things before I could start using the system.

The final score is not assigned directly, since it requires a conversion. As is indicated by Devin (2017), the odd items (1, 3, 5, 7 and 9) are evaluated by taking the value given by the user and subtracting 1 to each item. On the other hand, for the even items (2, 4, 6, 8 and 10), the sum of the value given by the respondents is subtracted from a score of 25. Then, the sum is multiplied by 2.5.

The final score obtained can be adequately interpreted following the suggestion of Gimeno (2018), who proposed assigning a rating as a function of the range of scores: a) bad (0-25 points); b) poor (25-50 points); c) good: (50-70 points); d) very good (70-90); and e) excellent (over 90 points). However, other authors establish the minimum desirable score at 68 points (Pedrosa, 2022).

According to some studies (Lewis, 2018), this scale does not evaluate a single factor, as different factor analyses have shown that items 4 and 10 can be grouped into a single item. Therefore, the scale would consist of two factors: usability and user satisfaction.

Lastly, it is important to highlight that the score of the SUS scale is only a measure of perceived usability, and it should not be the only metric to be used for the assessment of the usability of an entire system. Thus, the present study employed other items in the post-test to determine the perception of the students with regard to different technical and aesthetic aspects of the objects produced in VR.

2.3. Objects developed

The experience was carried out with two versions of an object developed in VR format, called "Women scientists in the streets of Seville. A visit with Virtual Reality". Using the streets and parks named after these women by the municipal corporation of Seville city, this object presents different women scientists and the historical moment in which they lived.

The objects contain three sections: description/presentation through an image of the woman and her activity; presentation of the fundamental aspects (social and historical) that occurred in Seville during her life; and indication of the date when the street or park was named after her by the municipal corporation. All this is described while touring the street or park that bears her name.

The material was integrated in a website, of which two versions were developed, modifying some design principles in them. Both versions can be consulted in the following links:

- https://innova01.us.es/cientificasid
- https://innova01.us.es/cientificassevillaid/

For their elaboration, different software programmes were used:

1. Krpano: Implementation of VR projects, creation of panoramic views and 360º videos, and development of interactive elements.
2. Adobe Photoshop: Advanced edition of 360º images and design of graphic materials, such as credits posters, home-menu interfaces, and navigation components.
3. Adobe Premiere Pro: Improvement of the resolution and reproduction quality of 360º videos.
4. Insta360 Studio: Processing and assembly of 360º images, with conversion to JPG format.
5. MyHeritage: Creation of animations with artificial intelligence to give life to the images of the women scientists, generating the illusion that they are talking.
6. Canva: Design of complementary visual contents and interactive icons for user navigation.

Both versions begin with the same covers (Figure 2), and were created in 360º format.

Figure 2

Beginning of the object in both versions.

The elements that were used to differentiate both versions are presented in Figure 3.

Figure 3

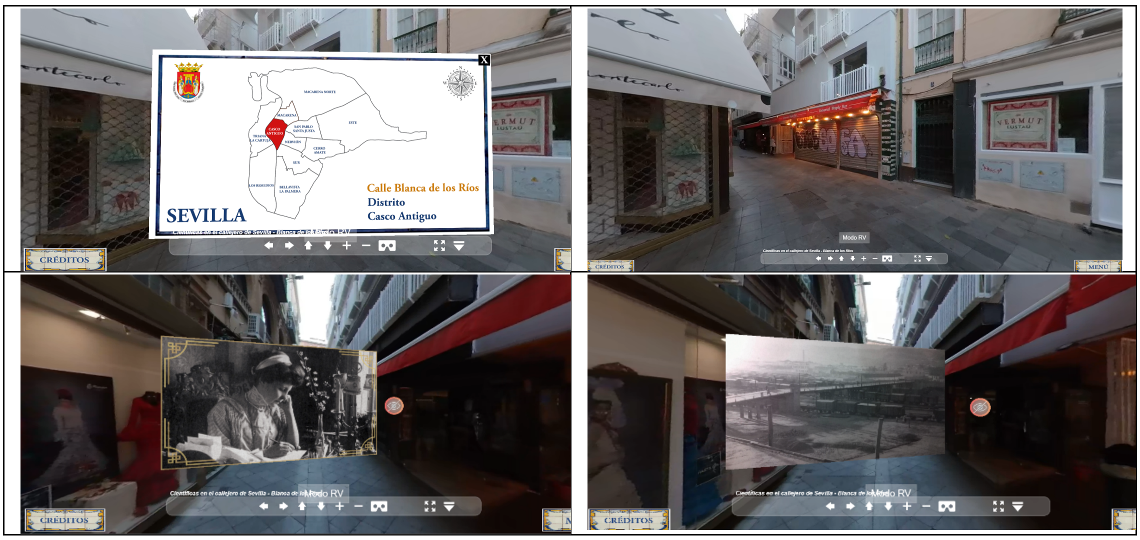
Elements used to distinguish between the two versions

Version 1	Version 2
Beginning of the street with a map of its location in the city.	Beginning directly at the street.
Incorporation of background music.	No music.
Hot points located in an alternate manner (left – right).	Hot points located in the same direction (left).
Video clip with images of the historical period for the presentation of the historical monument.	Description of the historical monument with a single image, which corresponds to the woman.
Redundancy of text and audio in the presentation of the date when the street or park was named after the woman by the municipal corporation.	Text-only presentation of the date when the street or park was named after the woman by the municipal corporation.

Figure 4 shows some elements used to differentiate between the two versions.

Figure 4

Some differentiating elements.



In this study, the objects were used in a desktop version, which was not immersive. The versions were observed by the students in class hours, and teachers were given the following instructions: start administering the pre-test, explain the topic of the object with which the students were going to interact, explain how one of the cases worked and how the students could move around them, give the students about 40 minutes to interact with the other cases, and, lastly, apply the post-test.

2.4. Sample

The study sample consisted of 554 university students, with different characteristics (Table 1). The participants were selected by convenience sampling.

Table 1

General characteristics of the sample.

		f	%
University	Pablo de Olavide University	156	28.2
	University of Seville	398	71.8
Gender	Female	440	79.4
	Male	110	19.9
	Did not wish to say	4	0.7
Age	Less than 20 years	321	57.9
	20 - 25 years	206	37.2
	25 - 30 years	14	2.5
	30 - 35 years	6	1.1
	Over 35 years	7	1.3
Educational centre	International centre	5	0.9
	Faculty of Education Science	428	77.3
	Faculty of Communication	116	20.9
	Faculty of Psychology	5	0.9
Academic year	1st	411	74.2
	2nd	120	21.7
	3rd	2	0.4
	4th	1	0.2
	Master’s degree	20	3.6

Of all the students who participated in this study, 379 interacted with version 1, and 175 interacted with version 2.

Finally, it is important to highlight that several students did not complete the pre-test and/or the post-test, with the latter being completed by only 467 students.

3. RESULTS

Regarding the reliability of the SUS scale, the Cronbach's alpha and McDonald's omega values obtained were 0.925 and 0.902, respectively, indicating high reliability levels of the instrument (O´Dwyer & Bernauer, 2014).

In relation to usability, Table 2 presents the values obtained both for the total scores and for each of the versions of the developed objects.

Table 2

Mean scores and standard deviations obtained in the two versions of the objects developed in VR on the SUS scale.

	Total		Version 1		Version 2	
	M	SD	M	SD	M	SD
I think that I would like to use this system frequently	3.99	.94	3.99	.94	3.98	.92
I think the system is unnecessarily complex	2.48	1.31	2.41	1.30	2.68	1.32
I think that the system is easy to use	4.19	.94	4.21	.97	4.14	.85
I think that I would need help from a person with technical knowledge in order to be able to use this system	2.09	1.35	2.01	1.34	2.30	1.34
I found that the different functions of this system are well integrated	3.95	.90	4.01	.87	3.79	.97
I believe that the system is very inconsistent	2.24	1.18	2.16	1.19	2.42	1.13
I presume that most people would learn to use this system very quickly	4.10	.98	4.14	.97	3.98	1.00
I found that the system is very difficult to use	1.99	1.27	1.91	1.26	2.20	1.27
I felt very safe using the system	4.08	.94	4.13	.93	3.95	.94
I needed to learn many things before I could start using the system	1.90	1.22	1.82	1.21	2.08	1.25

Table 3 presents the mean scores and standard deviations obtained in versions 1 and 2, although, in this case, considering the responses given by the students of Pablo de Olavide University and the University of Seville.

Table 3

Mean scores and standard deviations obtained in the two versions of the objects developed in VR in the SUS scale considering Pablo de Olavide University and the University of Seville.

	Pablo de Olavide University				University of Seville			
	Version 1		Version 2		Version 1		Version 2	
	M	SD	M	SD	M	SD	M	SD
I think that I would like to use this system frequently	4.13	.86	4.11	1.01	3.94	.97	3.94	.89
I think the system is unnecessarily complex	2.29	1.38	2.97	1.54	2.46	1.26	2.57	1.22
I think that the system is easy to use	4.28	.92	4.25	.94	4.18	.99	4.09	.82
I think that I would need help from a person with technical knowledge in order to be able to use this system	2.20	1.33	2.56	1.50	1.92	1.34	2.21	1.27
I found that the different functions of this system are well integrated	4.12	.832	3.69	1.09	3.97	.88	3.82	.92
I believe that the system is very inconsistent	2.02	1.09	2.53	1.34	2.23	1.22	2.37	1.05

	Pablo de Olavide University				University of Seville			
	Version 1		Version 2		Version 1		Version 2	
	M	SD	M	SD	M	SD	M	SD
I presume that most people would learn to use this system very quickly	3.97	1.05	3.92	.91	4.22	.92	4.00	1.04
I found that the system is very difficult to use	2.13	1.36	2.72	1.41	1.81	1.20	2.01	1.17
I felt very safe using the system	4.04	.98	4.03	.91	4.17	.91	3.92	.97
I needed to learn many things before I could start using the system	1.93	1.20	2.39	1.48	1.77	1.22	1.97	1.15

With the aim of determining the global level of usability attained in both versions and applying the previously described procedure to obtain the final score of the SUS, Table 4 presents the value obtained both for the total score of each version and for the total score obtained with the students of each of the participating universities.

Table 4

Score in the usability scale.

	SUS score
Version 1 - Total	75.88
Version 2 - Total	70.40
Total	74.03
Version 1 – Pablo de Olavide University	69.68
Version 2 – Pablo de Olavide University	67.08
Version 1 – University of Seville	75.73
Version 2 – University of Seville	71.60

All the obtained values exceeded, in both versions, the score of 68 points, established by different authors (Gimeno, 2018; Pedrosa, 2022). Therefore, it can be considered that both versions have a very adequate usability level and can be used in the teaching-learning process.

To analyse the existence of significant differences in the valuations carried out by the students with regard to the two versions developed, Mann-Whitney U-test was applied, considering that H0 (null hypothesis) refers to the non-existence of significant differences with a risk of errors of .05, and H1 (alternative hypothesis) refers to the existence of significant differences for the cited level (Table 5).

Table 5

*Mann-Whitney U-test for the score obtained in SUS with regard to version 1 and version 2 (note: **= significant at .01).*

Mann-Whitney U-test	17816.000
Wilcoxon's W	26594.000
Z	-3.274
Asymp. sig. (bilateral)	.001(**)

The obtained values allow rejecting H0 at p≤ .01, indicating that there are significant differences between the two versions in the valuations given by the students about usability.

With the aim of determining which version is favoured by the differences, the range test was applied, whose results are shown in Table 6.

Table 6

Range test for the two versions in the SUS scores.

	Object	f	Mean range	Sum of ranges
SUS	Version 1	335	246.82	82684.00
	Version 2	132	201.47	26594.00
	Total	**467**		

The values obtained in the mean range suggest that the students valued the usability of the developed object in version 1 to a greater degree compared to version 2.

To analyse whether the valuations of the students in the SUS scale varied as a function of the university to which they belonged, Mann-Whitney U-test was applied again, reaching the values displayed in Table 7.

Table 7

Mann-Whitney U-test for the score obtained in SUS, according to the universities of the participating students.

Mann-Whitney U-test	21585.000
Wilcoxon's W	31315.000
Z	-.909
Asymp. sig. (bilateral)	.363

The obtained values do not allow rejecting H0 at p≤ .05. Therefore, it can be stated that there are no significant differences between the two developed versions as a function of the university to which the students belonged.

Given that most of the students were enrolled in the Faculty of Education Science and the Faculty of Communication, we analysed the existence of differences as a function of these two faculties with a significance level of p≤ .05 in the valuations provided by the students. Table 8 presents the obtained scores.

Table 8

*Mann-Whitney U-test for the scores obtained in SUS as a function of the degrees in which the participants were enrolled (note: *= significant at .05).*

Mann-Whitney U-test	14108.000
Wilcoxon's W	83114.000
Z	-1.983
Asymp. sig. (bilateral)	.047(*)

The values attained allow rejecting H0 at p≤ .05, indicating that there are significant differences in the valuations of the students as a function of the degree in which they are enrolled. To determine the group that showed the highest scores, the range test was applied once again (Table 9).

Table 9

Range test for the two versions in the SUS scores as a function of the degree in which the participants were enrolled.

	Faculty	f	Mean range	Sum of ranges
SUS	Education Science	37 1	224.03	83114.00
	Communication	88	255.18	22456.00
	Total	45 9		

The results show that the students from the Faculty of Communication valued the usability of the developed objects more positively than the students from the Faculty of Education Science.

The last part of the questionnaire aimed to gather information of different dimensions. Table 10 displays the mean scores and standard deviations obtained in said dimensions. Once again, we present the mean scores and standard deviations for the total of both versions and for each of them, according to the university that the students belonged to.

Table 10

Mean scores and standard deviations of different technical and aesthetic aspects of the total score and the score of the two versions of the VR objects.

	Total		Version 1		Version 2	
	M	SD	M	SD	M	SD
Technical quality of the resource	7.81	1.91	7.92	1.86	7.55	2.01
Technical functioning of the programme	7.66	2.02	7.81	1.93	7.30	2.19
Aesthetic quality of the resource	8.32	1.80	8.29	1.86	8.39	1.62
Ease of use of the resource	8.34	1.74	8.39	1.77	8.20	1.67
Educational/social usefulness of this type of resource	8.46	1.63	8.44	1.70	8.50	1.45

As can be observed in Table 11, the scores obtained in all dimensions exceed the central value of the scale (5), with the scores in version 1 being higher than those in version 2.

With the aim of exploring the existence of significant differences in the valuations of each dimension as a function of the version of the object, the following hypotheses were formulated:

- Null hypothesis (H0): There are no significant differences in the technical quality of the resource, the technical functioning of the programme, the aesthetic quality, the ease of use or the educational usefulness between the two versions of VR objects, with an alpha risk of error of .05.
- Alternative hypothesis (H1): There are significant differences in the technical quality of the resource, the technical functioning of the programme, the aesthetic quality, the ease of use and the educational usefulness between the two versions of VR objects, with an alpha risk of error of .05.

To test these hypotheses, Mann-Whitney U-test was applied again, reaching the values presented in Table 11.

Table 11

*Mann-Whitney U-test for different dimensions (note: *=significant at p≤ .05).*

	Mann-Whitney U-test	Wilcoxon's W	Z	Sig.
Technical quality of the resource	19726.000	28504.000	-1.852	.064
Technical functioning of the programme	19191.000	27969.000	-2.259	.024(*)
Aesthetic quality of the resource	22107.500	30885.500	-.002	.998
Ease of use of the resource	19954.000	28732.000	-1.689	.091
Educational/social usefulness of this type of resource	21797.500	30575.500	-.246	.806

The obtained results only allow rejecting one of the H0 at a significance level of p≤ .05, which is the one that refers to the technical functioning of the programme. Once again, the range test was applied in this case to determine which version obtained higher scores (Table 12).

Table 12

Range test for the technical functioning of the programme.

	Version	f	Mean range	Sum of ranges
Technical functioning of the programme	1	335	242.71	81309.00
	2	132	211.89	27969.00

The results attained in the range test indicate that the students valued the technical functioning of the programme more positively in version 1 than in version 2.

Finally, we present the results obtained with respect to the acquisition of information, between the scores reached by the students in the pre-test and the post-test. These analyses were conducted both for the total of the two versions and for each of them separately (Table 13).

Table 13

*Mann-Whitney U-test for the pre-test and post-test (note: **= significant at p≤ .01).*

	Total	Version 1	Version 2
Mann-Whitney U-test	28317.000	9787.000	4402.500
Wilcoxon's W	182052.000	81797.000	19802.500
Z	-21.552	-19.548	-9.294
Asymp. sig. (bilateral)	.001(**)	.001(**)	.001(**)

These values (Table 13) allow rejecting those H0 that refer to the absence of significant differences and, consequently, indicate (with a significance level of p≤ .01) that the interaction of the students with the developed VR objects favours the acquisition of information, both contemplating the sum of the two versions and each of them separately. Therefore, it can be stated that VR technology can be used to acquire information.

To determine the effect size of the identified differences, Cohen's D statistic was applied (Cohen, 1988), whose values are presented in Table 14.

Table 14

Cohen's D for the analysis of the effect size.

	Cohen's D
Global	1.78
Version 1	2.08
Version 2	1.23

The results indicate high values in all cases, according to Cohen's proposition (1988), who pointed out that a value above ≥ 1.0 is a very high and significant value.

Once again, the range test was applied to determine whether higher scores were obtained in the pre-test or in the post-test. The results are presented in Table 15.

Table 15

Range test in the pre-test and post-test.

		f	Mean range	Sum of ranges
Global	Pre-test	554	328.61	182052.00
	Post-test	467	727.36	339679.00
	Total	**1021**		
Version 1	Pre-test	379	215.82	81797.00
	Post-test	335	517.79	173458.00
	Total	**714**		
Version 2	Pre-test	175	113.16	19802.50
	Post-test	132	208.15	27475.50
	Total	**307**		

As can be observed, the scores of the post-test are, in all cases, higher than those of the pre-test, indicating that the developed objects were useful for acquiring information.

Lastly, we analysed the existence of significant differences in academic performance as a function of the VR objects, between version 1 and version 2. Table 16 presents the obtained results.

Table 16

*Mann-Whitney U-test for the two versions as a function of academic performance (note: **=significant at p≤ .01).*

	Global
Mann-Whitney U-test	16970.000
Wilcoxon's W	25748.000
Z	-3.930
Asymp. sig. (bilateral)	.001(**)

Cohen's D statistic was applied again to determine the effect size. The value obtained in this case was 0.41, which, according to Cohen's proposal (1988), would indicate a small effect size.

To analyse which version obtained the greatest differences, the range test was applied, whose results are shown in Table 17.

Table 17

Range test.

Version	f	Mean range	Sum of ranges
Version 1	335	249.34	83530.00
Version 2	132	195.06	25748.00
Total	467		

The range test indicates that version 1 of the product favours the capacity to remember the information.

4. CONCLUSIONS AND LIMITATIONS OF THE STUDY

Firstly, it can be asserted that this study attained the two objectives set: 1) to analyse the students' evaluation of the usability of the developed objects, as well as different technical and aesthetic aspects of the latter; and 2) to analyse the interaction with the learning VR objects for the acquisition of information.

Regarding usability, the instrument showed high reliability levels, with values very similar to or even higher than those found in other studies (Castilla et al., 2023; Usman & Gustalika, 2022). Specifically, Lewis (2018), in a review of the studies conducted on the SUS scale in the last two decades, underlined that the mean of the reliability index obtained was above 0.80, in some cases even reaching scores over 0.90. This fact reinforces the idea expressed by Lewis (2028) that those researchers and professionals who need a mean of the perceived usability should consider the use of SUS in their studies.

Secondly, we can conclude that the two versions of the learning objects were valued very positively by the students regarding their usability, although version 1 obtained higher scores. This version incorporates different elements to facilitate the contextualisation of information, such as music to make the journey more appealing, variation of stimuli, modification of the "hot points" with calls for attention to prevent boredom, and information redundancy through images and sounds. The valuation of the students about this version was higher regardless of the university to which they belonged and the degrees they studied.

Thirdly, the objects were positively valued by the students in the different dimensions assessed, especially in terms of their technical quality and functioning, aesthetic quality and ease of use, both in the global score of the two versions and for each of them separately. It is worth highlighting that the students showed a positive attitude with respect to the educational/social usefulness of the VR resources, since, in this dimension, higher mean valuations were found, regardless of the university and degrees in which the participants were enrolled.

The above mentioned suggests the existence of a positive attitude of the students toward VR, in line with the results of previous studies (Lee & Shea, 2020; Saab et al., 2023; Espinoza-Castro et al., 2024; Valero-Franco & Berns, 2024; Rodríguez Gil et al., 2024).

This positive attitude of the students toward the incorporation of this technology into teaching is strengthened by the fact that the interaction of the students with this resource favoured the acquisition of information, which is strongly supported by the large effect size detected. It was also observed that performance was greater in version 1, which is the version that received the most positive valuation from the students in the SUS scale.

Fourthly, this study provides examples of learning objects designed with VR, which incorporate certain elements that must be highlighted: 360º videos, informative hot points, video, music and simultaneity, text, and speech. These elements are fundamental in guiding the design of this type of learning object with VR, as was suggested by Baldoni et al. (2023), who pointed out a lack of guidelines and examples of specific designs.

Finally, the current work proposes a set of future research lines. Firstly, the study should be replicated in other educational contexts with other learning objects that refer to more academic contents, from different disciplines. Secondly, to corroborate the findings of the present study, we propose the incorporation of other differentiating elements, such as: the use of evaluations and summaries, and increasing the degree of realism of the person who presents the information. Thirdly, future studies should replicate this work not with a desktop version of the VR objects, but with an immersive version. Lastly, in terms of information gathering, we propose the use of qualitative instruments, such as interviews and the nominal group technique.

5. FUNDING

The Metaverse: Extended Reality (Virtual and Augmented) in Higher Education: Design, Production, Evaluation, and Training of Extended Reality Programs for University Teaching (MEREVIA). 2021-2023 State Plan - Research-Oriented Projects. Ministry of Science and Innovation. REF: PID2022-136430OB-I00.

6. CONTRIBUTION OF THE AUTHORS

Conceptualization, J.C.-A., C.L.-C., and A.P.-R.; Data curation, J.C.-A. and V.B.-G.-P.; Formal analysis, J.C.-A., C.L.-C., and A.P.-R.; Funding acquisition, J.C.-A.; Investigation, J.C.-A., C.L.-C., and A.P.-R.; Methodology, J.C.-A., C.L.-C., and A.P.-R.; Project administration, J.C.-A., C.L.-C., and V.B.-G.-P.; Resources, V.B.-G.-P.; Software, C.L.-C.; Supervision, J.C.-A., C.L.-C., and A.P.-R.; Validation, J.C.-A., C.L.-C., and V.B.-G.-P.; Visualization, J.C.-A., C.L.-C., and A.P.-R.; Writing – original draft preparation, J.C.-A., C.L.-C., and V.B.-G.-P.; Writing – review and editing, J.C.-A., C.L.-C., and A.P.-R..

7. REFERENCES

AlGerafi, M.A.M., Zhou, Y., Oubibi, M. & Wijaya, T. (2023). Unlocking the Potential: A Comprehensive Evaluation of Augmented Reality and Virtual Reality in Education. *Electronics, 12*, 3953. https://doi.org/10.3390/electronics12183953

Alpizar, D., Adesope, O.O., & Wong, R.M. (2020). A meta-analysis of signaling principle in multimedia learning environments. *Educational Technology Research and Development*. https://doi.org/ /10.1007/s11423-020-09748-7

Alvian, M., Restu, S. & Darwis, M. (2022). Pengujian usability aplikasi pedulilindungi dengan metode System Usability Scale (SUS). *Jurnal Sistem Informasi dan Sains Teknology, 4*(2), 1-7. https://doi.org/10.31326/sistek.v4i2.1326

Artiles-Rodríguez, J., Guerra-Santana, M., Aguiar-Perera, M. V., & Rodríguez-Pulido, J. (2021). Agente conversacional virtual: la inteligencia artificial para el aprendizaje autónomo. *Pixel-Bit. Revista de Medios Y Educación, 62*, 107–144. https://doi.org/10.12795/pixelbit.86171

Ausín Villaverde, V., Rodríguez Cano, S., Delgado Benito, V., & Toma, R. B. (2023). Evaluación de una APP de realidad aumentada en niños/as con dislexia: estudio piloto: [Evaluation of an augmented reality APP for children with dyslexia: a pilot study]. *Pixel-Bit. Revista De Medios Y Educación*, 66, 87–111. https://doi.org/10.12795/pixelbit.95632

Baeza González, A., Marqués Molías , L., Usart Rodríguez, M., Bazo-Hernández, L., & Jiménez Herrera, M. (2024). Creación y validación de una guía de diseño de Simulaciones Virtuales Gamificadas. *RiiTE Revista interuniversitaria de investigación en Tecnología Educativa*, (16), 123–139. https://doi.org/10.6018/riite.607361

Baldoni, S., Had, M.S., Carli, M. & Battisti, F. (2023). Definition of guidelines for virtual reality application design based on visual attention. Multimedia Tools and Applications, https://doi.org/10.1007/s11042-023-17488-y

Barroso-Osuna, J. & Cabero-Almenara, J. (2016). Evaluación de objetos de aprendizaje en realidad aumentada: estudio piloto en el grado de Medicina. *Enseñanza y Teaching, 34*(2), 149-167, https://doi.org/10.14201/et2016342149167

Benítez, M. J. & Herrera, S. (2021). Buenas prácticas para guiar la atención del espectador en el reportaje inmersivo con vídeo en 360º. *Doxa Comunicación, 32*, 263-28. https://doi.org/10.31921/doxacom.n32a13

Caballero, M.P., Mejía, C., & Romero, J. (2020). Realidad aumentada vs. realidad virtual: Una revisión conceptual. Teknos. *Revista Científica, 19*(2), 10-19. https://doi.org/10.25044/25392190.991

Cabero Almenara, J., Miravete Gracia , M., Serrano Hidalgo, M., & Núñez Domínguez , T. (2025). Evaluación de objetos de Realidad Virtual en la educación: análisis de la usabilidad y aspectos técnicos y estéticos por estudiantes. *Hachetetepé. Revista científica De Educación Y Comunicación*, (30), 1101. https://doi.org/10.25267/Hachetetepe.2025.i30.1101

Cabero, J. & Valencia, R. (2021). Reflexionando sobre la investigación en tecnología educativa. *Revista Innovaciones Educativas, 23*(Número Especial), 7-11. https://doi.org/10.22458/ie.v23iEspecial.3761

Cabero-Almenara, J. (2023). La realidad extendida en educación, en J. Cabero-Almenra, (coods.). *Buenas prácticas de e-learning XXIII*, Ancypel, 87-148.

Cabero-Almenara, J., De-La-Portilla-De-Juan, F., Barroso-Osuna, J., & Palacios-Rodríguez, A. (2023a). Technology-Enhanced Learning in Health Sciences: Improving the Motivation and Performance of Medical Students with Immersive Reality. *Applied Sciences*, *13*(14), 8420. https://doi.org/10.3390/app13148420

Cabero-Almenara, J., Llorente Cejudo, M.C., & Gutiérrez-Castillo, J.J. (2017). Los alumnos como evaluadores de objetos de aprendizaje en Realidad Aumentada. RED. Revista de Educación a Distancia, 53, 4. https://doi.org/10.6018/red/53/4

Cabero-Almenara, J., Llorente-Cejudo, C., Palacios-Rodríguez, A., & Gallego-Pérez, Ó. (2023b). Degree of acceptance of virtual reality by health sciences students. *International Journal of Environmental Research and Public Health*, *20*(8), 5571. https://doi.org/10.3390/ijerph20085571

Cabero-Almenara, J., Serrano-Hidalgo, M., Palacios-Rodríguez, A. & Llorente-Cejudo, C. (2022). El alumnado universitario como evaluador de materiales educativos en formato t-MOOC para el desarrollo de la Competencia Digital Docente según DigCompEdu. Comparación con juicio de expertos*. Edutec. Revista Electrónica de Tecnología Educativa*, (81), 1-17. https://doi.org/10.21556/edutec.2022.81.2503

Campo-Prieto, P., Cancela, J.M., Machado, I. & Rodríguez-Fuentes, G. (2021). Realidad Virtual Inmersiva en personas mayores: estudio de casos. *Retos, 39*, 101-105. https://doi.org/10.47197/retos.v0i39.78195

Castilla, D., Jaen, I., Suso-Ribera, C., García-Soriano, G., Zaragoza, I., Bretón-López, J., Mira, A., Díaz-García, A., & García-Palacios, A. (2023). Psychometric Properties of the Spanish Full and Short Forms of the System Usability Scale (SUS): Detecting the Effect of Negatively Worded Items. *International Journal of Human-Computer Interaction*. https://doi.org/10.1080/10447318.2023.2209840

Cheah, W., Mat, N. Thwe, M., & Amin, A. (2022). Mobile Technology in Medicine: Development and Validation ofan Adapted System Usability Scale (SUS)Questionnaire and Modified Technology Acceptance Model (TAM) to Evaluate User Experience and Acceptability of a Mobile Application in MRI Safety Screening. *Indian Journal o Radiology and Imaging, 33*(1), 37-45. https://doi.org/10.1055/s-0042-1758198

Chen, J., Fu, Z., Liu, H. & Wang, J. (2023). Effectiveness of Virtual Reality on Learning Engagement: A Meta-Analysis. *International Journal of Web-Based Learning and Teaching Technologies, 19*(1), 1-14. https://doi.org/10.4018/IJWLTT.334849

Chen, M. & Cukurova (2024). Unleashing imagination: an effective pedagogical approach to integrate into spherical video-based virtual reality to improve students' creative writing. *Education and Information Technologies*, 29, 6499–6523. https://doi.org/10.1007/s10639-023-12115-7

Christopoulos, A., Pellas, N., Qushem, U. & Laakso, M. (2023). Comparing the effectiveness of video and stereoscopic 360° virtual reality-supported instruction in high school biology courses. *British Journal of Educational Technology*, 54:987–1005. https://doi.org/10.1111/bjet.13306

Cigdem, H., & Oncu, S. (2024). Understanding the Role of Self-Regulated Learning in Academic Success. A Blended Learning Perspective in Vocational Education. *Innoeduca. International Journal of Technology and Educational Innovation*, *10*(1), 45–64. https://doi.org/10.24310/ijtei.101.2024.17432

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Erlbaum.

Derisma, D. (2021). The Usability Analysis Online Learning Site for Supporting Computer programming Course Using System Usability Scale (SUS) in a University. *International Journal of Interactive Mobile Technologies (iJIM),* 182–195. https://doi.org/10.3991/ijim.v14i09.13123.

Díaz, A, & Guzmán, H. (2023). Análisis de la usabilidad del Sistema Integral de Información Financiera del Estado de Veracruz Versión 2.0. *Interconectando Saberes, (15),* 29-40. https://doi.org/10.25009/is.v0i15.2787

Espinoza-Castro, K. E., Plaza-Chalco, J. L., Bravo-Guzhñay, B. F. & Mogrovejo-Mogrovejo, E. M. (2024). Realidad Virtual y educación: retos y propuestas desde actores educativos del bachillerato público en Ecuador. *Atenas, 62*, e10771, 1-13.

Fernandes, J., Teles, A. & Teixeira, S. (2021). An Augmented Reality-Based Mobile Application Facilitates the Learning about the Spinal Cord. *Education. Sciences. 10*, 376, https://doi.org/10.3390/educsci10120376.

Gamarra, J., Chávez-Espinosa, W. & Segundo, L. (2021). Evaluación de la usabilidad percibida de Google Classroom, Drive y Meet en el proceso de enseñanza y aprendizaje de la Universidad Nacional de San Antonio Abad del Cusco durante la pandemia del COVID-19. *Interfases, 14*, 118-137. https://doi.org/10.26439/interfases2021.n014.5412

Geovana, J. (2024). Estudio Comparativo de Diferentes Herramientas de Realidad Virtual para la Enseñanza. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología*, Universidad Politécnica Salesiana.

Gimeno, S. (2018). *Cinco formas de interpretar un SUS*. Torresburriel, https://torresburriel.com/weblog/cinco-formas-de-interpretar-un-sus/.

Gronier, G. & Baudet, A. (2021). Psychometric Evaluation of the F-SUS: Creation and Validation of the French Version of the System Usability Scale. *International Journal of Human–Computer Interaction, 37*(16), 1571-1582. https://doi.org/10.1080/10447318.2021.1898828

Herranz, J., Caerolds, M. & Sidorenko, P. (2019). La realidad virtual y el vídeo 360º en la comunicación empresarial e institucional. *Revista de Comunicación, 18*(2), 177-199. https://doi.org/10.26441/RC18.2-2019-A9

Kartiko, I., Kavakli, M. & Cheng, K. (2010). Learning science in a virtual reality application: The impacts of animated-virtual actors' visual complexity. *Computer y Education, 55*, 881-891. https://doi.org/10.1016/j.compedu.2010.03.019

Lai, J. W., & Cheong, K. H. (2022). Adoption of Virtual and Augmented Reality for Mathematics Education: A Scoping Review. *IEEE Access, 10.* https://doi.org/10.1109/ACCESS.2022.3145991

Lee, D. & Shea, M. (2020). Exploring the use of virtual reality by pre-service elementary teachers for teaching science in the elementary classroom. *Journal of Research on Technology in Education, 52*:2, 163-177. https://doi.org/10.1080/15391523.2020.1726234

Lewis, J. (2018). The System Usability Scale: Past, Present, and Future. *International Journal of Human–Computer Interaction, 34*:7, 577-590. https://doi.org/10.1080/10447318.2018.1455307

Lirola Sabater, F. R., & Garcias, A. P. (2020). La usabilidad percibida por los docentes de la Formación Profesional a distancia en las Islas Baleares. *Pixel-Bit. Revista De Medios Y Educación, 59*, 183–200. https://doi.org/10.12795/pixelbit.76299

Llorente-Cejudo, C. (2024). Relationship and variation of dimensions in gamified experiences associated with the predictive model using GAMEX. *NAER: Journal of New Approaches in Educational Research, 13*(1). https://doi.org/10.1007/s44322-023-00002-5

López-Belmonte, J., Dúo-Terrón, P., Moreno-Guerrero, A.-J., y Marín-Marín, J.-A. (2024). Efectos de la realidad aumentada y virtual en estudiantes con TEA. *Pixel-Bit. Revista De Medios Y Educación*. https://doi.org/10.12795/pixelbit.103789.

Makransky, G., Terkildsen, Th. & Mayer, R. (2019). Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learning and Instruction* 60, 225–236, https://doi.org/10.1016/j.learninstruc.2017.12.007

Marín, V., Sampedro, B. & Vega, E. (2022). Promoviendo el aprendizaje a través del uso de videos en 360º. *Innoeduca. International Journal of Technology and Educational Innovation, 8(*2), 138-151. https://doi.org/10.24310/innoeduca.2022.v8i2.15120

Marougkas, A., Troussas, C., Krouska, A. & Sgouropoulou, C. (2023). How personalized and effective is immersive virtual reality in education? A systematic literature review for the last decade. *Multimedia Tools and Applications*. https://doi.org/10.1007/s11042-023-15986-7

Marzuki, M., Yaacob, N. & Yaacob, N. (2018). Translation, Cross-Cultural Adaptation, and Validation of the Malay Version of the System Usability Scale Questionnaire for the Assessment of Mobile Apps. *JMIR Human Factors, 5*(2), e10308. https://doi.org/10.2196/10308

Mata, F.J. & Hernández-Ruíz, I. (2019). Evaluación de usabilidad para un sitio de comercio electrónico: Desarrollo de una metodología y su aplicación al sitio crgourmetcoffee.com. En Y. Morales-López (Ed.). *Memorias del I Congreso Internacional* *de Ciencias Exactas y Naturales de la Universidad Nacional*, e62, 1-10). Universidad Nacional. https://doi.org/10.15359/cicen.1.9

Mayer, R., Makransky, G. & Parong, J. (2023). The Promise and Pitfalls of Learning in Immersive Virtual Reality. *International Journal of Human–Computer Interaction, 39*:11, 2229-2238, https://doi.org/10.1080/10447318.2022.2108563

Mayer, R.E. (2002). Multimedia learning. *Psychology of Learning and Motivation, 41*, 85–139. https://doi.org/10.1016/S0079-7421(02)80005-6

Mayer, R.E. (2021). *Multimedia learning*. Cambridge University Press.

Mogrovejo, J., Montalván, C., Barragan, G. y Cabrera, M. (2024). Fenomenología de la Realidad Virtual: Explorando la Experiencia Humana en Entornos Digitales Inmersivos. Journal of Economic and Social Science Research, 4(1), 149-159. https://doi.org/10.55813/gaea/jessr/v4/n1/88

Montiel, A., Morales, C., Ixmatlahua, S., Hernández, N., Marín, H.(2020). Ameyali: Evaluación de la usabilidad de la plataforma Integral para el control y monitoreo del servicio de agua potable en comunidades rurales bajo la escala de SUS. *ISTI*, 36, 116-131. https://doi.org/10.17013/risti.36.116–131

Mota, A. & Turrini, R. (2022). Evaluación de la usabilidad de una aplicación móvil para pacientes con catéter central de inserción periférica. *Rev. Latino-Am. Enfermagem, 30,* e3666, https://doi.org/10.1590/1518-8345.5817.3666

Mulders, M., Buchner, J. & Kerres, M. (2020). A Framework for the Use of Immersive Virtual Reality in Learning Environments. *International Journal of Emerging Technologies in Learning (iJET), 15*(24), 208–224. https://doi.org/10.3991/ijet.v15i24.16615

Ong, A.K.S., Prasetyo, Y.T., Robas, K.P.E., Persada, S.F., Nadlifatin, R., Matillano, J.S.A., Macababbad, D.C.B., Pabustan, J.R., & Taningco, K.A.C. (2023). Determination of Factors Influencing the Behavioral Intention to Play "Mobile Legends: Bang-Bang" during the COVID-19 Pandemic: Integrating UTAUT2 and System Usability Scale for a Sustainable E-Sport Business. *Sustainability, 15*, 3170 https://doi.org10.3390/su15043170

Panerai, S., Catania, V., Rundo, F., & Ferri, R. (2018). Remote Home-Based Virtual Training of Functional Living Skills for Adolescents and Young Adults with Intellectual Disability: Feasibility and Preliminary Results. *Frontiers in Psychology, 9*, 1-6. https://doi.org/10.3389/fpsyg.2018.01730

Parong, J., Mayer, R.E. (2021). Learning about history in immersive virtual reality: does immersion facilitate learning? *Education Tech Research Dev., 69*, 1433–1451. https://doi.org/10.1007/s11423-021-09999-y

Patience, A., Rahelya, P. & Tho, C. (2023). Usability Analysis of Text Generation by ChatGPT OpenAI Using System Usability Scale Method. *Procedia Computer Science, 227*, 381-388, https://doi.org/10.1016/j.procs.2023.10.537

Pedrosa, M. (2022). *¿La usabilidad puede medirse? Escala SUS y test de usuario. Flat101*, https://www.flat101.es/blog/diseno-ux/la-usabilidad-puede-medirse-escala-sus-y-test-de-usuario/.

Pincay, J., Herrera, J. & Delgado, W. (2021). La usabilidad y la escala diferencial de emociones en aplicaciones para Android. Un estudio de caso. Mikarimin. *Revista Científica Multidisciplinaria*, VII(1), 79-86.

Purwandani,I., Oktavia, N. & Nurwahyuni, S. (2023). Perceived Usability Evaluation of TikTok Shop Platform Using the System Usability Scale. *Sinkron:Jurnal dan Penelitian Teknik Informatika, 8*(3), 1389-1399. https://doi.org/10.33395/sinkron.v8i3.12473

Radianti, J., Majchrzak, T., Fromm, J. & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers y Education 147*, 103778, 1-19. https://doi.org/10.1016/j.compedu.2019.103778

Rauschnabel, Ph., Felix, R., Hinsch, Ch., Shahab, H., & Alt, F. (2022). What is XR? Towards a Framework for Augmented and Virtual Reality. *Computers in Human Behavior, 133*, 107289, 1-18. https://doi.org/10.1016/j.chb.2022.107289.

Reeves, Th., Lin, L. (2020). The research we have is not the research we need. *Education Tech Research Dev*, 68:1991–2001. https://doi.org/10.1007/s11423-020-09811-3

Rico, F. M. E., & Fernández, L. P. (2024). Simulación de realidad virtual en la formación de los estudiantes de Enfermería: una revisión sistemática. *Educación Médica, 25*(1), 100866. https://doi.org/10.1016/j.edumed.2023.100866

Rodríguez Gil, M. E., Sandu, B. M., & Santana-Perera, B. (2024). Self-efficacy beliefs in Spanish pre-service teachers. A microteaching case study using immersive virtual reality. [Percepciones de autoeficacia en docentes en formación en España: Un estudio de caso de microenseñanza utilizando realidad virtual inmersiva]. *Pixel-Bit. Revista De Medios Y Educación*. https://doi.org/10.12795/pixelbit.107712

Saab, M. M., Landers, M., Murphy, D.,O'Mahony, B., Cooke, E., O'Driscoll, M., & Hegarty, J. (2022).Nursing students' views of using virtual reality in healthcare: A qualitative study. *Journal Clinical Nursing, 31*, 1228–1242. https://doi.org/10.1111/jocn.15978

Schrepp, M., Kollmorgen, J. & Thomaschewski, J. (2023). A Comparison of SUS, UMUX-LITE, and UEQ-S. *Journal of User Experience, 18*(2), 86–104.

Setiawan, D. & Langgeng, S. (2020). Evaluasi Usability Google Classroom Menggunakan System Usability Scale. Walisongo *Journal of Information Technology, 2*(1), 71-78. https://doi.org/10.21580/wjit.2020.2.1.5792

Silva, C. & Turrini, R. (2019). Development of an educational mobile application for patients submitted to orthognathic surgery. *Revista. Latino-Americana. Enfermagem*, 27:e3143. https://doi.org/10.1590/1518-8345.2904.3143

Swidrak, J. (2023). Realidad virtual: ayer, hoy y mañana, en Ruiz, M. y Johnston, T. (eds.). *Realidad virtual y entornos inmersivos en educación superior*, Octaedro, 19-23.

Tecnic, A. (2018). Guidance in a 360-degree video with the help of special effects. Attracting attention to a specific object or segment in a 360-degree video using graphical. Tesis de licenciatura Universidad de Linnaeus. http://lnu.diva-portal.org/smash/get/diva2:1247362/FULLTEXT01.pdf

Usman, M. & Gustalika, M. (2022). Pengujian Validitas dan Reliabilitas System Usability Scale (SUS) Untuk Perangkat. Smartphone. *Jurnal Ecotipe, 9*(1), 19-24, https://doi.org/10.33019/jurnalecotipe.v9i1.2805

Valero-Franco, C., & Berns, A. (2024). Desarrollo de apps de realidad virtual y aumentada para enseñanza de idiomas: Un estudio de caso. *RIED-Revista Iberoamericana de Educación a Distancia, 27*(1), 163-185. https://doi.org/10.5944/ried.27.1.37668

Vlachogianni, P. & Tselios, N. (2022). Perceived usability evaluation of educational technology using the System Usability Scale (SUS): A systematic review. *Journal of Research on Technology in Education*, 54:3, 392-409. https://doi.org/10.1080/15391523.2020.1867938

Wang, Q. & Li, Y. (2024). How virtual reality, augmented reality and mixed reality facilitate teacher education: A systematic review. Journal of Computer Assisted Learning. https://doi.org/10.1111/jcal.12949

Wang, X., Hampton, J., Ritzhaupt, A. D., & Dawson, K. (2022). Trends and Priorities of Educational Technology Research: A Delphi Study. *Contemporary Educational Technology*, *14*(4), ep383. https://doi.org/10.30935/cedtech/12317

Welda, W., Putra, D. M. D. U., & Dirgayusari, A. M. (2020). Usability Testing Website Dengan Menggunakan Metode System Usability Scale (Sus)s. *International Journal of Natural Science and Engineering, 4*(3), 152–161. https://doi.org/10.23887/ijnse.v4i2.28864

Zilles, E. (2020). Audiovisuales ampliados en la realidad virtual: inmersión, multisensorial y escenarios 360°. *Sphera Publica, 1*(20), 78–94. https://sphera.ucam.edu/index.php/sphera-01/article/view/383

To cite this work

Cabero-Almenara, J., Llorente-Cejudo, C., Basilotta-Gómez-Pablos, V., & Palacios-Rodríguez, A. (2025). Los estudiantes como evaluadores de objetos de aprendizaje en realidad virtual: usabilidad y valoración técnica y estética. *Edutec, Revista Electrónica de Tecnología Educativa*, (93), 209-232. https://doi.org/10.21556/edutec.2025.93.4069