Abstract: Extended reality, which encompasses virtual, augmented, and mixed reality, emerges as an important didactic resource, offering great potential to bring heritage closer to the educational environment. Heritage education is a challenge for today’s society, contributing to cultural and social development. Therefore, the aim of this systematic review is to analyze documents related to heritage in education through extended reality. The search was conducted using Scopus and Web of Sciences databases, allowing for an international search. We excluded any document that was not a scientific article published in a journal. A total of 52 documents were analyzed, all of which were open-access articles. Preliminary results indicate that virtual reality and augmented reality are utilized in education to work with architectural, historical, archaeological, and musical heritage. Extended reality has been applied in all the stages of the education system, and in formal and non-formal settings, thereby demonstrating its versatility. These experiences increase motivation and academic performance in comparison to less innovative methodologies, which is in line with other studies on this topic. In conclusion, extended reality has the potential to make a significant impact on education, particularly when combined with heritage. The creation of multidisciplinary groups will enhance research in the near future.

Keywords: cultural heritage; extended reality; education; technological innovation

1. Introduction

Technology is a fundamental part of 21st century society. Due to the rapid development of technology in the modern era, education systems are confronted with the challenge of updating their methods and resources to achieve inclusive and high-quality education [1]. Thus, there is a need to adapt teaching and learning processes to the possibilities offered by technology, with the goal of fostering educational innovation [2]. Consequently, extended reality (XR) appears as a novel didactic resource to support teaching–learning processes [3]. Extended reality (XR), a term that encompasses virtual reality (VR), augmented reality (AR), and mixed reality (MR), allows users to explore new environments where the physical and the digital converge. On the one hand, VR immerses users in a fully virtual, computer-generated environment that replaces the real world, although it can also simulate it. This is achieved mainly through the use of VR headsets, also known as head-mounted displays (HMDs) [4]. This type of technology also enables the manipulation of virtual objects [5]. On the other hand, AR combines reality with virtual components, transforming everyday scenarios by means of digital elements, using devices such as smartphones or tablets [6], although HMDs can also be used. Therefore, the key difference between VR and AR lies in the environment accessed: AR modifies our reality, while VR replaces it. Finally, mixed reality (MR) combines aspects of VR and AR, offering users the option of immersing themselves either in a fully virtual world or in the real world while interacting with digital elements [7].
These technologies have been in development for some time [8], even though limitations related to cost and accessibility had prevented them from being adopted by the general public [9]. Today, XR is spreading to a wider audience and is gradually being introduced in the field of education, as evidenced by theoretical and empirical studies on this topic [4–7]. XR has been applied at different levels from early childhood education [10] to higher education [11]. It has also been implemented within different subjects such as experiential learning [12], medical education, art, design [13], and the social sciences [14]. However, the effective incorporation of technology in formal education remains a challenge for the education system [15]. One of the most significant obstacles in exploiting its potential within the classroom lies in the level of training of both teachers and students, despite the assumption that students are digital natives [16,17].

In the social sciences, XR is being applied primarily in the context of cultural heritage, including both tangible and intangible aspects. Heritage represents an invaluable legacy for societies, as it serves as a vehicle for transmitting the customs and ways of life of different generations. It also allows people to know where they come from and how they organize themselves as a society, as well as to enjoy the cultural wealth of their ancestors. Heritage education has traditionally been a neglected topic in the education system. Since the 1990s, there has been a notable expansion in heritage-related educational programs globally [18,19]. Nevertheless, it was not until the advent of the 21st century that formal education began to fully exploit their didactic potentiality [20]. This is why some authors consider it necessary for heritage education to begin to be taught from the earliest levels of schooling, providing students with the opportunity to engage with heritage from a young age. The aim being to educate people to be better prepared to value, respect, and understand it [21]. This implies the commitment to use innovative methodologies for the transmission and teaching of cultural heritage, which, in turn, leads to the need for research on heritage education [22].

1.1. Related Studies

One of the innovative methodologies employed in this field is the use of technological resources, which facilitate the perception, interaction, and learning about heritage in different ways. Among these tools, as has been mentioned, immersive technologies, such as XR, stand out in the service of cultural heritage, offering a multitude of possibilities to favor and ease its dissemination. Numerous studies have analyzed the benefits of using these tools in both formal and non-formal educational environments for the transmission of cultural heritage [23,24]. Thus, Cecotti et al. [25] posits that the utilization of this technology by students may enhance their motivation and commitment to learning. Concurrently, the deployment of this technology also facilitates the retention of information by students [26,27]. These benefits are corroborated by Di Natale et al. [28] and Pellas et al. [29], who demonstrate that VR is directly linked to improved academic performance and motivation towards learning experiences, provided that the structure of the experience is coherent, and the didactic objectives are well defined [30]. Moreover, the implementation of these technologies in educational settings has been shown to foster collaborative learning and facilitate the personalization of education. This allows for the adaptation of content and resources to the individual needs of each student [31].

Focusing on formal education, which occurs within official educational institutions, the potential of these technologies in the classroom seems to be manifold. Studies such as that of Rizvic, Boskovic, and Okanovic [32] put emphasis on the use of interactive digital storytelling (IDS) and “serious games” with the aim of presenting historical information in a playful and motivating way. In line with this, other authors have designed, together with the Taiwan Symphony Orchestra, a technological experience through AR aimed at music education at the early childhood education stage [33].

Among the possibilities offered by XR, immersive 360° tours can be mentioned. Through the use of VR, they seek to disseminate both local and global heritage [34–36]. One use case of a 360° immersive experience applied in higher education can be found
in [11]. All these demonstrate the remarkable versatility of XR to adapt to different educational levels and stages [8]. For instance, Corrales et al. [37] describe a VR experience with tablets conducted with primary education students, while Cheng and Tsai [38], Fabola and Miller [39], and Taranilla et al. [40] provide examples of XR experiences in secondary education. Similarly, in the field of higher education, we find experiences such as those proposed by Yildirim et al. [41], Huaman et al. [42], and Hutson and Olsen [43].

Regarding non-formal education, which takes place in non-scholarly settings, one of the most common uses of XR is the creation of interactive applications designed to facilitate and improve experiences in museums and interpretation centers [44]. Currently, there is a tendency in research towards the development of apps with heritage content aimed at non-formal education, thereby expanding their potential [24]. For instance, Mikalef and Chorianopoulos [45] proposed a mixed reality game in which users visit an art museum. Lin et al. [46] employed XR to learn about local cultural heritage in Taiwan. Further examples of the utilization of XR in non-formal educational settings can be found in [47–49]. In addition to bringing cultural heritage closer, XR experiences can be also used to facilitate research by archaeologists and historians, as well as to preserve and conserve cultural heritage [50].

1.2. Relevant Reviews

Some similar studies that have reviewed the literature on the use of XR in education have concluded that these technologies enhance the teaching–learning process, improving academic results and encouraging motivation for learning [1]. Currently, these technologies are being increasingly implemented in the field of education, with STEAM education and cultural heritage identified as potential applications [4]. Nonetheless, other research indicates that a significant percentage of teachers are not sure about the utility of this technology and opt for traditional training and learning. In part, they are reluctant to integrate XR into their educational practice due to the difficulty of designing and using XR experiences [51].

A further review of the literature on the use of XR for the dissemination of cultural heritage reveals the necessity of establishing guidelines on how to proceed with its use to optimize its potential [44]. Other authors add that these technologies play a significant role in heritage education as an attractive and useful tool, provided that teachers are willing to implement more innovative methodologies [51].

Furthermore, the multiple advantages of utilizing these technologies for heritage education has led to an increase in their use in the tourism sector, promoting interest, knowledge, and user participation [52], thereby highlighting the adaptability of these tools to different contexts.

In light of the aforementioned premises and the current increase in studies on this subject, it is mandatory to conduct research to ascertain the efficacy of XR as a tool for education, with a particular focus on the transmission of heritage. Furthermore, this study should also investigate the actual impact of these technologies on students’ performance and motivation. It is assumed that the dissemination and preservation of cultural heritage are necessary for the promotion of sustainable development, the strengthening of society, and the creation of a more prosperous, balanced, and harmonious future.

The general objective of this work is to analyze and study the use of cultural heritage as a didactic resource by means of extended reality. To address this objective, it is first necessary to pose a series of research questions, which were formulated as listed below:

1. Where and when has there been a greater concern for the use of XR for heritage education?
2. What type of XR is most commonly used for the dissemination of cultural heritage and what type of tangible or intangible heritage is being worked on?
3. Have these experiences been put into practice?
4. Are these virtual experiences intended for formal or non-formal education?
5. Does the use of XR to transmit heritage influence the participants’ learning/performance on the subject?
6. Does XR influence the motivation of participants with respect to heritage learning?
7. Are there any differences between “traditional” heritage teaching and teaching through extended reality?

To this end, and as a foundation for future research on this topic, it is necessary to conduct an updated and systematic bibliographic review as presented in this paper, that is structured as follows: Section 2 presents the Materials and Methods, including the inclusion–exclusion criteria and variables. Section 3 offers a comprehensive analysis of the results obtained. Finally, Section 4 provides critical discussion and conclusions based on the analysis presented in Section 3.

2. Materials and Methods

This research employs the inductive method to conduct a systematic analysis of the documents. To do so, the works of Sánchez-Meca [53], Gómez-Jiménez [54], and Rodríguez-Caldera [1] have been used as guiding examples. Likewise, this systematic review was carried out in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [55].

The procedure employed for the present review is outlined in Figure 1.

![Figure 1. Outline of the procedure followed in conducting the systematic review.](image)

2.1. Search Strategies and Selection Criteria

A preliminary search was conducted on 7 February 2024, using the following keywords in Scopus and Web of Science: “augmented reality”, “virtual reality”, “heritage”, and “education”. The Boolean operator “AND” was employed, resulting in the following search equation:

“augmented reality” AND “virtual reality” AND “heritage” AND “education”

The search was conducted on both databases through the “Abstract” option. The initial search yielded 145 documents, comprising 83 from Scopus and 62 from Web of Science. Following the application of the exclusion and inclusion criteria and the reading of the abstracts, the number of documents was reduced to 27.

Since this first search did not return the expected number of articles, we conducted a second search on 15 April 2024, in the same databases, with the addition of supplementary keywords. The search terms included “virtual reality”, “augmented reality”, “extended reality”, “mixed reality”, “heritage”, “archeological site”, “historic buildings”, and “education”. Consequently, the Boolean operators AND and OR were incorporated into the search strategy, which was as follows:

(“virtual reality” OR “augmented reality” OR “extended reality” OR “mixed reality”) AND (heritage OR “archeological site” OR “historic buildings”) AND education

Following the introduction of the search strategy, the initial number of documents identified was 463. However, upon selecting the “articles only” option, this number was reduced to 187. Once all the articles had been obtained, the inclusion and exclusion criteria
were applied, and the articles were discarded based on their titles and abstracts. This process resulted in a total of 48 documents. Similarly, based on other similar works [56], it was deemed beneficial to incorporate four additional articles from the initial search that had not been identified in the subsequent search, resulting in a final total of 52 articles.

The following exclusion criteria were used to select articles for this review:

- Duplicate articles.
- Systematic or bibliographic reviews and meta-analyses.
- Books and book chapters.
- Conferences and congresses.
- Theses and dissertations.
- Papers not related to education.
- Papers that do not deal with heritage transmission.

In addition to the above, the following inclusion criteria were employed:

- Articles published in scholarly journals.
- Published in any language.
- Open access.

Figure 2 shows a flow chart of the document selection process.

Figure 2. PRISMA 2020 flow diagram for updated systematic reviews which included searches of databases and registers only. After Page et al. [56].
2.2. Variables

The variables analyzed and, for some of them, the categorization system used are specified below.

- Author(s).
- Year of publication.
- Language. The following languages are established: Spanish, English, Portuguese and Korean.
- Country.
- Type of technology: virtual reality (VR), augmented reality (AR) and mixed reality (MR) (consider when the document mentions that the two previous ones have been used).
- Technological tools used.
- Type of heritage.
- Implemented: Yes and No.
- Type of teaching. A distinction is made between: Formal (students), Non-formal (tourists and other participants), and Both (when the article specifies that the experience has been carried out with both students and tourists or other users).
- Learning: Increases, Decreases, Remains unchanged, and Not reported.
- Motivation: Increases, Decreases, Remains unchanged, and Not reported.
- Differences between traditional teaching and teaching through extended reality: Differences, No differences, and Not Reported.

It should be noted that not all the articles selected for review explicitly describe these variables. Therefore, they have been adapted according to our criteria.

3. Results

Once the search had been completed and the documents located, a statistical analysis of the documents was conducted according to the variables set out in Figure 2. The studies selected after this process are listed in Table 1 and referenced in Appendix A. This section presents the results obtained, which are as follows.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Country</th>
<th>Language</th>
<th>Type of Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bozelli et al. [A2]</td>
<td>2019</td>
<td>English</td>
<td>Italy</td>
<td>MR</td>
</tr>
<tr>
<td>Cai et al. [A3]</td>
<td>2018</td>
<td>English</td>
<td>Singapore</td>
<td>VR</td>
</tr>
<tr>
<td>Cerdá et al. [A5]</td>
<td>2022</td>
<td>Spanish</td>
<td>Spain</td>
<td>MR</td>
</tr>
<tr>
<td>Chen et al. [A6]</td>
<td>2024</td>
<td>English</td>
<td>China</td>
<td>AR</td>
</tr>
<tr>
<td>Kai-Chun et al. [A7]</td>
<td>2023</td>
<td>English</td>
<td>Taiwan</td>
<td>AR</td>
</tr>
<tr>
<td>Chrysanthakopoulou et al. [A8]</td>
<td>2021</td>
<td>English</td>
<td>Greece</td>
<td>VR</td>
</tr>
<tr>
<td>Corrales et al. [A9]</td>
<td>2024</td>
<td>English</td>
<td>Spain</td>
<td>VR</td>
</tr>
<tr>
<td>De Fino et al. [A10]</td>
<td>2022</td>
<td>English</td>
<td>Italy</td>
<td>VR</td>
</tr>
<tr>
<td>De Paolis et al. [A11]</td>
<td>2018</td>
<td>English</td>
<td>Italy</td>
<td>AR</td>
</tr>
<tr>
<td>Frontoni et al. [A12]</td>
<td>2019</td>
<td>English</td>
<td>Italy</td>
<td>AR</td>
</tr>
<tr>
<td>Ho et al. [A13]</td>
<td>2023</td>
<td>English</td>
<td>Taiwan</td>
<td>AR</td>
</tr>
<tr>
<td>Hutson, and Fulcher [A14]</td>
<td>2023</td>
<td>English</td>
<td>United States</td>
<td>VR</td>
</tr>
<tr>
<td>Jung et al. [A16]</td>
<td>2019</td>
<td>Korean</td>
<td>Republic of Korea</td>
<td>AR</td>
</tr>
<tr>
<td>Kim and Yoo [A17]</td>
<td>2021</td>
<td>Korean</td>
<td>Republic of Korea</td>
<td>AR</td>
</tr>
</tbody>
</table>
Table 1. Cont.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Country</th>
<th>Language</th>
<th>Type of Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim et al. [A18]</td>
<td>2006</td>
<td>English</td>
<td>United States</td>
<td>VR</td>
</tr>
<tr>
<td>Kleftodimos et al. [A19]</td>
<td>2023</td>
<td>English</td>
<td>Greece</td>
<td>MR</td>
</tr>
<tr>
<td>Kleftodimos et al. [A20]</td>
<td>2023</td>
<td>English</td>
<td>Greece</td>
<td>AR</td>
</tr>
<tr>
<td>Lacet et al. [A21]</td>
<td>2018</td>
<td>English</td>
<td>Brazil</td>
<td>MR</td>
</tr>
<tr>
<td>Leavy [A22]</td>
<td>2006</td>
<td>English</td>
<td>Australia</td>
<td>VR</td>
</tr>
<tr>
<td>Lee et al. [A23]</td>
<td>2021</td>
<td>English</td>
<td>Republic of Korea</td>
<td>AR</td>
</tr>
<tr>
<td>Li et al. [A24]</td>
<td>2022</td>
<td>English</td>
<td>China</td>
<td>VR</td>
</tr>
<tr>
<td>Li et al. [A25]</td>
<td>2022</td>
<td>English</td>
<td>China</td>
<td>AR</td>
</tr>
<tr>
<td>Luigini et al. [A26]</td>
<td>2020</td>
<td>English</td>
<td>Italy</td>
<td>VR</td>
</tr>
<tr>
<td>Maçães et al. [A27]</td>
<td>2011</td>
<td>English</td>
<td>Portugal</td>
<td>AR</td>
</tr>
<tr>
<td>Manzollino et al. [A28]</td>
<td>2023</td>
<td>English</td>
<td>Italy</td>
<td>VR</td>
</tr>
<tr>
<td>Martinez-Graña et al. [A29]</td>
<td>2013</td>
<td>English</td>
<td>Spain</td>
<td>AR</td>
</tr>
<tr>
<td>Martinez-Graña et al. [A30]</td>
<td>2014</td>
<td>English</td>
<td>Spain</td>
<td>AR</td>
</tr>
<tr>
<td>Mavrogeorgi et al. [A31]</td>
<td>2009</td>
<td>English</td>
<td>Greece</td>
<td>MR</td>
</tr>
<tr>
<td>Mendoza et al. [A32]</td>
<td>2015</td>
<td>English</td>
<td>Colombia</td>
<td>AR</td>
</tr>
<tr>
<td>Mendoza et al. [A33]</td>
<td>2019</td>
<td>English</td>
<td>Colombia</td>
<td>AR</td>
</tr>
<tr>
<td>Mendoza et al. [A34]</td>
<td>2015</td>
<td>English</td>
<td>Colombia</td>
<td>AR</td>
</tr>
<tr>
<td>Mendoza-Garrido et al. [A35]</td>
<td>2021</td>
<td>English</td>
<td>Colombia</td>
<td>AR</td>
</tr>
<tr>
<td>Minh et al. [A36]</td>
<td>2021</td>
<td>English</td>
<td>Vietnam</td>
<td>MR</td>
</tr>
<tr>
<td>Paolanti et al. [A37]</td>
<td>2023</td>
<td>English</td>
<td>Italy</td>
<td>VR</td>
</tr>
<tr>
<td>Park [A38]</td>
<td>2005</td>
<td>Korean</td>
<td>Republic of Korea</td>
<td>VR</td>
</tr>
<tr>
<td>Paulauskas et al. [A39]</td>
<td>2023</td>
<td>English</td>
<td>Lithuania</td>
<td>VR</td>
</tr>
<tr>
<td>Perra et al. [A40]</td>
<td>2019</td>
<td>English</td>
<td>Italy</td>
<td>AR</td>
</tr>
<tr>
<td>Pervolarakis et al. [A41]</td>
<td>2023</td>
<td>English</td>
<td>Greece</td>
<td>MR</td>
</tr>
<tr>
<td>Plecher et al. [A42]</td>
<td>2022</td>
<td>English</td>
<td>Germany</td>
<td>VR</td>
</tr>
<tr>
<td>Puggioni et al. [A43]</td>
<td>2021</td>
<td>English</td>
<td>Italy</td>
<td>MR</td>
</tr>
<tr>
<td>Rahman et al. [A44]</td>
<td>2013</td>
<td>English</td>
<td>Malaysia</td>
<td>AR</td>
</tr>
<tr>
<td>Resende and Pinto [A45]</td>
<td>2021</td>
<td>Portuguese</td>
<td>Brazil</td>
<td>VR</td>
</tr>
<tr>
<td>San Martin and Andrés [A46]</td>
<td>2019</td>
<td>English</td>
<td>Argentina</td>
<td>AR</td>
</tr>
<tr>
<td>Seo [A47]</td>
<td>2019</td>
<td>Korean</td>
<td>Republic of Korea</td>
<td>AR</td>
</tr>
<tr>
<td>Soto-Martin et al. [A48]</td>
<td>2015</td>
<td>English</td>
<td>Spain</td>
<td>VR</td>
</tr>
<tr>
<td>Su et al. [A49]</td>
<td>2023</td>
<td>English</td>
<td>China</td>
<td>MR</td>
</tr>
<tr>
<td>Torres et al. [A50]</td>
<td>2022</td>
<td>English</td>
<td>Spain</td>
<td>VR</td>
</tr>
<tr>
<td>Zhou et al. [A51]</td>
<td>2017</td>
<td>English</td>
<td>Japan</td>
<td>VR</td>
</tr>
<tr>
<td>Zhou et al. [A52]</td>
<td>2016</td>
<td>English</td>
<td>Japan</td>
<td>MR</td>
</tr>
</tbody>
</table>

3.1. Descriptive Analysis of Documents by Year of Publication

The first step in the analysis was to determine the year in which the articles used in this study were published. Given that XR is an emerging technology, it was of interest to ascertain when researchers first began to investigate its potential for heritage education and how this field of research is evolving. No specific range of years was selected for this study.
As illustrated in Figure 3, the year 2005 marks the inaugural year of published articles on this topic, with a subsequent peak in 2019, comprising 15.38% of the total documents. This figure then declines in the following year, 2020. Similarly, from the year 2021 onwards, the number of publications increased once more, with 2023 being the year with the highest number of papers published on this topic, representing 19.23% of the total publications.

![Figure 3. Number of articles on the use of extended reality in heritage transmission according to their year of publication.](image)

Conversely, the years 2005, 2008, 2009, 2011, 2016, and 2017 exhibited the lowest number of publications, with 1.92% each.

It is important to note that the year 2024 cannot be considered in the same manner as the other years, as only five months have elapsed since it began and only two articles related to this topic have been published (3.85% of the documents analyzed).

3.2. Descriptive Analysis of Documents by Language and Country of Publication

Upon analysis of the documents according to the country of publication, it is revealed that Italy is the country with the highest number of articles published on the topic of this literature review, accounting for 17.31% of the total number of documents. Republic of Korea and Spain follow with 11.54% each (Figure 4).

![Figure 4. Number of articles on the use of extended reality in the transmission of heritage according to the country of publication.](image)
It is noteworthy that, despite the aforementioned classification, the majority of the documents analyzed were written in English (86.54%), as this is the international language for sharing research. Furthermore, 9.62% of the total were published in Korean, which is the second most prevalent language among the articles in the study. The languages with the lowest number of publications on this topic were Portuguese and Spanish, both with 1.92% of the documents, as illustrated in Figure 5.

3.3. Descriptive Analysis of Documents According to the Type of Technology Used

As illustrated in Figure 6, the most prevalent technology utilized is augmented reality (AR), with 42.31% of the analyzed articles incorporating AR into their design or implementation. This is comparable to the prevalence of virtual reality (VR), which was employed in 36.54% of the articles.

Finally, mixed reality (MR), which combines AR and VR, is the least utilized technology, with a usage rate of 21.15%.

3.4. Descriptive Analysis of Documents According to the Software or Devices Used

Regarding the tools utilized for experience design, it is noteworthy that 14 of the analyzed documents, representing 26.92% of the total, lack any information pertaining to this aspect or have employed previously developed experiences. In contrast, the remaining 38 documents indicate that Unity3D was the most utilized software, selected in 44.74% of cases. This software was employed in conjunction with Vuforia on four occasions, as well as...
Blender, Substance Painter, and 3Ds Max in other cases. Unity3D was primarily utilized for virtual reality (VR) applications (47.06%), followed by augmented reality (AR) applications (29.41%) and real-time modeling (RM) applications (23.53%), as illustrated in the graph in Figure 7. Google Earth, which was used in 15.79% of the analyzed documents, was the next most prevalent software, all for AR applications. The Autodesk Maya software is utilized in 7.89% of the cases, with an equal distribution among the three technologies. The AR Core software is used in 5.26% of the cases. Only one case of the use of Unreal Engine (2.63%) was found, this time focused on VR. The remainder of the documents analyzed employ a variety of solutions and commercial proposals, as shown in Figure 8.

![Figure 7](image)

**Figure 7.** Use of Unity 3D software according to the type of extended reality.

![Figure 8](image)

**Figure 8.** Software used in the development of experiences reported in the articles analyzed.

With regard to the devices utilized, it can be stated that HMDs are the most prevalent for VR experiences (although, in one article, AR glasses are referenced). Among these, the HTC Vive stands out, being mentioned in four documents; the Oculus Rift glasses are utilized in three experiences, and in another case, Oculus Quest. Google Cardboard is even mentioned on one occasion. In three additional documents, the devices are only mentioned in a general sense as “head-mounted displays”, “VR glasses”, and “VR and AR headsets”. Additionally, the use of mobile devices (phones and tablets) was also mentioned. Another document also mentions the use of a Leap Motion controller.

3.5. Descriptive Analysis of Documents According to the Relationship between Type of Technology and Type of Heritage

Table 2 reveals that the most prevalent type of heritage is cultural, accounting for 32.87% of the documents. The most common method of transmission is AR, representing 15.59% of the documents. The second most prevalent type of heritage is historical, com-
prising 18.94% of the documents. The most prevalent technology for the transmission of historical heritage is VR, representing 11.39% of the documents.

Table 2. Relationship between type of technology and type of heritage.

<table>
<thead>
<tr>
<th>Heritage</th>
<th>MR</th>
<th>AR</th>
<th>VR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anthropological</td>
<td>0.00%</td>
<td>0.00%</td>
<td>3.41%</td>
<td>3.41%</td>
</tr>
<tr>
<td>Archaeological</td>
<td>5.66%</td>
<td>3.77%</td>
<td>2.76%</td>
<td>12.19%</td>
</tr>
<tr>
<td>Architectural</td>
<td>2.03%</td>
<td>0.51%</td>
<td>2.98%</td>
<td>5.52%</td>
</tr>
<tr>
<td>Artistic</td>
<td>0.00%</td>
<td>8.20%</td>
<td>3.19%</td>
<td>11.39%</td>
</tr>
<tr>
<td>Archaeological and architec</td>
<td>0.00%</td>
<td>0.00%</td>
<td>2.69%</td>
<td>2.69%</td>
</tr>
<tr>
<td>Architectural and Artistic</td>
<td>2.03%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>2.03%</td>
</tr>
<tr>
<td>Cultural</td>
<td>7.62%</td>
<td>14.59%</td>
<td>10.66%</td>
<td>32.87%</td>
</tr>
<tr>
<td>Geological</td>
<td>0.00%</td>
<td>0.58%</td>
<td>0.00%</td>
<td>0.58%</td>
</tr>
<tr>
<td>Historical</td>
<td>0.00%</td>
<td>7.55%</td>
<td>11.39%</td>
<td>18.94%</td>
</tr>
<tr>
<td>Historical and cultural</td>
<td>3.34%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>3.34%</td>
</tr>
<tr>
<td>Musical</td>
<td>0.00%</td>
<td>3.63%</td>
<td>0.00%</td>
<td>3.63%</td>
</tr>
<tr>
<td>Natural and geological</td>
<td>0.00%</td>
<td>0.65%</td>
<td>0.00%</td>
<td>0.65%</td>
</tr>
<tr>
<td>Underwater</td>
<td>0.00%</td>
<td>0.00%</td>
<td>2.76%</td>
<td>2.76%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>20.68%</td>
<td>39.48%</td>
<td>39.84%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

3.6. Descriptive Analysis of Documents According to Whether They Have Been Implemented or Not

In order to analyze the variables proposed in this review, it was necessary to ascertain the extent to which the selected documents were implemented. The results indicated that the majority of the selected documents (65.38%) were implemented (see Figure 9).

![Figure 9. Number of items according to the type of extended reality used.](image)

Consequently, to analyze variables such as type of teaching, performance, motivation, and differences between traditional teaching and teaching through technologies, only articles that reported on experiences of heritage transmission through extended reality that had been carried out are included in the analysis.
3.7. Descriptive Analysis of Documents According to the Type of Education to Which the Experience Was Oriented

As previously stated, only documents containing experiences carried out have been considered for analysis.

Table 3 illustrates that the majority of experiences of heritage transmission through extended reality have been carried out in the context of formal education (54.12%), followed by non-formal education (35.97%) and, finally, those carried out in both types of education (9.92%).

<table>
<thead>
<tr>
<th>Education</th>
<th>MR</th>
<th>AR</th>
<th>VR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal</td>
<td>8.40%</td>
<td>19.16%</td>
<td>26.56%</td>
<td>54.12%</td>
</tr>
<tr>
<td>Non-formal</td>
<td>6.89%</td>
<td>20.50%</td>
<td>8.57%</td>
<td>35.96%</td>
</tr>
<tr>
<td>Both</td>
<td>4.71%</td>
<td>5.21%</td>
<td>0.00%</td>
<td>9.92%</td>
</tr>
<tr>
<td>Total</td>
<td>20.00%</td>
<td>44.87%</td>
<td>35.13%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Similarly, it can be stated that the most prevalent technology utilized in formal education is VR (26.25%). However, the most prevalent technology in non-formal education and in those activities in which both types of education are combined was AR, with 20.50% and 5.21%, respectively.

3.8. Descriptive Analysis of Documents Relating Learning with Extended Reality

Regarding academic performance, Table 4 shows that most of the articles analyzed conclude that the learning of heritage-related content is enhanced by the use of extended reality (71.43%). Conversely, 7.56% of the papers argue that it is diminished.

<table>
<thead>
<tr>
<th>Learning</th>
<th>MR</th>
<th>AR</th>
<th>VR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases</td>
<td>16.47%</td>
<td>35.97%</td>
<td>18.99%</td>
<td>71.43%</td>
</tr>
<tr>
<td>Decreases</td>
<td>3.53%</td>
<td>0.00%</td>
<td>4.03%</td>
<td>7.56%</td>
</tr>
<tr>
<td>Remains unchanged</td>
<td>0.00%</td>
<td>5.71%</td>
<td>0.00%</td>
<td>5.71%</td>
</tr>
<tr>
<td>Not reported</td>
<td>0.00%</td>
<td>3.19%</td>
<td>12.11%</td>
<td>15.30%</td>
</tr>
<tr>
<td>Total</td>
<td>20.00%</td>
<td>44.87%</td>
<td>35.13%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

As illustrated in the table, augmented reality is the technology most associated with increased academic performance, with a rate of 35.79%. This is followed by virtual reality (18.99%) and mixed reality (16.47%).

A total of 15.29% of the publications analyzed do not specify whether learning increases or decreases with these technologies.

3.9. Descriptive Analysis of Documents Relating Motivation with Extended Reality

Table 5 provides evidence that 80.50% of the studies analyzed indicate an increase in student motivation. In contrast, only 3.53% of the articles examined conclude that these technologies decrease motivation for heritage learning.
Table 5. Differences between traditional teaching and teaching through technology.

<table>
<thead>
<tr>
<th>Motivation</th>
<th>MR</th>
<th>AR</th>
<th>VR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increases</td>
<td>12.77%</td>
<td>38.49%</td>
<td>29.24%</td>
<td>80.50%</td>
</tr>
<tr>
<td>Decreases</td>
<td>3.54%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>3.54%</td>
</tr>
<tr>
<td>Remains unchanged</td>
<td>0.00%</td>
<td>5.71%</td>
<td>0.00%</td>
<td>5.71%</td>
</tr>
<tr>
<td>Not reported</td>
<td>3.70%</td>
<td>0.67%</td>
<td>5.88%</td>
<td>10.25%</td>
</tr>
<tr>
<td>Total</td>
<td>20.01%</td>
<td>44.87%</td>
<td>35.12%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

It is noteworthy that 5.71% of the articles indicate that performance is maintained using extended reality, while 10.25% do not specify whether motivation increases, decreases, or is maintained, as this was not the objective of their research.

3.10. Descriptive Analysis of Documents According to the Existence of Differences between Traditional Teaching and Teaching through Extended Reality

To ascertain whether there were discrepancies between conventional teaching and instructing through technology, we analyzed only those articles whose experiences were implemented in practice.

Thus, we found that the majority of the articles did not specify whether these differences exist (69.58%), while 30.42% of the articles considered that there are differences between both teaching methods, as presented in Table 6. This suggests that the activities with extended reality contribute to the improvement of heritage learning, motivation, and interest of participants, as well as collaboration between them.

Table 6. Differences between traditional teaching and teaching through technology.

<table>
<thead>
<tr>
<th>Differences</th>
<th>MR</th>
<th>AR</th>
<th>VR</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6.22%</td>
<td>9.68%</td>
<td>14.62%</td>
<td>30.52%</td>
</tr>
<tr>
<td>No</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Not reported</td>
<td>13.78%</td>
<td>35.20%</td>
<td>20.50%</td>
<td>69.48%</td>
</tr>
<tr>
<td>Total</td>
<td>20.00%</td>
<td>44.88%</td>
<td>35.12%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

4. Discussion and Conclusions

XR allows users to interact and access virtual scenarios that go beyond the real ones, eliminating the barrier of distance. As can be seen, the use of emerging technologies, specifically VR, AR and MR applied to cultural heritage, requires the design and planning of innovative educational experiences adapted to the user and the type of heritage to be transmitted, whether tangible or intangible.

The main objective of this paper was to analyze and study the use of cultural heritage as a didactic resource using extended reality. Therefore, a bibliographic review of scientific articles related to this topic was conducted. This was achieved through a search in the Scopus and Web of Science databases and the subsequent analysis of the documents based on a series of research questions previously formulated.

In relation to the first question (where and when has there been a greater concern for the use of XR for heritage education?), the study reveals that, despite the fact that these new technologies have only been in use for approximately two decades, there is a growing concern regarding their use, with 2019 and 2023 being the years in which most such articles were published. In relation to the countries of publication, some European countries such as Italy or Spain stand out, as well as Asian countries like Republic of Korea. In sum, Europe is the most productive continent in this sense (25 documents), followed by Asia and America. It is also worth mentioning that the vast majority of papers were published in English.
The second issue raised was: What type of XR is the most commonly used for the dissemination of cultural heritage? and What type of heritage is being worked on? The results in Section 3 reflect the fact that the most used type of XR for cultural heritage education is AR, although there are no major discrepancies between the number of papers employing AR and those where VR is utilized. These results are encouraging as they demonstrate that both types of technologies provide benefits to the educational field, thus widening the range of possibilities. Additionally, XR technology has been used to work with different types of heritage, historical, artistic, and archaeological, thereby demonstrating the versatility of this technology in the field analyzed. This is in line with other studies [57] which highlight the use of XR for the reconstruction of historical monuments, buildings, or archaeological sites. It is worth noting that most of the papers designed didactic activities aimed at cultural heritage as a didactic resource, covering various aspects.

In relation to the third and fourth questions (Have these experiences been put into practice?, and, if so, Are these virtual experiences intended for formal or non-formal education?) the data indicate that most of the experiences with XR on heritage education have been implemented, above all those aimed at official educational environments. Although it is also noteworthy that a considerable number of activities were developed in spaces such as museums, interpretation centers, or cultural centers. It can be concluded that the design of experiences and activities with XR are focused on both formal and non-formal education [23,24], highlighting their relevance and usefulness in the field of tourism, for instance, according to other studies [52].

Related to the success of these experiences and activities, the following questions were posed: Does the use of XR to transmit heritage influence the participants’ learning/performance on the subject? Does XR influence the motivation of participants with respect to heritage learning?

Most of the papers analyzed point to an increase in academic performance and motivation for heritage learning when using more innovative strategies such as XR, which is in line with other studies [57,58]. A minority of the studies reviewed report that both performance and motivation remain unchanged or even decrease when compared to traditional methodology. In such instances, it is detailed that, on occasion, these experiences may not be very stimulating due to their poor usability or design, as other studies claim [59]. This is why, according to other authors, it will be necessary to create good practices and strategies for their use [44,51].

The final question raised in relation to the effectiveness of these technologies in the educational field is: Are there differences between “traditional” heritage teaching and teaching through extended reality? Analysis of the results indicates that individuals who have worked with innovative methodologies, such as AR, VR or MR, for teaching content related to cultural heritage hold more positive opinions than those who have utilized a traditional methodology. Learners or users who have participated in experiences with XR technologies such as AR, VR or MRI prefer them to traditional methodologies.

In conclusion, based on this review it can be assumed that emerging technologies are making a significant impact in the field of education, particularly for the dissemination of cultural heritage. One of the advantages of these technological tools, as mentioned, is their polyvalence and versatility. They can be adapted to different educational contexts, to different population groups, as well as to different types of cultural heritage.

The literature shows that their use motivates learning, which increases academic achievement. The most successful technology in the field of heritage education in this respect is AR. This may be due to its greater ease of implementation in the design of educational experiences, its manageability, and its availability in commonly used devices. Although XR experiences designed ex-profeso are consistent, this requires technological knowledge that is not yet available to all teachers. Training teaching professionals to use such tools is one of the principal challenges for the near future. In the meantime, commercial solutions are being used to facilitate the teacher’s task. The creation of multidisciplinary
groups that bring together computer vision experts with specialists in heritage research and conservation, as well as teachers, can enrich research in this field.

The results of this study also indicate that, despite the existence of scientific literature on this subject since the beginning of the 21st century, it is only in the last five years that it has reached its peak. This can be explained, mainly, by the rapid technological evolution of the devices and the reduction in their cost, which has made them accessible to a wider public. It is therefore reasonable to posit that this trend will continue to grow, augmented, and supported by the possibilities offered by artificial intelligence. Furthermore, it can be concluded that the reference language for research continues to be English. The case of the Spanish-speaking world is significant as, despite Spanish being the second most spoken language in the world, of the 11 documents obtained in the search, only one was written in this language.

Among the limitations of this study, we can point out that, by limiting the search to scientific articles published in high-impact journals and included in the two most important research databases, we may have overlooked other significant examples, which, given the relative novelty of the topic, are mainly shared in other areas of scientific discussion and exchange of ideas, such as congresses and conferences.

In terms of future research, it would be beneficial to expand the range of works to be analyzed to gain a more comprehensive understanding of the current state of the field. This would enable a more nuanced examination of the utilization and evolution of these works.

Author Contributions: Conceptualization, M.J.M.; methodology, A.D. and E.L.; software, A.D. and E.L.; validation, M.J.M. and P.M.; formal analysis, M.J.M., A.D. and E.L.; investigation, A.D. and E.L.; data curation, A.D. and E.L.; writing—original draft preparation, M.J.M., A.D. and E.L.; writing—review and editing, M.J.M. and P.M.; supervision, M.J.M. and P.M.; project administration, P.M.; funding acquisition, P.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Agencia Estatal de Investigación (Ministerio de Ciencia, Innovación y Universidades), grant number PID2020-114954GB-I00, as well as by the Consejería de Economía, Ciencia y Agenda Digital (Junta de Extremadura) and the European Regional Development Fund (ERDF) “A way to make Europe”, grant number IB20172.

Data Availability Statement: Data are contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

The following is a list of the articles that were analyzed in this systematic review of the literature:


3. Ab

References


References


33. Ho, C.L.; Lin, T.G.; Chang, C.R. Interactive multi-sensory and volumetric content integration for music education applications. Multimed. Tools Appl. 2023, 82, 4847–4862. [CrossRef]

34. De Luca, V.; Marcantonio, G.; Barba, M.C.; De Paolis, L.T. A Virtual Tour for the Promotion of Tourism of the City of Bari. Information 2022, 13, 339. [CrossRef]


**Disclaimer/Publisher’s Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.