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Quality Requirements for Implementing Augmented Reality in Heritage Spaces: Teachers' Perspective

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Abstract: As a consequence of the scarcity of studies of augmented reality (AR) in Spain, this study developed a questionnaire to evaluate teachers' perceptions on the use of AR for heritage teaching (n = 347 teachers: n = 131 in-service/n = 216 in-training). The objectives were to: (1) identify teachers' existing knowledge about AR; (2) evaluate educational strategies teachers value most in AR apps for teaching; (3) evaluate necessary AR functions; (4) determine desired technical and functional characteristics; and (5) compare any significant differences between the two groups. The results provide a contribution to the increasing implementation of AR apps in heritage education, which promotes the understanding, enjoyment, experience and knowledge of heritage. Heritage education is increasingly present in Spanish classrooms due to awareness of the country's rich heritage, and AR is a good tool for understanding and linking society with its heritage. From the results, it is clear that, despite their desire for implementation, there is a lack of teacher training in applying AR; both subsamples pointed out the importance of humanising the explanations in AR apps with experts or actors who mediate heritage and value the ease of use of these apps, multifunctionality, low battery consumption, and use in the background. Significant differences suggest potentially greater educational commitment among active teachers who seek deep and meaningful learning, above the superficiality and enjoyment reported by teachers in training and, on the contrary, the value placed on technical and visual aspects, related to the high use of mobile devices.

Keywords: augmented reality in education; heritage education; teachers; cultural heritage; ICT

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1. Introduction

The arrival of mobile devices in our daily lives changed our way of receiving information, communicating and interacting. Consequently, agents of transformation and change, such as schools and institutions for safeguarding and conveying heritage, have adapted to this new, unstable and constantly moving landscape [1]. Since Caudell and Mizell coined the term augmented reality (AR) in 1992 [2], this technology—combining the real world with the virtual one, interactive in real-time and registered in 3D—has been redefined on multiple occasions [3–5]. AR is a digital technique that can complement reality through the recreation of scenarios, environments or superimposed characters, in relation to heritage. AR makes it possible to interpret archaeological remains or modified urban plots, to visualize part of an object, to integrate a virtual guide in a visit or to show virtual information superimposed on heritage spaces. Nevertheless, it was not until the game *Pokémon GO* appeared and its popularity soared that people became more familiar with the term AR and the technology was viewed as a real breakthrough [6].

1.1. Augmented Reality and the Virtuality Continuum

We consider it necessary to dedicate a few lines to clarify the distinction between the terms augmented reality (AR) and Virtual Reality (VR), as they are sometimes used interchangeably and correspond to different technologies, as stated by [7] in their taxonomy.

Both authors establish a flow or Virtuality Continuum (see Figure 1); that is, a continuous scale that would go from the purely real and physical (Real Environment—RE) to the exclusively virtual and without components of the tangible world (Virtual Reality—VR), passing through augmented reality (AR) and augmented virtuality (AV). AR, characterised by the enrichment of the real world with superimposed virtual elements through electronic devices, would be in a position close to real space, while VR involves the generation of environments parallel to our real context, creating fully virtual 3D environments through computers in which we can interact if we have the appropriate equipment—it corresponds to one end of the Virtuality Continuum.

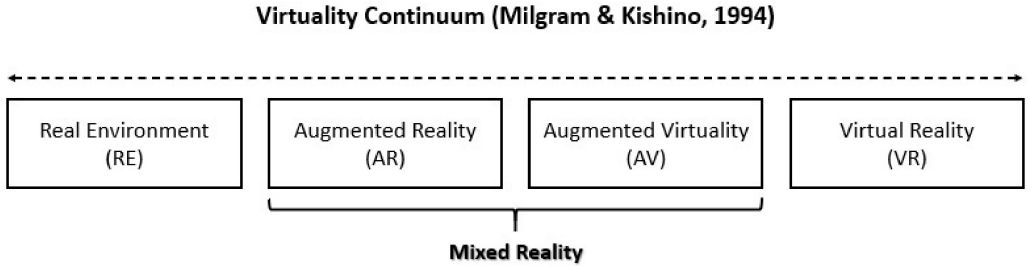

Figure 1. Diagram that reflects the taxonomy proposed by the authors Milgram and Kishino (1994) for the Virtuality Continuum [7].

1.2. Augmented Reality in the Educational Context

In the last decade, several reports such as the Horizon report published by the NMC (New Media Consortium) have emphasized that AR is one of the emerging technologies with the greatest impact on the educational world, due to its potential to modernize educational contexts. Horizon has been analysing AR's gradual introduction into classrooms since 2010 and has found that this technology is here to stay in the educational context [8].The use of AR as an educational tool has been the focus of several recent studies [9,10] that have highlighted benefits such as improved academic performance due to its motivational, creative and entertainment potential; its capacity to enhance and contextualise information; and the possibility of other types of learning [11–15]. The systematic review of the literature arisen from the use of AR for educational purposes is today an open and constantly evolving line of research [13,16–19].

As AR is a multifaceted technology, it can be used to form 3D educational content, to implement ubiquitous, collaborative and situated learning, or to develop students' senses of presence, immediacy and immersion [20–22] and many other educational possibilities outlined in other studies [23–25]. These learning environments, which are richer and closer to learners [16,26–28], favour the development of several skills based on experiences in real contexts [29]. When we refer to real contexts, what is stated is that AR favours the acquisition and understanding of knowledge through the superimposed image or recreation that AR allows us in a heritage space—for example, recreating a fire in a cave—or in the classroom itself; the combination of the place with the image allows a more holistic understanding of the culture. This experience can take place on a site or in a school classroom, but we always need a place where AR can be superimposed; that is what we mean by real context. This technology can provide learning experiences in and outside the classroom and enables reality to be contextualised by deploying links with virtual elements. It allows us to build new immersive learning ecosystems that are educationally novel and engaging for students [30].

In the educational field, a prominent meta-analysis study [14]—based on a comparison of experiences that have used AR with others that have not—highlighted better understanding of content, more sustained retention in long-term memory, improvements in performing physical tasks, and student collaboration and motivation as strengths; other studies, however, have identified that AR is effective in improving students' learning performance, motivation, attitude and commitment [17].

References have identified several limitations, which include technical difficulties in maintaining the superimposed information, excessive attention to virtual information and considering AR as an intrusive technology [17]. Since it was introduced in education, ineffective integration in the classroom and learning differences among students have been underscored [14]. Shortcomings in students' attitudes and motivation due to systematic use—likely abuse—in curricula were also mentioned [13], as was reluctance to use it in educational but non-entertainment contexts, problems with interfaces, the need to train teachers, restrictive legal loopholes when using electronic devices in schools, and a possible lack of interest—inherent in every passing fad—which can lead to AR losing its role as an incentive.

The review of the literature from the educational field and, particularly, from its application to heritage spaces -expanded in the following sub-sections-, forms the theoretical framework for developing the questionnaire, the guiding instrument of this study. It is therefore necessary to include the advantages and disadvantages of a new tool such as AR, its benefits and limitations, as well as the objectives on which the studies that have already been carried out have focused. This study gives a voice to teachers, beyond the users, visitor, tourist or heritage agents and managers. From the educational field. we wonder about the aspects that can benefit or harm the implementation of AR in formal education. If AR is so positive and achieves more holistic learning, why is it not really being applied in formal education? What characteristics should these applications have? Is there a real possibility of implementation or are we drawing castles in the air? And most importantly, are teachers aware of it? Is there a real possibility of implementation? These are some starting questions that led us to investigate a reality that exists in the literature but is not in line with classroom practices.

1.3. AR Applied to Heritage Education and Cultural Spaces

In the past ten years, museums have experienced an unprecedented technological revolution that has invigorated contents and experiences by making them more engaging and educational after virtual enhancing of real spaces. Recent studies have highlighted the potential of AR and virtual reality (VR) as one of the major impacts of heritage mediation [31]; the pieces and the spaces have been digitised, their contents have been expanded and access to culture has been improved by breaking down geospatial barriers [32].

One of the more recent studies put forward a list of ten best practices for introducing AR in contexts in which heritage is at risk [18]. The courses of action include the need for exhaustive documentation, a prior socioeconomic study, an assessment of the potential for tourism at the site, economic viability, optimal Internet connection and the creation of a free app. AR scenarios help students have a more comprehensive view of objects, places or assets, based on techniques and strategies that provide additional dynamic and appealing information—re-creation, reconstruction, pigmentation, viewing animations, etc.—using a variety of media and symbolic systems, which aid individual training and the integration of a learning system open to multiple intelligences [33]. As AR integrates the many facets of information, using it makes a holistic and sensory learning experience possible, resulting in better understanding of the space or the assets by reconstructing or recreating historical facts and places [34]. With AR, students can interact with objects generated virtually by manipulating them in the physical space without the need for sophisticated devices [35]. Simultaneously, AR facilitates understanding of complex phenomena and concepts by breaking down an object or phenomenon into its phases, stages or pieces—or by demonstrating how it works or how it is used [36]. Finally, besides educational aspects, documentation and protection factors have been identified as this technology enables culture to be preserved digitally while optimising sustainable development through managing and respecting heritage [37–40].

The use of AR facilitates accessibility, cultural understanding and proposes that new forms of teaching and learning and interaction with heritage have a direct impact on the development of digital competence. This is one of the key competences established by the

Council of Europe in 2006 to promote lifelong learning for the benefit of knowledge and the integral development of society as a major asset [41] and has recently been extended by the European Framework for the Digital Competence of Educators: DigCompEdu [42] as one of the primary objectives of teacher and learner education. In line with digital competence, AR work applied to knowledge of heritage aims to foster a commitment to care and conservation in public space that contributes to its sustainability and the active participation of citizens as a driver of change; a goal integrated into the Sustainable Development Goal "Goal 11. Sustainable Cities and Communities" of the 17 set out in the United Nations 2030 Agenda for Sustainable Development [43].

Current research on using AR applied to educational heritage is motivated by analyses of, for example, interactive technologies in museums [44] or the use of screens with AR in interactive exhibitions [45,46]. One of the most prolific lines—as it is a heritage category that AR particularly enhances—is the development and application of AR at archaeological sites [47,48]. This type of heritage enables us to get closer to our past, although any visualisation, re-creation or contextualisation exercise involving an interpretative approach to a piece, remains or site will enhance our understanding and experience of history, art and culture. This study is based on this premise, since AR—and VR as well—can be a highly useful tool implemented in several ways: creating a virtual guide to accompany visits and explain the collection [49]; proposing an interactive game during the visit superimposed on reality and virtuality [47,50]; adding supplementary information such as data, anecdotes or videos on the places visited [51]; reconstructing the visible part of remains [49]; or showing the entire context surrounding the heritage asset in question [24,52]; and many other possibilities.

1.4. Research Rationale and Research Questions

This entire review has been woven through threads that derive from AR applied to heritage spaces from non-formal education and, also, compiling the advantages and disadvantages that this medium can bring to learning and understanding of culture, history and heritage, since it is at the educational level where more studies are being developed. In contrast to this context, there is a considerable gap in its application in formal education; we find some scarce experiences that analyse projects or educational actions. Studies such as [31] have highlighted: the Formapps project that promotes educational innovation through virtual spaces; networks and equipment [53]; the Baetica project, which promotes the creation of learning communities through multidisciplinary research projects [53]; and the SmartMarca project, an Italian proposal for the transmission of content in AR and VR about culture and heritage, which aims to provide students with learning methods. This study evaluated how the application of AR can enhance the acquisition of new knowledge from the potential to be attractive, interactive, realistic and close to the students [54]. A valuable study in this regard is that of Espinosa [55] who collects and analyses more specific examples of real classroom practices using augmented reality, predominantly in secondary and university education, although he presents some in elementary education and from different areas of knowledge. Other authors [56–58] collect specific experiences, seeking educational innovation with the implementation of AR, but always in higher education. From the beginning, the focus has been on formal education, under the belief that AR is a clear contribution to achieve more comprehensive and meaningful learning, but there is not very advanced implementation in classrooms, and we wonder why it is not being applied in the classrooms of Spanish centres if its significant benefits have been demonstrated. Numerous questions revolve around this central idea: what characteristics do these applications need to have; do teachers really know what AR is; are they aware of AR as a learning resource; is there a real possibility of implementation or are we theorizing something abstract? These are the starting questions that lead us to investigate a reality that exists but is not being coupled to education in the classroom.

2. Present Study

Heritage education today is a consolidated research field that is vitally important due to its interdisciplinary education offering and its link to relevant current problems [19]. This study is part of two specific lines of research: firstly, technology applied in museums and heritage education [50,59–61] and, secondly, the technology linking museums, visitors and residents [62–65].

In the Spanish context, some authors [66] point out that we learned the first results from applying virtuality to heritage in 2000 [67,68]. Although within this national scope, in museum and heritage spaces, the starting point for this technology did not arrive until 2010 [68], when the first museum installations using AR gradually appeared in Europe [64]. Spain is a country rich in heritage, and the third largest in the world, in terms of the number of properties recognised by UNESCO, and this incentive has made it the leading country internationally in terms of scientific production in heritage education, where one of its lines has been articulated in the last decade on the basis of projects and research focused on ICT and virtual environments [69]. Implementation of AR has evolved considerably in recent years and now virtual and augmented reality applications can be found in several museums and heritage spaces [20,66,70,71]. In the last decade, AR has become a consolidated avenue of research with a variety of topics such as its functionality in heritage apps [71], user satisfaction and motivation [22], its use in tourism [21,71–73] and the assessment of programmes and apps integrating AR [15,31,74,75]. However, so far, no applicability studies have been located from the perspective of teachers to take advantage of both the technological and cultural resources that we consider essential to raise awareness or inculcate in students the protection, preservation and safeguarding of heritage, commit them to its sustainability and developing the digital competences that AR can promote. Therefore, it is worth asking whether AR is a valid resource for teachers, what educational professionals can look for in AR, what educational possibilities will be most valued, what characteristics an AR resource must fulfil and how its implementation can be promoted.

As its applications are so diverse, this study aims to learn which features and functionalities education professionals prefer. In our ongoing review, we have not yet found any exploratory studies researching this collective's perception. However, professionals designing interfaces (programmers and engineers) and educational staff (teachers and educators) should move in the same direction, but rather respond to requests for quality and efficiency in using them. Consequently, this study aims to identify these elements with a questionnaire that includes three key factors: (1) rating of AR educational applications and strategies; (2) preferred function in implementing it in a cultural setting; and (3) technical, usability and learning features.

3. Materials and Methods

3.1. Research Objectives

The main aim of this research is to discover the features teachers and teachers in training want to see in an app offering AR in a cultural setting—museum or heritage space.

To achieve this main aim of the research, the following questions have been answered:

Q1. Do teachers know and implement AR as a beneficial tool for learning and understanding cultural assets in and outside the classroom?
Q2. What are the teaching strategies teachers rate most highly when implementing AR in a classroom, museum or heritage space? (strategies)
Q3. Which function do teachers prefer when implementing a resource with AR? (function)
Q4. Which of an app's technical and usability features do teachers and teachers in training rate more highly when using it in a museum, at an archaeological site or a historical place? (features)
Q5. Are there significant differences between the two groups' requirements?

3.2. Sample

Our study sample is comprised of two independent convenience subsamples as the questionnaire was shared on the social networks of the researchers and of students in the Bachelor's degree in Primary Education and in the Master's degree in Secondary School Teacher Training at the University of Zaragoza. In total, the sample includes n = 347 questionnaires, where n = 216 were completed by teachers in training and n = 131 by practising teachers.

The difference between both samples not only lies in the teachers' professional experience but also in a significant age difference (see Table 1), since in the sample of teachers in training (n = 216), 72.7% of the participants were born between 1996 and 2001 and have between two and nine months of teaching experience. In the sample of practising teachers (n = 131), 58.8% were born after 1979. We can compare the interests of both samples using these data, since we would expect the former to be more familiar with the user's experience as young people use this type of technology more [74].

Table 1. Study sample.

Teachers in Training			Teachers		
Age Range	**No.**	**%**	**Age Range**	**No.**	**%**
19 to 24 (born between 2001 and 1996)	157	72.7%	20 to 30 (born between 1990 and 2000)	8	6.1%
25 to 30 (born between 1995 and 1990)	39	18.1%	Over 30 (born after 1989)	31	23.7%
Over 30 (born after 1989)	18	8.3%	Over 40 (born after 1979)	38	29.0%
Over 50 (born after 1969)	2	0.9%	Over 50 (born after 1969)	54	41.2%
Total:	216	100%		131	100%

3.3. Instrument

The data collection instrument is a questionnaire comprising 31 questions, two diagnostic or exploratory questions on awareness and application of AR in the classroom for the teachers, and only 30 questions, after removing the application questions, for teachers in training, as well as a common set of 29 questions divided into three blocks: (1) teaching strategies; (2) technical and usability features; and (3) preferred function of AR implementation in cultural spaces (see Table 2). The elaboration of the questionnaire is based on the theoretical review reflected in the previous sections, which supports its construction together with the current state curricular legislation [76]. Said legislation sustains in the field of Social Sciences the criterion that governs our research "To value the importance of museums, sites and historical monuments as spaces where teaching and learning take place, showing an attitude of respect for their environment and culture, appreciating the cultural heritage" (p. 26) to which it is associated four learning standards [76]. As mentioned above, the questionnaire has been constructed from the previous literature. Blocks 1 and 2 were designed based on the possibilities offered by AR in cultural spaces, guided by studies such as [77], who offer a classification of the application possibilities of immersive reality systems that helped us to outline the educational possibilities included in the questionnaire. These include types of modelling in virtual environments, reconstructions, simulations, content overlay, among others. Likewise, previous studies developed by the research team based on the analysis of national AR applications [66,71] and the analysis of educational programmes that integrate AR applications were also taken as a reference [31]. These background studies initiated the line of research and have served as a reference to determine the study blocks. Block 3 responds to studies developed in other contexts and countries such as Korea [78], where examples of AR applied to cultural heritage have been tested by analysing some variables such as usability (understanding or learning), usefulness (use, quality, speed) and satisfaction (design and interface). Interaction interfaces have also been

analysed in other studies already cited [77]. The aim of the latter lies in the development of new cultural content for sectors such as education, industry or tourism. All of them differ from the present research either because of the sample studied or because of the context or the objective of their proposal, however, they have served as a substrate for the conceptualisation of the present questionnaire. Following this review of the literature, a battery of questions was drawn up and discussed with the rest of the experts on the team to select those that responded most accurately to the research objectives, responding to the categories of sufficiency, clarity, coherence and relevance proposed by [79], reducing those that were repetitive and eliminating those that gave rise to ambiguity, and a pilot test was carried out. Finally, the IBM SPSS Statistics 26 statistical package was used for validation, and reliability analysis was applied using Cronbach's alpha, as it is one of the most appropriate statistics for obtaining reliability with Likert-type instruments [80]. The 29-item questionnaire, on a Likert-type response scale in incremental levels where 1 is "not at all" or "never" and 5 is "very much" or "always", obtained a high reliability coefficient of 0.87 for all 29 items, both in the full sample (0.87) and in each of the two subgroups of teachers (0.87 -in training- and 0.88 -in service-). After studying each block/dimension separately, it was found that this high degree of reliability was maintained in Teaching and Usability, in both groups indistinctly. Only in the 3rd dimension, Functions, a lower but acceptable reliability (>0.60) was found. It was found that eliminating this block or some of the items whose homogeneity index was somewhat lower did not improve the reliability of the total set, which is in itself high. Therefore, the values achieved allow us to indicate an adequate reliability coefficient, both overall and in the different dimensions that constitute it [80,81].

Table 2. Questionnaire items and Likert-type scale applied in each group.

Scale	Item
A. Indicate from 1 to 5 whether the following ideas would help learning or not where 1 is 'would not help at all' and 5 is 'would help a lot' (Corresponds to learning content and goals)	A.1 Having a complete reconstruction of the piece because it is very destroyed A.2 Having a cartoon character explain the work of art A.3 Having a museum staff member explain the work of art as if they were a personal guide A.4 Seeing a complete reconstruction of the place even though I already know what it is (for example, I know I am looking at a palace) A.5 Having an actor in costume explain the work of art/place, etc. A.6 Seeing an interpretation of the drawings of a pot, for example (or a sculpture, painting, etc.) A.7 Representing useful data that help me understand what I am seeing A.8 Seeing what colour it was or how the colours or shape of the piece I am looking at evolved A.9 Recreating the setting the piece might have been in (grave goods, a room, etc.) and understanding its context better A.10 Seeing characters using the piece or the place and understanding what it was for or how it was used (a tool, a place, etc.) A.11 Seeing a moving painting A.12 Seeing a reconstruction of the colours of a wall or painting A.13 Finding out who the characters are in the image (a painting, sculpture, etc.)
B. Which features do you or would you rate more highly in an app to use in a museum where 1 is 'not at all important' and 5 is 'very important' (concerns design and application)	B.14 Does not use up much of the electronic device's battery B.15 Does not use much of my data B.16 Can be active in the background so I can use the device to take photos, listen to music, send messages, etc. B.17 Does not take up much memory in my electronic device B.18 Easy to use, the more intuitive the better B.19 Allows me to take original photos and add figures or characters, for example, and share them on social media B.20 Offers me itineraries in a more appealing and visual way B.21 Allows me to discover the most interesting places or most representative monuments in a more original way B.22 Will also work as an audio guide or map, for example, if I do not want to activate the augmented reality B.23 Does not require constant updates B.24 Allows users to add new information to make it more interesting and complete
C. Imagine you can use augmented reality in a museum. Indicate your priority for the following functions where 1 is 'no priority' and 5 is 'top priority' (concerns the purpose of the application)	C.25 As an advertising ploy (take a selfie with one of our characters) C.26 As a guide to understand a work of art or heritage asset C.27 Seeing the reconstruction of a heritage asset that has deteriorated or of which only traces remain C.28 Seeing an animation that enables me to understand how the piece was used or what it was for C.29 Seeing a painting or a sculpture with a small animation (a nod of the head, a handclasp, a spear going through the air, etc.)

4. Results

4.1. Teachers' Awareness of and Experience with AR

First, we present the responses obtained on awareness and implementation of AR in their teaching. Initially, we asked whether they were aware of this resource and a significant part of the sample said they were not familiar with the concept of AR (15.3%) or did not know how to explain it (28.2%). Furthermore, there was an option to reliably demonstrate if they knew how to differentiate it from VR by providing two definition options, one on AR and another on VR, resulting in 23.9% of the sample giving an erroneous response (see Table 3).

We also contrasted the differences between the groups of trainee and in-service teachers, finding a statistical significance with $p < 0.05$ (Table 3), which is mainly due to the fact that: (a) there are more participants who do not know how to explain what AR is in the group of trainee teachers: 32.4% vs. 21.4%; while (b) among active teachers, there is a higher rate of correct answers (42.0% vs. 26.9%) and at the same time a lower rate of wrong answers (20.6% vs. 25.9%).

Table 3. Responses on the sample's awareness of the AR concept.

Question 1: Do You Know What Augmented Reality Is?	Percentage (Frequency)		
	Total Sample (*n* = 347)	**Teachers in Training (*n* = 216)**	**Teachers (*n* = 131)**
A. No, this is the first time I have heard of it	15.3% (53)	14.8% (32)	16.0% (21)
B. Yes, I have heard of it, but I do not know how to explain it	28.2% (98)	32.4% (70)	21.4% (28)
C. Yes, this is when we see a completely different reality using an electronic device and we can even immerse ourselves in it using goggles, for example	23.9% (83)	25.9% (56)	20.6% (27)
D. Yes, this is when we see virtual elements using an electronic device in the physical world	32.6% (113)	26.9% (58)	42.0% (55)

Test Chi-square: Value $Chi^2 = 10.29$; 3 gl; p-value = 0.016.

Only 32.4% of the sample gave the correct answer compared to 67.6% who heard of the term for the first time, had heard of it but did not know how to explain it or confused AR and VR. Therefore, lack of knowledge about this resource is quite pronounced, so it is unlikely to be implemented soon if there is no prior awareness or experience. The teachers demonstrate more awareness (42.0%) compared with the teachers in training (26.9%), contrary to the starting hypothesis based on their familiarity with these technologies.

Next, as contextualisation for respondents that did not know the technology, the questionnaire contained a short definition and visual examples (see Figures 2 and 3).

Figure 2. Example I of augmented reality. A visitor using de app 'Museo Carlos V' in Spain (**left**). An image of the app 'Cisneros Go' in Spain (**right**). Reprinted or adopted with permission from Museo Carlos V and Cisneros GO (2021). Copyright Year 2021 Copyright [21].

Figure 3. Example II of augmented reality. Visitors using de app 'La Alhambra. Castillo Rojo' (**left**) and (**right**). Reprinted or adopted with permission from Alhambra on line (2021). Copyright Year 2021 Copyright [21].

Practising teachers were also asked whether they had used AR as a resource in their classes (see Table 4), which enabled us to observe that its implementation is still at an early stage. Only 11.5% had practical experience with AR as a teaching resource and 9.2% in the classroom; however, three out of every four of the teachers surveyed (76.9%) are interested in introducing AR, but they state they do not have the resources or equipment.

Table 4. Responses on the educational implementation of AR in teaching.

Question 2: Have You Introduced Augmented Reality in Your Classes?	Percentage (Frequency)
Yes, I have done an activity in the classroom	9.2% (123)
Yes, we have had a session with an expert who brought the necessary equipment	1.5% (2)
Yes, we use it on cultural trips to a museum/archaeological site	0.8% (1)
No, I would like to, but I do not have the necessary equipment	76.9% (100)
No, I could have, but I do not think it is useful or it involved more problems than advantages	11.5% (15)
Total	100% (130)

After these questions, the three main blocks of analysis are started by means of inferential contrast tests between groups for the 29 items of the questionnaire, which will be broken down by each of the blocks.

4.2. The Use of AR as an Educational Tool: The Highest Rated Resources to Achieve Learning

Firstly, through comparison, the study focused on discovering which teaching resources both subsamples rated more highly to help their students learn. As described above, the questionnaire used a Likert-type scale where 1 is 'nothing' and 5 is 'a lot'. Using their educational criteria and a level scale, the sample participants rated 13 items accompanied by images as examples showing a range of educational strategies previously extracted from the prior literature (see Table 5).

As the results in the table reveal, all the ratings for the suggestions in the questionnaire obtained very positive scores, since all the means were above 3. However, since this study aims to show priorities for using AR in teaching, the most significant items have been highlighted based on the rating given. These include the use of AR in reconstructions of both materials (item A.1) and historical places (item A.4) and recreating the setting for the piece at archaeological sites (item A.9). In all the items mentioned, the strategy gives clues to understand and visualise them completely; they are not based on mere motivation as items rated less highly are, corresponding to accompanying visits with guides, avatars and characters. Therefore, the teaching strategy based on AR rated most highly by the teachers to promote knowledge, interpretation and awareness of heritage focuses on its potential to recreate the asset's original appearance and context or setting. This facilitates understanding as it is experienced more comprehensively with the original condition and

setting superimposed on the preserved element without students needing prior knowledge or complex abstraction abilities.

Table 5. Mean of the subsamples' responses based on the 'teaching strategies' variable.

ITEM/Content	Mean (Standard Deviation)		Mann–Whitney Test	
	Teachers in Training (n = 216)	Teachers (n = 131)	Value	p-Value
A.1 Complete reconstruction of the piece because it is very destroyed	4.74 (0.58)	4.87 (0.45)	−2.83 **	0.005
A.2 Having a cartoon character explain the work of art or place	3.14 (1.17)	3.00 (1.19)	1.03 N.S.	0.303
A.3 Physical guide of the digitised museum accompanying visitors and explaining the pieces	3.90 (1.04)	4.06 (1.09)	−1.78 †	0.074
A.4 Complete reconstruction of a place because there are remain	4.66 (0.61)	4.71 (0.63)	−1.28 N.S.	0.198
A.5 Having an actor in costume explain the work of art/place, etc.	3.71 (1.11)	3.63 (1.15)	0.59 N.S.	0.552
A.6 Interpretation and animation of the drawings of a pot, for ex-ample (or a sculpture, painting, etc.)	3.82 (1.05)	3.95 (1.18)	−1.66 †	0.098
A.7 Superimposed representation of useful data that help to under-stand or interpret the piece or place	4.45 (0.72)	4.53 (0.76)	−1.49 N.S.	0.136
A.8 Visualisation of the original condition and development or deterioration of the piece	4.28 (0.82)	4.49 (0.74)	−2.45 *	0.014
A.9 Recreating the setting the piece might have been in (grave goods, a room, etc.) and understanding its context better	4.51 (0.72)	4.73 (0.57)	−3.05 **	0.002
A.10 Recreating characters, function, use and/or handling of tools or places to understand what they were for or how they were used	4.48 (0.74)	4.65 (0.61)	−2.13 *	0.033
A.11 Immersive animation of a moving structure	3.61 (1.16)	3.47 (1.44)	0.52 N.S.	0.603
A.12 Reconstruction of the colours of a wall or painting (pigmentation)	4.33 (0.82)	4.49 (0.84)	−2.30 *	0.021
A.13 Audiovisual animation describing characters or elements of a work of art (it can be a painting, a sculpture, etc.)	4.38 (0.84)	4.62 (0.72)	−3.17 **	0.002

N.S. = NOT significant † = Nearly significant * = Significant ** = Highly significant.

The responses of both groups were noticeably unanimous, although the scores were slightly lower on AR's usefulness to provide new data that help to understand the work of art or the place, as well as its use to see how a character uses the piece, or to learn what the pigmentation was or the decorative development of archaeological remains (items A.8 and A.12).

Regarding the inferential contrast test, highly significant differences were found, with $p < 0.01$, in the variables of items A.1, A.9 and A.13, as well as significant differences with $p < 0.05$ in items: A.8, A.10 and A.12. In all these cases, the significance is due to the fact that the participants in the teachers' group present a higher mean value, i.e., they value the use of the strategies indicated in these items more highly. We could also speak of a quasi-significance ($p < 0.10$) in the same sense, in the differences that exist in items A.3 and A.6. In the rest of the items, the differences do not reach statistical significance or come close to it ($p > 0.10$).

Furthermore, both groups were asked a question about the more humanised side of the museum using a mediating agent. Based on this premise, the participants were offered four guide options to accompany them on the route, explain the works of art, their context and other possibilities (see Table 6).

As we can observe, both the teachers and the teachers in training chose a museum staff member to explain the work of art as their preferred option (52.8% and 61.1%), while the second favourite option was an actor in costume explaining the work (30.6% and 25.2%). Lastly, the 'They would not add anything to the experience' option was the least selected by both groups (5.1% and 6.1%), so there is a positive trend towards use of AR to increase knowledge and as a guide for the route using museum staff as guides, whether in costume or not. In our opinion, specialised museum staff represent scientific precision and that is why they are the most highly rated option. Actors in costume also have a relevant educational potential as they spontaneously introduce students to aspects of daily life in a specific age simply through their clothing if this is recreated with historical accuracy.

In this case, when applying the contrast test between the subsamples, no statistically significant differences were found ($p > 0.05$) in the preferences expressed.

Table 6. Mean subsample responses on preference in virtual mediation of heritage.

Question 3: If You Could Use AR to Learn More about a Museum Piece, Which of These Options Would You Prefer?	Percentage (Frequency)		
	Total Sample (n = 347)	Teachers in Training (n = 216)	Teachers (n = 131)
A. An actor in costume should explain the work of art to me	28.5% (99)	30.6% (66)	25.2% (33)
B. A museum staff member should explain the work of art to me as if they were my personal guide	55.9% (194)	52.8% (114)	61.1% (80)
C. A cartoon character should explain the work of art to me	10.1% (35)	11.6% (25)	7.6% (10)
D. They would not add anything to the experience; I prefer the audio guide or to read the labels	5.5% (19)	5.1% (11)	6.1% (8)

Test Chi-square: Value Chi^2 = 3.23; 3 gl; p-value = 0.357.

4.3. Preferred Function of the AR App in a Museum or Heritage Space

Lastly, a third block enables us to identify the overriding function teachers give to implementing AR in a museum or a heritage space (see Table 7). Within this variable, we have proposed advertising and tourist attraction initiatives—interactions with AR elements and Web 2.0 dissemination—(C.25), entertainment initiatives such as moving GIFs (C.29), and purely educational initiatives (C.26, C.27 and C.28). The function seen as prominent will largely have determined the type of resource considered most useful if the responses are homogenous.

Table 7. Mean of responses of the subsamples based on the variable: 'Desirable function in using AR in a cultural setting'.

ITEM/Content	Mean (Standard Deviation)		Mann–Whitney Test	
	Teachers in Training (n = 216)	Teachers (n = 131)	Value	p-Value
C.25 As an advertising ploy (take a selfie with one of our characters)	2.94 (1.13)	2.30 (1.30)	4.80 **	0.000
C.26 As a guide to understand a work of art or heritage asset	3.96 (1.00)	3.92 (1.05)	0.22 N.S.	0.822
C.27 Seeing the reconstruction of a heritage asset that has deteriorated or of which only traces remain	4.48 (0.81)	4.34 (1.02)	0.70 N.S.	0.486
C.28 Seeing an animation that enables me to understand how the piece was used or what it was for	4.32 (0.85)	4.17 (1.02)	1.02 N.S.	0.308
C.29 Seeing a painting or a sculpture with a small GIF.	3.06 (123)	2.68 (1.34)	2.67 **	0.007

N.S. = NOT significant ** = Highly significant.

As we can observe from the responses obtained, items C.27 and C.28, stand out. These items focus on reconstruction and animation using AR for an educational purpose, to reconstruct a heritage element and to visualise how it was used or its function; both opinions have achieving learning as their aim. The purpose of applying AR for teachers seems clear: superimposed reconstruction of the heritage item in its context to understand the heritage.

In the contrast between the groups, highly significant differences were found for items: C.25 ($p < 0.001$) and C.29 ($p < 0.01$). In both, it is the teachers in training who score higher and therefore agree more with the statement of the items. In the rest of the items, no differences were found that reached statistical significance or were close to it ($p > 0.10$).

4.4. Technical Features and Specifications Teachers Rate Most Highly

Secondly, to understand the technical requirements or features the teachers rate most highly when implementing an app in the classroom, a museum or a cultural setting, we use factors such as usability, functionality, interaction, accessibility or learning ability [82] (see Table 8). This set of questions, comprising 11 items, concerns technical aspects such as battery consumption or updates (items B.14, B.15, B.16 and B.17), usability (items B.18 and B.23) and educational and entertainment capacity (items B.19, B.20, B.21 and B.22).

Table 8. Mean of responses of the subsamples based on the variable: 'most highly rated features in implementing AR in a cultural setting'.

ITEM/Content	Mean (Standard Deviation)		Mann–Whitney Test	
	Teachers in Training (n = 216)	Teachers (n = 131)	Value	p-Value
B.14 Reduced battery consumption	3.98 (1.11)	3.50 (1.41)	2.92 **	0.004
B.15 Reduced data consumption	4.13 (1.01)	3.80 (1.29)	1.99 *	0.046
B.16 The app can be active in the background to use the device for other purposes: photos, music, messages, etc.	3.87 (1.08)	3.59 (1.28)	1.81 †	0.071
B.17 Does not take up much of the device's memory	4.09 (0.97)	3.92 (1.18)	0.82 N.S.	0.411
B.18 Intuitive and easy to use	4.37 (0.82)	4.47 (0.86)	−1.62 N.S.	0.105
B.19 Allows me to take original photos and add figures or characters and share them on social media	3.42 (1.26)	3.20 (1.32)	1.49 N.S.	0.136
B.20 Offers itineraries in a more appealing and visual way	4.06 (0.90)	4.11 (0.97)	−0.83 N.S.	0.406
B.21 Allows me to discover the most interesting places or most representative monuments in a more innovative and dynamic way	4.32 (0.79)	4.23 (0.96)	0.40 N.S.	0.691
B.22 Will also work as an audio guide or map if I do not want to activate the augmented reality	4.21 (0.91)	4.27 (1.00)	−1.12 N.S.	0.262
B.23 Does not require constant updates	3.94 (1.11)	3.98 (1.14)	−0.20 N.S.	0.845
B.24 Allows users to add new information to make it more interesting and complete	3.68 (1.04)	3.69 (1.11)	−0.23 N.S.	0.815

N.S. = NOT significant † = Nearly significant * = Significant ** = Highly significant.

In this questionnaire section, we wanted to highlight scores above 4 since, on this occasion, the responses were less unanimous and, as a result, the means were lower than in the previous block. Since this disparity in the responses is shown in the deviation, we believe it is due to the sample subjects' differing perceptions on the use of their mobiles or tablets. This difference is also seen in the subsamples where the youngest or teachers in training place more importance on consuming data, memory or battery than the practising teachers do.

Lastly, we also wanted to know whether they would like that the use of ICTs at a cultural location became an opportunity for a co-creation process of content with other students (B.24) [83]; however, this was not one of the features more highly rated by the teachers.

The respondents gave the highest priority to the app being as easy to use and as intuitive as possible (B.18), no doubt a consequence of the need for simplicity and immediacy in using ICTs. High scores were also obtained in items referring to innovative learning as they appreciated the app offering content in a more appealing and visual way (B.20 and B.21). Lastly, both groups gave a very positive rating to the app not only being used for AR but also as an audio guide or a map (B.22) and they indicated a preference for a multifunctional app.

When contrasting the mean values of both groups with each other, it was found that significance only appears in two items: B.14 ($p < 0.01$) and B.15 ($p < 0.05$), being in both the mean of the participants of the group of teachers in training higher than that of the active teachers. We could also speak of a quasi-significance ($p < 0.10$) in item B.16, with the same sense as the previous ones. In the rest of the items, no significance was found, nor a tendency towards it ($p > 0.10$).

4.5. Differences between Participants According to Their Responses in Relation to Their AR Knowledge

After analysis by blocks and groups of teaching staff, particularly significant results were found in the following areas:

(a) Educational strategies receive higher average values from practising teachers for those items that provide the student with reconstructions, recreations of the heritage

environment or context, audiovisual animations describing pieces or characters, visualisations of the original state, recreations of characters or functions and pigmentations.

(b) The functions on the advertising claim and the creation of gifts with the pieces presenting high values by the teachers in training.

(c) The technical features concerning low battery and data consumption, which have again been highlighted by the high average of trainee teachers.

These three perceptions lead us to interpret that active teachers have a much greater awareness of their practice and are looking for students to achieve greater knowledge and understanding, wanting AR apps to provide a greater educational use of the experience, while trainee teachers (most likely by generation) are looking for better technical features in apps based on their experience—remember that a large part of their time is spent using apps and social networks, and whose advertising or animated gifts functions are far from an educational function. These differences do not preclude educational search but do manifest higher levels in these functions and characteristics that are not as relevant for in-service teachers.

In a second analysis, the total sample was separated into (a) those teachers who said they had no knowledge—subjects who answered "No, this is the first time I have heard of it" or "Yes, I have heard of it, but I do not know how to explain it"—and (b) those who answered that they did know about it, including those who confused VR with AR—it was considered that the former cannot have any knowledge or experience with AR, while the latter do have it (at least partially).

The first group consists of $n = 151$ participants, the second of $n = 196$ remaining (56.5%). Among the $n = 151$ with no manifest knowledge: $n = 49$ are teachers and $n = 102$ are teachers in training. Among the $n = 196$ with knowledge (right or wrong): $n = 82$ teachers and $n = 114$ teachers in training.

With this variable as a possible explanatory factor, the items of the three blocks of the questionnaire were contrasted (results in Tables 9–11).

Table 9. Comparison of the means of the responses according to the knowledge of AR of the items in the block: 'teaching strategies'.

ITEM/Content	Mean (Standard Deviation)		Mann–Whitney Test	
	YES Knowledge ($n = 196$)	NO Knowledge ($n = 151$)	Value	p-Value
A.1 Complete reconstruction of the piece because it is very destroyed	4.86 (0.43)	4.70 (0.65)	3.10 **	0.002
A.2 Having a cartoon character explain the work of art or place	2.99 (1.15)	3.22 (1.22)	−1.91 †	0.056
A.3 Physical guide of the digitised museum accompanying visitors and explaining the pieces	3.90 (1.08)	4.03 (1.03)	−1.11 N.S.	0.266
A.4 Complete reconstruction of a place because there are remain	4.71 (0.61)	4.63 (0.63)	1.80 †	0.071
A.5 Having an actor in costume explain the work of art/place, etc.	3.77 (1.04)	3.58 (1.22)	1.26 N.S.	0.206
A.6 Interpretation and animation of the drawings of a pot, for ex-ample (or a sculpture, painting, etc.)	3.87 (1.13)	3.88 (1.05)	−0.13 N.S.	0.896
A.7 Superimposed representation of useful data that help to under-stand or interpret the piece or place	4.52 (0.71)	4.44 (0.77)	0.97 N.S.	0.331
A.8 Visualisation of the original condition and development or deterioration of the piece	4.42 (0.79)	4.28 (0.79)	1.98 *	0.048
A.9 Recreating the setting the piece might have been in (grave goods, a room, etc.) and understanding its context better	4.72 (0.60)	4.44 (0.74)	4.14 **	0.000
A.10 Recreating characters, function, use and/or handling of tools or places to understand what they were for or how they were used	4.57 (0.70)	4.51 (0.69)	1.05 N.S.	0.296
A.11 Immersive animation of a moving structure	3.41 (1.27)	3.74 (1.26)	−2.58 **	0.010
A.12 Reconstruction of the colours of a wall or painting (pigmentation)	4.42 (0.83)	4.35 (0.83)	0.95 N.S.	0.340
A.13 Audiovisual animation describing characters or elements of a work of art (it can be a painting, a sculpture, etc.)	4.46 (0.81)	4.48 (0.79)	−0.35 N.S.	0.728

N.S. = NOT significant † = Nearly significant * = Significant ** = Highly significant.

Table 10. Comparison of the means of the responses according to the knowledge about AR of the items in the block: 'Desirable function in using AR in a cultural setting'.

ITEM/Content	Mean (Standard Deviation)		Mann–Whitney Test	
	YES Knowledge (n = 196)	NO Knowledge (n = 151)	Value	p-Value
C.25 As an advertising ploy (take a selfie with one of our characters)	2.63 (1.23)	2.78 (1.24)	−1.02 N.S.	0.306
C.26 As a guide to understand a work of art or heritage asset	4.02 (1.03)	3.86 (1.01)	1.65 †	0.098
C.27 Seeing the reconstruction of a heritage asset that has deteriorated or of which only traces remain	4.63 (0.77)	4.17 (0.98)	5.23 **	0.000
C.28 Seeing an animation that enables me to understand how the piece was used or what it was for	4.39 (0.87)	4.10 (0.96)	3.02 **	0.002
C.29 Seeing a painting or a sculpture with a small GIF.	2.83 (1.36)	3.03 (1.17)	−1.58 N.S.	0.115

N.S. = NOT significant † = Nearly significant ** = Highly significant.

Table 11. Comparison of the means of the answers according to the knowledge about AR of the items of the block: 'most highly rated features in implementing AR in a cultural setting'.

ITEM/Content	Mean (Standard Deviation)		Mann–Whitney Test	
	YES Knowledge (n = 196)	NO Knowledge (n = 151)	Value	p-Value
B.14 Reduced battery consumption	3.83 (1.23)	3.77 (1.28)	0.33 N.S.	0.740
B.15 Reduced data consumption	4.07 (1.13)	3.92 (1.14)	1.41 N.S.	0.158
B.16 The app can be active in the background to use the device for other purposes: photos, music, messages, etc.	3.91 (1.16)	3.57 (1.15)	2.95 **	0.003
B.17 Does not take up much of the device's memory	4.07 (1.08)	3.96 (1.03)	1.33 N.S.	0.183
B.18 Intuitive and easy to use	4.47 (0.78)	4.33 (0.90)	1.31 N.S.	0.189
B.19 Allows me to take original photos and add figures or characters and share them on social media	3.34 (1.33)	3.33 (1.22)	0.23 N.S.	0.816
B.20 Offers itineraries in a more appealing and visual way	4.09 (0.88)	4.06 (0.99)	0.05 N.S.	0.959
B.21 Allows me to discover the most interesting places or most representative monuments in a more innovative and dynamic way	4.31 (0.88)	4.25 (0.84)	0.94 N.S.	0.348
B.22 Will also work as an audio guide or map if I do not want to activate the augmented reality	4.32 (0.87)	4.11 (1.02)	1.88 †	0.061
B.23 Does not require constant updates	4.01 (1.15)	3.93 (1.09)	0.97 N.S.	0.332
B.24 Allows users to add new information to make it more interesting and complete	3.68 (1.08)	3.70 (1.05)	−0.01 N.S.	0.993

N.S. = NOT significant † = Nearly significant ** = Highly significant.

As can be seen in Table 9, there is a very significant difference ($p < 0.01$) in items A1 and A9:A1 and A9, where participants with knowledge score higher than those without experience (knowledge), and, in the same sense, significance in item A8 ($p < 0.05$). In the opposite direction, i.e., higher scores for those with no knowledge of AR, there is significance ($p = 0.01$) in item A11. Finally, we can speak of a tendency towards significance ($p < 0.10$) in items A2 and A4, each in one direction.

Regarding the comparison of the desirable function of AR applications (see Table 10), the results of the analysis show a high significance in items C27 ($p < 0.001$) and C28 ($p < 0.01$), in which participants who do have some knowledge score higher. A quasi-significance ($p < 0.10$) can be reported for item C26, in the same sense as the previous items.

Finally, the inferential contrast test is applied to the technical characteristics block (see Table 11). In the latter, there is less variability, with significance only appearing in item B16 ($p < 0.01$) in which subjects with knowledge of AR score higher than those without. Likewise, we can speak of a quasi-significance ($p < 0.10$) in item B22, the difference observed being in the same direction as the previous one.

These results show that teachers with previous knowledge of AR, who are aware of the educational potential of this technology, are more demanding with regard to its application in educational processes, demanding quality reconstructions, recreations and original or evolutionary visualisations for heritage assets, as well as other parallel functions such as audio guides or explanatory maps; on the other hand, those teachers who do not have knowledge and/or experience in AR focus, above all, on the most superficial part of

this type of technology: the visual and attractive component, such as cartoons explaining the works or immersive processes with moving works.

5. Discussion

Recent studies support the use of AR as a tool to attain significant learning in museums [84], highlighting its motivation capacity in an interactive learning context [30]. Many museum installations use AR and apps for contextualised learning of heritage [49,71,85,86].

However, the integration of AR in formal educational contexts is proving slow and varies widely, at least in Spain, for several reasons: a legal framework limiting the use of mobile and personal devices in the classroom [87]; the existing digital divide [88]; and the lack of resources and training for teachers [66,89] that some international studies have already exposed [90–93]. In this sense, as we can see from our study, there is still a large proportion of teachers (almost half of our total sample—67.4%) who do not know what augmented reality really is or confuses it with VR—which can also be extrapolated to the world population, as other studies indicate [94–96] — making it impossible to integrate it into the classroom as a resource for mediated heritage reading. Other countries have already considered these limitations and propose their own spaces for learning to use AR without the need for specific training in programming [97], such as apps used in museums and heritage spaces, which is why we believe this is one of the methods that can be integrated more easily into the educational context.

5.1. Teachers' Knowledge of AR: Essential Training for Its Implementation

Focusing on the Spanish context, we tried to locate, in an initial state, educational proposals that implemented AR in educational centres in order to learn about teaching practices, and what we found were user satisfaction studies from museum institutions, which still demonstrated the isolated nature of its implementation in formal education. Currently, although heritage education is a well-established discipline, it continues to have training needs among teachers, both in training and active [98,99], so implementing AR is a double effort that requires deepening not only in teaching skills in heritage education, but also in digital environments as a learning tool [1,100]. Several authors nationally and internationally are asking about the competences required for heritage professionals, emerging roles and digital competences [100–103]. This brings us directly to the first question.

This course of action suitably corresponds to the usability features highlighted by the sample users in point 3.4 and provides a response to the first of our questions (Q1), demonstrating that teachers rate AR as a beneficial tool for learning but do not have the resources to implement it (76.9%). It is also a first contact, from a comfort zone, for those that so far do not know or have not experienced AR as an educational resource (15.3%) or state that they do not think it is useful or see more problems than advantages (11.5%).

In an overall analysis of the data, we cannot ignore that all the educational items on the use of AR included in this questionnaire have been rated with a mean above three points, mostly closer to four points or higher, which infers a great deal of interest in applying AR in formal teaching and confidence in its educational possibilities.

In Spain, there are several studies that have asked future teachers about their training in heritage education and only 20% of the participants indicated having had adequate training [100], which is a worrying figure for facing the new demands, challenges and challenges of the 21st century [104,105]. In line with this low figure, this study showed a demonstrative knowledge of AR on the part of 32.6% of teachers, which confirms the lack of updating in their training. This figure also conflicts with the lines of action of the new frameworks that seek to promote the development of digital competence [41–43].

These innovative tools require dedication on the part of the teacher, a recycling and updating of knowledge which, in many cases, stems from the autonomous commitment of teachers and this is something that must be reversed, because if there are new forms, techniques, contexts, tools or teaching-learning resources and we want society to benefit from them, there must be a commitment on the part of the institutions to train and bring

these new possibilities to teachers. If these new technologies remain stagnant in museums, the interpretation leads us to think about the only return they want to get, the economic potential that can promote the tourism sector attracted by these applications as a lure, something already addressed by [31,71]. The latter point out that "cultural tourism has not been unaffected by the extraordinary development of Industry 4.0, finding in it new tools and ways of interacting with the visitor, in order to increase and enrich the attractiveness of heritage sites and increase the market of potential visitors [106]" and, therefore, more and more tourist sites are incorporating experiences with AR technology.

Throughout the study, numerous research studies have been collected that delve into the educational possibilities of AR [14,16–19,26–28] and the role of AR among education professionals in the Spanish context, where heritage education and heritage spaces are of particular importance [1,31,71].

This study highlights the possibilities and benefits that AR can bring to the understanding of heritage, providing learners with a reflective and experiential approach, not just knowledge. Even more so in this new scenario brought about by the COVID-19 pandemic, where virtuality, online spaces and digital archives have been the main driver of knowledge [107].

5.2. Understanding Heritage, a Key Objective for Teachers: The Most Valued Teaching Strategies and Functions in AR

Concerning our second aim—corresponding to the educational strategies most highly rated by teachers (Q2)—they highlighted processes of reconstruction, the superimposed representation of information for understanding, re-creation and audiovisual animation, which have already been mentioned in previous studies [24,51,52,108]. These strategies involve experimentation in real contexts [29] providing a holistic and sensory experience of learning already outlined in theory [34]. In this triangulation we should also point out that the results obtained in this first questionnaire block—reconstruction and animation—are repeated in the third block on the preferred function when implementing AR (Q3); it is, therefore, demonstrated that the completion of the questionnaire was coherent and consistent.

In contrast, the lowest rating was given to implementing a cartoon as a guide to interpret the heritage, an item that was later checked using the adjacent question on preferences in virtual mediation. Both the teachers and teachers in training prefer human interaction with either a character in costume or simply a museum guide. The results obtained confirm the theories of authors such as [109], who discussed the potential of virtual humans, use of avatars or personifications as accompaniment during visits or to explain the museum collections as a positive strategy for institutions that meets with the approval of users. This idea has also been put forward by other authors [110] and is associated with empathy and emotions. It has been implemented successfully in some apps offering a range of activities with AR [71]. The rigour of museum employees as virtual guides [49] or the use of strategies such as storytelling by actors in costumes to recreate and facilitate understanding of aspects of daily life and of the historical context of heritage assets [86] could explain the preference of respondents for mediation or human accompaniment as an extension of the kind of interaction that would take place without ICTs—instead of using a fictional component (an avatar or a cartoon character).

5.3. Multi-Functionality and Intuitive Use, Main Demands in AR Application

Concerning the third block in the questionnaire, corresponding to an app's technical and usability features most highly rated by teachers in implementing AR (Q4), the answers demonstrate the need for an application to be easy and intuitive—an item included previously on the limitations of implementing AR in the classroom and the non-availability of suitable resources—multifunctionality and dynamic and innovative knowledge of places. Based on the abovementioned arguments, and expanding on the first of them, several studies state that the technical drawbacks include the fact that software developments are still too expensive for the budget of most institutions managing local heritage [40] and they

highlight that the apps are short-lived due to technical updating issues, which makes the educational potential of these tools hard to critically rate and, consequently, they are barely known, disseminated or used by teachers [66]. Some studies mentioned that it was hard for the adult population to use a touchscreen, or difficulties associated with a graphic design that was not well adapted to mobile devices [111,112]. However, our study focuses on other kinds of technical specifications such as device autonomy due to battery consumption or data use. Nevertheless, both subsamples prioritise ease of use and multifunctionality over other technical aspects.

The data on the second factor, multifunctionality, give us clues about demand and expectations concerning AR resources. Any institution wishing to design a heritage education experience supported by VR, AR or mixed reality (X reality) must consider factors such as usability or multifunctionality when developing the app and offer partial and complete reconstructions of the pieces and their contexts to achieve significant learning. Examples of good practices in this regard are becoming increasingly more frequent and can serve as a guide for other applications [59,61,71].

Lastly, the third factor—innovation and dynamism to discover places—emphasises the importance of promoting original interaction experiences between the user and the space, with processes and suggestions adapted to every scenario [113] and educational change [105], offering different types of learning [12,13,22] and creating these abovementioned new immersive, engaging and novel learning ecosystems [30]. Heritage cannot be extrapolated from a physical plane to a virtual one and still be rooted in a positivist and academic vision. As part of this innovation, some authors say that using AR in a series of gamified activities can be easy to apply, stimulating and productive for visitors to achieve significant learning [47,50], provided the app is adapted to visitors' ages, for example by offering several levels of difficulty applied to every piece [60].

The most prominent differences in the responses occurred in this variable, which leads us directly to the last question: discovering whether there are significant differences between the subsamples (Q5).

5.4. Understanding Heritage, a Key Objective for Teachers: The Most Valued Teaching Strategies and Functions in AR

To conclude the discussion, we turn to the last of the proposed objectives, to compare whether there are differences between the sub-samples (Q5). This has been done by distinguishing between teachers in training and those who are active and, in a second stage, taking into account the variable of manifest or unmanifest knowledge of AR. In the first case, the responses obtained were fairly homogeneous if we look at a simple comparison of averages, so there are no significant differences. This may be due to the fact that, especially in the case of the teaching staff, we are talking about a teaching body that is aware of and often trained in the use of ICT in the classroom; however, the in-service teachers show higher averages in relation to the value they give to educational strategies that respond to deeper understanding processes such as the complete reconstruction of the heritage, the recreation of the context or environment of the heritage asset or the audiovisual animation that describes it, as well as the functions of visualisation of the original or its pigmentation, which leads to the interpretation of a high desire to facilitate the understanding of heritage through AR. On the other hand, trainee teachers gave higher ratings than active teachers to functions such as advertising to attract users or animation through gifts or technical features related to low battery or data consumption, which can be explained by the fact that they belong to a generation of digital consumption in which they are immersed, where the hours of use of mobile devices, apps and social networks is increasingly higher [114,115] and, as such, they are looking for a type of feature that allows them to be connected more and more, with more simultaneous functions and low consumption.

In the second variable, the results can be interpreted as a whole, as the sub-sample with no knowledge shows higher values for simple educational strategies, immersion in a moving work or an animated drawing that explains the heritage asset, while those with prior knowledge show higher values for reconstruction, recreation or original or

evolving visualisation of the heritage asset. From these differences, we can see that those who have no prior knowledge have no idea of the educational potential of RA, which is why this training and experimentation is necessary. In this case, their assessments focus on attractive or motivating visual elements for their students instead of comprehensive learning strategies. In addition to this, the subsample with some prior knowledge demand more functions from the apps, such as being able to keep it in the background to have other applications or functions active and also to serve as an audio guide or explanatory map, with which they know more reliably what it can offer and propose improvements for its implementation; something that the study [77] points out to increase the scope of AR by seeking a greater reach than its potential guarantees through multimodal interfaces or tangible interaction.

There are no previous studies with which we can discuss the results obtained on this last point, at least in this particular field between contrasting samples; however, the differences can be explained by the teaching development itself. There are studies that do address the transitions from trainee to practising teachers and that help us to weave some of the interpretations gathered here. According to [116], teachers in the early years undergo a transformative process from student to teacher that is full of tensions and learning in unfamiliar contexts, a fundamental stage in which they must acquire knowledge and which, in today's much more changing society, some authors [117] define as "adaptive experts". This stage is essential in teacher growth, however, it must be provided with the maximum knowledge and experience in its formative stage, as students' learning and experiences will depend on what teachers know and implement [118]. The lack of knowledge leads us to obtain in the sample that does not know AR a lower motivation in its implementation and a preference for more basic functions in its application, in addition to the implicit lack of knowledge of its possibilities. It is also true that not only will experience provide teachers with greater expertise, but they must also reflect and train continuously, and it is therefore understandable that in-training teachers show a lower preference for items that deal with more complex processes in educational terms. Likewise, other factors such as age influence their choices, as it is sometimes taken for granted that the new generations are digital natives, and this is not the case [119,120], far from this premise being true, their knowledge and technological use differ as some studies have already pointed out [121–123]. This is why the results obtained do not emphasise the superior AR knowledge of trainee teachers compared to practising teachers, but rather that it is parallel and indifferent in both samples. These findings lead us again and again to conclude that what is truly significant is the knowledge, which also presents greater demands in its application due to the sample subjects' own experimentation with the use of AR.

6. Conclusions

The main aim of this research was to discover the features teachers and teachers in training want to see in an app offering augmented reality in a cultural setting—museum or archaeological site—for entertainment and educational purposes with the heritage, in communion with other studies [77,78,85].

Considering the results obtained, we can conclude that (6):

1. Both the teachers and the teachers in training consider the use of AR a priority for the synchronous reconstruction of the heritage piece and its context to enhance experience [13,16,28]. As mentioned above, these are more holistic processes that favor the understanding of the heritage asset—what it was like, how it has evolved, what its use, function or operation was—and this preference involves the highest possible level of exploration of the piece or place, so if the possibility exists, the teacher will look for the most complete learning process in AR.
2. There is a consensus on using humanised figures to interpret the heritage, for the apps to have mediation with experts to ensure the information is precise, or images of actors in costume so the students can form a picture of the age, thus improving their understanding of the context of the historical moment referred to. Respondents

moved away from simple animations that guide the visit in favour of a more real and tangible knowledge of the heritage, not even teachers in training at lower levels expressed this preference.

3. Ease of use and multifunctionality are the two most appreciated features by both subsamples when using an app in a museum or at an archaeological site, as well as the need for it to be compatible with the simultaneous use of the user's other apps and low battery consumption. These characteristics are more pronounced in young people due to the massive use of digital devices and by subjects who have greater knowledge of AR, precisely because the knowledge of the possibilities of AR makes their demand on its strategies, functions and characteristics greater.
4. Active teachers are looking for more complete educational strategies that allow them to understand the heritage in depth, above the superficiality of knowledge and enjoyment, the result of what experience shapes in the teacher. These show higher results in favour of more holistic educational procedures.
5. Teachers in training are experiencing a generational change—greater consumption of mobile devices—which leads to a greater demand for improved technical features, and where, as they are in a training process, their objective is not only educational but also to attract publicity. As mentioned in the discussion, this result will change as teachers grow, because with experience their objectives will become more didactic, and they will seek a higher educational performance.
6. The participants with prior knowledge express a greater demand for the educational and technical possibilities of AR, while those without are looking for a more attractive and animated aspect such as drawings or moving artworks, a more superficial aspect of the potential of this new technology.

Some unavoidable needs can be extracted from this study, such as the need for training and educational policies for the incorporation, application and development of virtual environments for cultural heritage or research into models, interactive designs and virtual prototypes to promote knowledge of heritage, as already stated [31,94,124]. Future studies should investigate the perception of active teachers be-fore and after receiving training on the implementation of AR in the classroom or after using it in a guided tour.

Future studies should address the specific suggestions made by teachers and teachers in training so they can be implemented in the classroom, in museums and at archaeological sites. As already mentioned, one of the directions to follow should be creating joint projects, for designers and educators to pursue the same objective; the teachers must learn the educational possibilities of AR and the designers the content of the curricula in the educational stages and learning contexts to foster technical and cognitive accessibility. However, a first contact should be related to user-level knowledge of AR, since there is a large part of the sample that does not know what AR really is or confuses it with VR. Knowledge, therefore, emerges as a first step for the implementation of this resource in formal education, an aspect already pointed out by other studies [94,124].

In prospective terms, AR research offers a wide range of possibilities, with the short- and medium-term lines of action being the evaluation of learning from the implementation of educational practices with AR around heritage and the creation of didactic content on the design of AR experiences to implement in the classroom and thus provide new motivating training possibilities for students. In addition, delving into the perception of museum managers and curators may be of interest to contrast what is sought or valued in each of the links of formal and non-formal education. Finally, this line must reach the real implementation, so we are designing applicable experiences that allow us to know these learnings and assess the real experimentation of AR in educational spaces—applied both to the classroom and to heritage spaces—, and give voice to teachers, students and other agents to obtain a holistic view of the proposed research.

The Implication of AR in Digital Education

To conclude, we must consider the coming economic and cultural context with the 2030 Agenda and Sustainable Development Objectives [43], as well as the obvious interest in promoting the use of digital resources and strategies to develop digital competence [40,103,125]. Both aspects must be considered by private companies and public institutions supporting the creation of apps to protect and research heritage and the production of AR tools that can be used in formal education. The conclusions outlined in this article must also be addressed. Both the teachers and teachers in training not only adopt the tools and possibilities ICTs offer as their own, but they also require them to mainly facilitate contents of both the piece to be analysed and other integral aspects—context, development, function and usefulness—so the heritage can be understood holistically and significantly, which may lead to awareness of and commitment to it as the ultimate aim of the educational process.

Society has witnessed how quickly teachers have adapted to this new scenario, and, in turn, the polarisation of both society and teachers according to the economic resources of students and the digital skills developed by teachers, which has differentiated the educational experiences of learners, some being enriched in terms of hours and dedication and others being almost non-existent, thus accentuating the differences in learning levels that will have their most immediate repercussions in the coming courses [107]. Therefore, this line deals with a relevant and emerging topic, as it is necessary to update education, adapt to new needs and develop digital competence [41], the SDGs [43] and the European Framework for the Digital Competence of Educators [42], for which AR is a key tool in the knowledge, understanding, experimentation and enjoyment of heritage; the closer we get to knowledge, the more we value it and care for it, as the sequence of patrimonialisation rightly points out [126]. This article contributes to making these absences visible by identifying the main objectives to be achieved, the most valued functions to be fulfilled, and, most importantly, it opens up a latent problem, the absence of a practical scenario that would allow us to investigate its application in line with the theory that has been developed.

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References

1. Ibáñez-Etxeberria, A.; Kortabitarte, A.; De Castro, P.; Gillate, I. Competencia digital mediante apps de temática patrimonial en el marco DigComp. *Rev. Interuni. Form. Prof.* **2019**, *22*, 13–27. [CrossRef]
2. Caudell, T.; Mizell, D. Augmented reality: An application of heads-up display technology to manual manufacturing processes. In Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences, Kauai, HI, USA, 7–10 January 1992; Volume 2, pp. 659–669. [CrossRef]
3. Bareld, W.; Hendrix, C. The Effect of Update Rate on the Sense of Presence within Virtual Environments. *Virtual. Real.* **1995**, *1*, 3–16. [CrossRef]
4. Azuma, R. A Survey of Augmented Reality. *Presence Teleoper. Virtual Environ.* **1997**, *6*, 355–385. [CrossRef]
5. Azuma, R. Augmented Reality: Approaches and Technical Challenges. In *Fundamentals of Wearable Computers and Augmented Reality*; Barfield, W., Caudell, T., Eds.; Lawrence Erlbaum Associates: Mahwah, NJ, USA, 2001; pp. 27–63, ISBN 0-8058-2901-6.
6. Piqueras Casado, E.M.; Cózar Guitérrez, R.; González-Calero Somoza, J.A. Incidencia de la realidad aumentada en la enseñanza de la historia. Una experiencia en tercer curso de educación primaria. *Enseñ. Teach.* **2017**, *36*, 23–39. [CrossRef]
7. Milgram, P.; Kishino, F. A Taxonomy Of Mixed Reality Visual Displays. *Ieice Trans. Inf. Syst.* **1994**, *E77-D*, 1321–1329.
8. Blázquez-Sevilla, A. Realidad Aumentada en Educación. Universidad Politécnica de Madrid. Gabinete de Tele-Educación. 2017. Available online: http://oa.upm.es/45985/1/Realidad_Aumentada__Educacion.pdf (accessed on 21 March 2021).
9. Chang, Y.-S.; Chen, C.-N.; Liao, C.-L. Enhancing English-Learning Performance through a Simulation Classroom for EFL Students Using Augmented Reality—A Junior High School Case Study. *Appl. Sci.* **2020**, *10*, 7854. [CrossRef]
10. Fernández-Enríquez, R.; Delgado-Martín, L. Augmented Reality as a Didactic Resource for Teaching Mathematics. *Appl. Sci.* **2020**, *10*, 2560. [CrossRef]
11. Bacca-Acosta, J.; Baldiris, S.; Fabregat, R.; Kinshuk, D.; Graf, S. Mobile Augmented Reality in Vocational Education and Training. *Procedia Comput. Sci.* **2015**, *75*, 49–58. [CrossRef]
12. Cabero, J.; Barroso, J. Posibilidades educativas de la Realidad Aumentada. *New Approaches Educ. Res.* **2016**, *5*, 46–52. [CrossRef]
13. Fombona, J.; Pascual-Sevillano, M.; González-Videgaray, M. M-learning and augmented reality: A review of the scientific literature on the WoS repository. [M-learning y realidad aumentada: Revisión de literatura científica en el repositorio WoS]. *Comunicar* **2017**, *52*, 63–72. [CrossRef]
14. Radu, I. Augmented reality in education: A meta-review and cross-media analysis. *Pers. Ubiquitous Comput.* **2014**, *18*, 1533–1543. [CrossRef]
15. Di Serio, A.; Ibáñez, M.; Delgado-Kloos, C. Impact of an augmented reality system on students' motivation for a visual art course. *Comput. Educ.* **2013**, *68*, 586–596. [CrossRef]
16. Dalgarno, B.; Lee, M.J.W. What are the learning affordances of 3-D virtual environments? *Br. J. Educ. Technol.* **2010**, *41*, 10–32. [CrossRef]
17. Bacca, J.; Baldiris, S.; Fabregat, R.; Graf, S.; Kinshuk. Augmented reality trends in education: A systematic review of research and applications. *Educ. Technol. Soc.* **2014**, *17*, 133–149.
18. Alzahrani, N.M. Augmented Reality: A Systematic Review of Its Benefits and Challenges in E-learning Contexts. *Appl. Sci.* **2020**, *10*, 5660. [CrossRef]
19. Majeed, Z.; Ali, H. A review of augmented reality in educational applications. *Int. J. Adv. Technol. Eng. Explor.* **2020**, *7*, 20–27. [CrossRef]
20. Delgado-Algarra, E.J. *ICTs and Innovation for Didactics of Social Sciences*; IGI Global: Hershey, PA, USA, 2020. [CrossRef]
21. Geroimenko, V. (Ed.) *Augmented Reality in Education. A New Technology for Teaching and Learning*; Springer: Berlin/Heidelberg, Germany, 2020.
22. Wu, H.-S.; Lee, S.; Chang, H.-Y.; Liang, J. Current status, opportunities and challenges of augmented reality in education. *Comput. Educ.* **2013**, *62*, 41–49. [CrossRef]
23. Barrado-Timón, D.A.; Hidalgo-Giralt, C. The Historical City, Its Transmission and Perception via AugmentedReality and Virtual Reality and the Use of the Past as a Resource for the Present: A New Era for UrbanCultural Heritage and Tourism? *Sustainability* **2019**, *11*, 2835. [CrossRef]
24. Petrucco, C.; Agostini, D. Teaching our cultural heritage using mobile augmented reality. J.E. *Learn. Knowl. Soc.* **2016**, *12*, 115–128.
25. Rivas, Y.C.; Valdivieso, P.A.V.; Rodríguez, M.A.Y. Virtual reality and 21st century education. *Int. Res. J. Manag. IT Soc. Sci.* **2020**, *7*, 37–44. [CrossRef]
26. Squire, K.; Klopfer, E. Augmented reality simulations on handheld computers. *J. Learn. Sci.* **2007**, *16*, 371–413. [CrossRef]
27. Dunleavy, M.; Dede, C.; Mitchell, R. Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. J. *Sci. Educ. Technol.* **2009**, *18*, 7–22. [CrossRef]
28. Chen, C.M.; Tsai, Y.N. Interactive augmented reality system for enhancing library instruction in elementary schools. *Comput. Educ.* **2012**, *59*, 638–652. [CrossRef]
29. Bujak, K.; Radu, I.; Catrambone, R.; Macintyre, B.; Zheng, R.; Golubski, G. A psychological perspective on augmented reality in the mathematics classroom. *Comput. Educ.* **2013**, *68*, 536–544. [CrossRef]

30. Cózar, R.; De Moya, M.V.; González-Calero, J.A.; Villena, R. *Realidad Aumentada en las aulas Universitarias. Valoración de Una Experiencia en el Grado de Maestro*; En Jornadas Universitarias de Tecnología Educativa: Burgos, Spain, 2017.
31. Ibáñez-Etxeberria, A.; Gómez-Carrasco, C.J.; Fontal, O.; García-Ceballos, S. Virtual Environments and Augmented Reality Applied to Heritage Education. An Evaluative Study. *Appl. Sci.* **2020**, *10*, 2352. [CrossRef]
32. Ruiz, D.; Gant, M.L.B. La presencia de la realidad aumentada en los museos del siglo XXI: Difusión y accesibilidad a través de lo virtual. In *ArTecnología. Conocimiento Aumentado y Accesibilidad*; Andrade, V., Colorado, A., Moreno, I., Eds.; Universidad Complutense de Madrid: Madrid, Spain, 2014; pp. 218–223.
33. Fabregat, R. Combinando la realidad aumentada con las plataformas de e-elearning adaptativas. *Enl@Ce Rev. Venez. Inf. Tecnol. Conoc.* **2012**, *9*, 69–78.
34. Graziano, T.; Privitera, D. Cultural heritage, tourist attractiveness and augmented reality: Insights from Italy. *J. Herit. Tour.* **2020**, *15*, 666–679. [CrossRef]
35. Wojciechowski, R.; Cellary, W. Evaluation of learners' attitude toward learning in ARIES augmented reality environments. *Comput. Educ.* **2013**, *68*, 570–585. [CrossRef]
36. García, I.; Peña-López, I.; Johnson, L.; Smith, R.; Levine, A.; Haywood, K. *Informe Horizon: Edición Iberoamericana*; The New Media Consortium: Austin, TX, USA, 2010.
37. González-Rodríguez, M.R.; Díaz-Fernández, M.C.; Pino-Mejías, M.Á. The impact of virtual reality technology on tourists' experience: A textual data analysis. *Soft Comput.* **2020**, *24*, 13879–13892. [CrossRef]
38. Little, C.; Bec, A.; Don-Moyle, B.; Patterson, D. Innovative methods for heritage tourism experiences: Creating windows into the past. *J. Herit. Tour.* **2020**, *15*, 1–13. [CrossRef]
39. Lv, M.; Wang, L.; Yan, K. Research on Cultural Tourism Experience Design Based on Augmented Reality. In Proceedings of the 8th International Conference, C&C 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, 19–24 July 2020. [CrossRef]
40. Templin, T.; Popielarczyk, D. The Use of Low-Cost Unmanned Aerial Vehicles in the Process of Building Models for Cultural Tourism, 3D Web and Augmented/Mixed Reality Applications. *Sensors* **2020**, *20*, 5457. [CrossRef]
41. Consejo de Europa. Recomendación 2006/962/CE del Parlamento Europeo y del Consejo, de 18 de Diciembre de 2006, Sobre las Competencias Clave para el Aprendizaje Permanente, Diario Oficial L 394 de 30.12.2006. Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:394:0010:0018:ES:PDF (accessed on 21 March 2021).
42. Redecker, C.; Punie, Y. (Eds.) *European Framework for the Digital Competence of Educators*; DigCompEdu. Publications Office of the European Union: Luxenbourg, 2017. Available online: https://publications.jrc.ec.europa.eu/repository/handle/JRC107466 (accessed on 15 March 2021).
43. UNESCO; UNICEF; The World Bank; UNFPA; UNDP; UN Women; UNHCR. Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. ED-2016/WS/28 W. In Proceedings of the World Education Forum 2015, Incheon, Korea, 19–22 May 2015. Available online: http://uis.unesco.org/sites/default/files/documents/education-2030-incheon-framework-foraction-implementation-of-sdg4-2016-en_2.pdf (accessed on 20 March 2021).
44. Sparacino, F.; Davenport, G.; Pentland, A. Media in performance: Interactive spaces for dance, theater, circus, and museum exhibits. *IBM Syst. J.* **2000**, *39*, 479–510. [CrossRef]
45. Brown, B.; MacColl, I.; Chalmers, M.; Galani, A.; Randell, C.; Steed, A. Lessons from the lighthouse: Collaboration in a shared mixed reality system. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03), Ft. Lauderdale, FL, USA, 5–10 April 2003; Association for Computing Machinery: New York, NY, USA, 2003; pp. 577–584. [CrossRef]
46. Bowers, J.; Bannon, L.; Fraser, M.; Hindmarsh, J.; Benford, S.; Heath, C.; Taxén, G.; Ciolfi, L. From the Disappearing Computer to Living Exhibitions: Shaping Interactivity in Museum Settings. In *The Disappearing Computer. Lecture Notes in Computer Science*; Streitz, N., Kameas, A., Mavrommati, I., Eds.; Springer: Berlin/Heidelberg, Germany, 2007; Volume 4500. [CrossRef]
47. Angelopoulou, A.; Economou, D.; Bouki, V.; Psarrou, A.; Jin, L.; Pritchard, C.; Kolyda, F. Mobile Augmented Reality for Cultural Heritage. In Proceedings of the Mobile Wireless Middleware, Operating Systems, and Applications, Proceedings of the 4th International ICST Conference, Mobilware, London, UK, 22–24 June 2011; Venkatasubramanian, N., Getov, V., Steglich, S., Eds.; Springer: New York, NY, USA, 2012; pp. 15–22.
48. Escaplés, J.; Tejerina, D.; Bolufer, J.; Esquembre, M.A. Sistema de Realidad Aumentada para la musealización de yacimientos arqueológicos. *Virtual Archaeol. Rev.* **2013**, *4*, 42–47. [CrossRef]
49. Chatzidimitris, T.; Kavakli, E.; Economou, M.; Gavalas, D. Mobile Augmented Reality edutainment applications for cultural institutions. In Proceedings of the 4th International Conference on Information, Intelligence, Systems and Applications—IISA2013, Mikrolimano, Greece, 10–12 July 2013; pp. 10–12.
50. Perra, C.; Grigoriou, E.; Liotta, A.; Song, W.; Usai, C.; Giusto, D. Realidad aumentada para la educación del patrimonio cultural. In *2019 IEEE IX Conferencia Internacional de Electrónica de Consumo*; ICCE: Berlín, Germany, 2019; pp. 333–336.
51. Furata, H.; Takahashi, K.; Nakatsu, K.; Ishibashi, K.; Aira, M. A mobile application system for sightseeing guidance using augmented reality. In Proceedings of the 6th International Conference on Soft Computing and Intelligent Systems and the 13th International Symposium on Advanced Intelligence Systems, Kobe, Japan, 20–24 November 2012; pp. 20–24.
52. Zhang, Y.; Han, M.; Chen, W. The strategy of digital scenic area planning from the perspective of intangible cultural heritage protection. *EURASIP J. Image Video Process.* **2018**, *1*, 130. [CrossRef]

53. BOCyL. ORDEN EDU/832/2015, De 2 De Octubre, Por la Que se Regula el Proyecto Denominado "FORMapps" para la Implantación de Nuevas Metodologías de Formación Permanente del Profesorado en su Competencia Digital, en Centros Educativos Sostenidos con Fondos Públicos de la Comunidad de Castilla y León. 2015. Available online: http://bocyl.jcyl.es/boletines/2015/10/14/pdf/BOCYL-D-14102015-1.pdf (accessed on 20 September 2019).
54. Pierdicca, R.; Frontoni, E.; Puggioni, M.P.; Malinverni, E.S.; Paolanti, M. Evaluating Augmented and Virtual Reality in Education through a User-Centered Comparative Study: SmartMarca Project. In *Virtual and Augmented Reality in Education, Art, and Museums*; IGI Global: Hershey, PA, USA, 2020; pp. 229–261. Available online: https://www.igi-global.com/gateway/chapter/241603 (accessed on 27 May 2021).
55. Espinosa, C.P. Realidad aumentada y educación: Análisis de experiencias prácticas. *Pixel-Bit. Rev. de Medios y Educ.* **2015**, *46*, 187–203. [CrossRef]
56. Almenara, J.C.; Jiménez, F.G.; Osuna, J.B. La producción de objetos de aprendizaje en "Realidad Aumentada": La experiencia del SAV de la Universidad de Sevilla. *IJERI Int. J. Educ. Res. Innov.* **2016**, *6*, 110–123. Available online: http://hdl.handle.net/11441/41045 (accessed on 16 June 2021).
57. Cabero-Almenara, J.; Vázquez-Cano, E.; López-Meneses, E. Uso de la Realidad Aumentada como Recurso Didáctico en la Enseñanza Universitaria. *Form. Univ.* **2018**, *11*, 25–34. [CrossRef]
58. Quesada, M.B.; Poveda, A.M.S. Realidad aumentada como tecnología aplicada a la educación superior: Una experiencia en desarrollo. *Innov. Educ.* **2016**, *17*, 41–50.
59. Margetis, G.; Apostolakis, K.C.; Ntoa, S.; Papagiannakis, G.; Stephanidis, C. X-Reality Museums: Unifying the Virtual and Real World Towards Realistic Virtual Museums. *Appl. Sci.* **2021**, *11*, 338. [CrossRef]
60. Paliokas, I.; Patenidis, A.T.; Mitsopoulou, E.E.; Tsita, C.; Pehlivanides, G.; Karyati, E.; Tsafaras, S.; Stathopoulos, E.A.; Kokkalas, A.; Diplaris, S.; et al. A Gamified Augmented Reality Application for Digital Heritage and Tourism. *Appl. Sci.* **2020**, *10*, 7868. [CrossRef]
61. Pehlivanides, G.; Monastiridis, K.; Tourtas, A.; Karyati, E.; Ioannidis, G.; Bejelou, K.; Antoniou, V.; Nomikou, P. TheVIRTUALDiver Project. Making Greece's Underwater Cultural Heritage Accessible to the Public. *Appl. Sci.* **2020**, *10*, 8172. [CrossRef]
62. Cuenca-López, J.M.; Molina-Puche, S.; Martín-Cáceres, M.J. Identidad, ciudadanía y patrimonio. Análisis comparativo de su tratamiento didáctico en museos de Estados Unidos y España. *Arbor* **2018**, *194*, a447. [CrossRef]
63. Copeland, T. Archaeological heritage education: Citizenship from the ground up. *Treballsd'Arqueologia* **2009**, *15*, 9–20.
64. Smith Bautista, S. *Museums in the Digital Age. Changing Meanings of Place, Community, and Culture*; Altamira Press: Lanham, MD, USA, 2014.
65. Semedo, A. Representações e Identidade em Exposições de Museus. Clío. History and History Teaching. 41.Recuperado de. 2015. Available online: http://clio.rediris.es/n41/articulos/mono/MonAsemedo2015.pdf (accessed on 23 July 2021).
66. Luna, Ú.; Ibáñez-Etxeberría, Á.; Rivero, P. El patrimonio aumentado. 8 apps de Realidad Aumentada para la enseñanza-aprendizaje del patrimonio. *Rev. Interuniv. Form. Prof.* **2019**, *94*, 43–62.
67. Noh, Z.; Sunar, M.S.; Pan, Z. A Review on Augmented Reality for Virtual Heritage System. In *Learning by Playing. Game-Based Education System Design and Development. Edutainment 2009*; Lecture Notes in Computer Science; Chang, M., Kuo, R., Kinshuk, C.G.D., Hirose, M., Eds.; Springer: Berlin/Heidelberg, Germany, 2009; Volume 5670. [CrossRef]
68. Ruiz-Torres, D. Realidad aumentada, educación y museos. *Icono 14 Rev. de Comun. y Nuevas Tecnol.* **2011**, *9*, 212–226. [CrossRef]
69. Fontal, O.; Ibáñez-Etxeberria, A. La investigación en Educación Patrimonial. Evolución y estado actual a través del análisis de indicadores de alto impacto. *Rev. Educ.* **2017**, *375*, 184–214. [CrossRef]
70. Röder, D. Smartphone apps: Their Use of History and Use for History Teaching. In *E-Teaching History*; Wojdon, J., Ed.; Cambridge Scholars Publishing: London, UK, 2016; pp. 140–152.
71. Rivero, P.; García-Ceballos, S.; Aso, B.; Navarro-Neri, I. Augmented Reality and Heritage Education in Spain. In *Augmented Reality in Tourism, Museums and Heritage. A New Technology to Inform and Entertain*; Geroimenko, V., Ed.; Springer: Berlin/Heidelberg, Germany, 2021; pp. 109–123. [CrossRef]
72. Chung, N.; Hyunae, L.; Jin-Young, K.; Chulmo, K. The Role of Augmented Reality for Experience-Influenced Environments: The Case of Cultural Heritage Tourism in Korea. J. *Travel Res.* **2017**, *57*, 627–643. [CrossRef]
73. Grevtsova, I. El patrimonio urbano al alcance de la mano: Arquitectura, urbanismo y apps. *Her Mus. Herit. Mus.* **2013**, *5*, 36–43.
74. Hughes, K.; Moscardo, G. Connecting with New Audiences: Exploring the Impact of Mobile Communication Devices on the Experiences of Young Adults in Museums. *Visit. Stud.* **2017**, *20*, 33–55. [CrossRef]
75. Marto, A.; Gonçalves, A. Mobile AR: User Evaluation in a Cultural Heritage Context. *Appl. Sci.* **2019**, *9*, 5454. [CrossRef]
76. Real Decreto 126/2014, de 28 de Febrero, Por el Que se Establece el Currículo Básico de la Educación Primaria. Available online: https://bocyl.jcyl.es/boletines/2015/10/14/pdf/BOCYL-D-14102015-1.pdf (accessed on 2 July 2021).
77. Bekele, M.K.; Pierdicca, R.; Frontoni, E.; Malinverni, E.S.; Gain, J. A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage. *Comput. Cult. Herit.* **2018**, *11*, 1–36. [CrossRef]
78. Kim, K.H.; Yu, J.M. Development of a Mobile Augmented Reality Application using Cultural Products. *J. Korea Soc. Comput. Inf.* **2021**, *26*, 85–92. [CrossRef]
79. Escobar, J.; Cuervo, A. Validez de contenido y juicio de expertos: Una aproximación a su utilización. *Av. En Med.* **2008**, *6*, 27–36.
80. O'Dwyer, L.M.; Bernauer, J.A. *Quantitative Research for the Qualitative Researcher*; SAGE Publications Inc.: Thousand Oaks, CA, USA, 2014. [CrossRef]

81. González, J.; Pazmiño, M. Cálculo e interpretación del Alfa de Cronbach para el caso de validación de la consistencia interna de un cuestionario, con dos posibles escalas tipo Likert. *Rev. Pub.* **2015**, *2*, 62–77.
82. Kabassi, K. Evaluating museum websites using a combination of decision-making theories. *J. Herit. Tour.* **2019**, *14*, 544–560. [CrossRef]
83. Piancatelli, C.; Massi, M.; Vocino, A. #artoninstagram: Engaging with art in the era of the selfie. *Int. J. Market. Res.* **2020**, *63*, 134–160. [CrossRef]
84. Chin, K.Y.; Wang, C.S. Effects of augmented reality technology in a mobile touring system on university students' learning performance and interest. Australas. *J. Educ. Technol.* **2021**, *37*, 27–42. [CrossRef]
85. Ibáñez-Etxeberria, A.; Fontal Merillas, O.; Rivero Gracia, P. Educación patrimonial y TIC en España: Marco normativo, variables estructurantes y programas referentes. *Arbor* **2018**, *194*, a448. [CrossRef]
86. Falomo Bernarduzzi, L.; Bernardi, E.M.; Ferrari, A.; Garbarino, M.C.; Vai, A. Augmented Reality Application for Handheld Devices: How to Make It hAPPen at the Pavia University History Museum. *Sci. Educ.* **2021**, *18*, 1–19. [CrossRef]
87. Ministerio de Educación y Formación Profesional. Estadística de la Sociedad de la Información y la Comunicación en los Centros Educativos no Universitarios. Curso 2016–2017. 2018. Available online: http://www.educacionyfp.gob.es/dms/mecd/servicios-al-ciudadano-mecd/estadisticas/educacion/no-universitaria/centros/sociedad-informacion/2016-2017/Nota-Resumen.pdf (accessed on 15 March 2021).
88. Sánchez-Prieto, J.C.; Olmos Migueláñez, S.; García-Peñalvo, F.J. ¿Utilizarán los futuros docentes las tecnologías móviles? Validación de una propuesta de modelo TAM extendido. *RED—Rev. de Educ. Distancia* **2017**, *52*, 5. [CrossRef]
89. Osuna-Acedo, S.; Frau-Meigs, D.; Marta-Lazo, C. Educación en medios y formación de profesores. Educomunicación más allá de la alfabetización mediática. *Rev. Interuni. Form. Prof.* **2018**, *91*, 29–42.
90. Bittencourt-Francisco, J. Connected Brazil and digital humanities: The perspective of interpreting museums in Porto Alegre. *История* **2020**, *51*, 106–116. [CrossRef]
91. Giannini, T.; Bowen, J.P. (Eds.) Transforming Education for Museum Professionals in the Digital Age. *Springer Ser. Cult. Comput.* **2019**, 457–480. [CrossRef]
92. Czerkawski, B.; Berti, M. Learning experience design for augmented reality. *Res. Learn. Technol.* **2021**, 29. [CrossRef]
93. Rocha, P.M. The importance of educommunication in the training of mass communication professionals in contemporaneity. *Communicatio* **2015**, *41*, 192–205. [CrossRef]
94. Tzima, S.; Styliaras, G.; Bassounas, A. Augmented Reality Applications in Education: Teachers Point of View. *Educ. Sci.* **2019**, *9*, 99. [CrossRef]
95. Lee, E.; Hannafin, M.J. A design framework for enhancing engagement in student-centeredlearning: Own it, learn it, and share it. *Educ. Tech. Res. Dev.* **2016**, *64*, 707–734. [CrossRef]
96. Ramtohul, A.; Kumar, K. User Experience and Engagement in Augmented Reality Systems for the Cultural Heritage Domain. In *Augmented Reality in Tourism, Museums and Heritage. A New Technology to Inform and Entertain*; Geroimenko, V., Ed.; Springer: Berlin/Heidelberg, Germany, 2021; pp. 227–256. [CrossRef]
97. Puggioni, M.; Frontoni, E.; Paolanti, M.; Pierdicca, R. ScoolAR: An Educational Platform to Improve Students' Learning Through Virtual Reality. *IEEE Access* **2021**, *9*, 21059–21070. [CrossRef]
98. Castro, L.; López-Facal, R. Educación patrimonial: Necesidades sentidas por el profesorado de infantil, primaria y secundaria. *Re-Vista Interuniv. de Form. del Profr.* **2019**, *94*, 97–114. [CrossRef]
99. Conde, J.; Armas, X. Social representations of primary education students on heritage. Study by the word association. *Rev. Interuniv. de Form. del Profr. Rifop* **2019**, *94*, 187–201.
100. Fontal, O.; García-Ceballos, S.; Aso, B. Desarrollo de competencias docentes en educación patrimonial mediante plataformas 2.0 y entornos digitales como herramienta de aprendizaje. *Investig. e Innov. Educ.* **2020**, *101*, 1–14. [CrossRef]
101. Ott, M.; Pozzi, F. Towards a new era for cultural heritage education: Discussing the role of ICT. *J. Comput. Hum. Behav.* **2011**, *27*, 1365–1371. [CrossRef]
102. Carvalho, A.; Matos, A. Museum Professionals in a Digital World: Insights from a Case Study in Portugal. *Mus. Int.* **2018**, *70*, 34–47. [CrossRef]
103. Tammaro, A.M. New Profiles, New Skills, New Education for Digital Heritage Professionals: European Spotlight on Competency-Based System. *Int. Inf. Libr. Rev.* **2017**, *49*, 290–296. [CrossRef]
104. Klarin, M.V. Twenty-First Century Educational Theory and the Challenges of Modern Education: Appealing to the Heritage of the General Teaching Theory of the Secondary Educational Curriculum and the Learning Process. *J. Russ. Educ. Soc.* **2016**, *58*, 299–312. [CrossRef]
105. Solé, J. El cambio educativo ante la innovación tecnológica, la pedagogía de las competencias y el discurso de la educación emocional. Una mirada crítica. *Teor. Educ.* **2020**, *32*, 101–121. [CrossRef]
106. Bernad, M.S. Nuevas tecnologías y difusión del turismo cultural: Descubriendo a Goya con realidad au-mentada. *ROTUR—Rev. de Ocio y Tur.* **2020**, *14*, 81–93. [CrossRef]
107. García-Ceballos, S.; Aso, B. Patrimonio confinado: Nuevos diálogos, desafíos y competencias educativas. *Rev. Com Censo* **2020**, *7*, 160–169.
108. Chang, K.; Chang, C.; Hou, H.; Sung, Y.; Chao, H.; Lee, C. Development and behavioral pattern analysis of a mobile guide system with augmented reality for painting appreciation instruction in an art museum. *Comput. Educ.* **2014**, *71*, 185–197. [CrossRef]

109. Sylaiou, S.; Kasapakis, V.; Gavalas, D.; Dzardanova, E. Avatars as storytellers: Affective narratives in virtual museums. *Pers. Ubiquitous Comput.* **2020**, *24*, 829–841. [CrossRef]
110. Weibel, D.; Wissmath, B.; Mast, F.W. Influence of mental imagery on spatial presence and enjoyment assessed in different types of media. *Cyberpsychol. Behav. Soc. Netw.* **2011**, *14*, 607–612. [CrossRef] [PubMed]
111. Chaparro-Aranguren, R.L.; Gutiérrez-Ríos, R.S. Implementación de realidad aumentada como experiencia en el aula universitaria. In *Tecnología Innovación e Investigación en los Procesos de Enseñanza-Aprendizaje*; Roig-Vila, R., Ed.; Octaedro: Barcelona, Spain, 2016.
112. Muñoz-Sajama, M.; Cornejo-Mejías, R.; Navarrete-Álvarez, M.; Aracena-Pizarro, D. Una aplicación de Realidad Aumentada para recorrer el sitio patrimonial "Aldea de San Lorenzo". *Ingeniare. Rev. Chil. de Ing.* **2018**, *26*, 65–76. [CrossRef]
113. Chiappe, A.; Amado, N.; Leguizamón, L. Educommunication in digital environments: An interaction's perspective inside and beyond the classroom. *Innoeduca. Int. J. Technol. Educ. Innov.* **2020**, *6*, 42–52. [CrossRef]
114. Dafonte-Gómez, A.; Maina, M.F.; García-Crespo, O. Uso del smartphone en jóvenes universitarios: Una oportunidad para el aprendizaje. *Píxel-Bit. Rev. de Medios y Educ.* **2021**, *60*, 211–227. [CrossRef]
115. Giraldo-Luque, S.; Fernández-Rovira, C. Redes sociales y consumo digital en jóvenes universitarios: Economía de la atención y oligopolios de la comunicación en el siglo XXI. *Prof. de la Inf.* **2020**, *29*, e290528. [CrossRef]
116. Marcelo, C. Los comienzos en la docencia: Un profesorado con buenos principios. *Rev. de Curric. y Form. del Profr.* **2009**, *13*, 1–26.
117. Bransford, J.; Darling-Hammond, L.; LePage, P. Introduction. In *Preparing Teachers for a Changing World*; Darling-Hammond, L., Bransford, J., Eds.; Jossey Bass S.: San Francisco, CA, USA, 2005; pp. 1–39.
118. Darling-Hammond, L. *El derecho de Aprender. Crear Buenas Escuelas Para Todos*; Ariel: Barcelona, Spain, 2001.
119. Helsper, E.J.; Eynon, R. Digital natives: Where is the evidence? *Br. Educ. Res. J.* **2010**, *36*, 503–520. [CrossRef]
120. Acosta-Silva, D.A. Tras las competencias de los nativos digitales: Avances de una metasíntesis. *Rev. Latinoam. de Cienc. Soc. Niñez y Juv.* **2017**, *15*, 471–489. [CrossRef]
121. Dias da Silva, M.; da Silva, D.; do Amaral, S.L. The Y generation myth: Evidences based on the causality relations among age, diffusion and adoption of technology of college students of São Paulo State. *Future Stud. Res. J. Trends Strateg.* **2014**, *6*, 32–52. [CrossRef]
122. Fajardo, I.; Villalta, E.; Salmerón, L. ¿Son realmente tan buenos los nativos digitales? Relación entre las habilidades digitales y la lectura digital. *An. de Psicol.* **2015**, *32*, 89–97. [CrossRef]
123. Bennett, S.; Maton, K.; Kervin, L. The «digital natives» debate: A critical review of the evidence. *Br. J. Educ. Technol.* **2008**, *39*, 775–786. [CrossRef]
124. Sáez-López, J.M.; Cózar-Gutiérrez, R.; González-Calero, J.A.; Gómez Carrasco, C.J. Augmented Reality in Higher Education: An Evaluation Program in Initial Teacher Training. *Educ. Sci.* **2020**, *10*, 26. [CrossRef]
125. Akçayır, M.; Akçay, G. Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educ. Res. Rev.* **2017**, *20*, 1–11. [CrossRef]
126. Fontal, O. *La Educación Patrimonial, del Patrimonio a Las Personas*; Trea: Gijón, Spain, 2003.