



Towards participatory activities with augmented reality for cultural heritage: A literature review

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ABSTRACT

The preservation of cultural heritage is a basilar to support the feeling of identity and community. In this context, cultural tourism emerges as an effective strategy that, when combined with participatory activities, may increment tourist perceptions, contributing simultaneously to the acquisition of knowledge associated with cultural heritage. This literature review aimed to explore how mobile augmented reality applications using games, narrative, or craft design and convey knowledge associated with the cultural heritage of a particular place. In addition, it was intended to understand how their evaluation protocol is administered, as well as how can this genre of applications influence the tourist experience. The literature search was operationalized in the Scopus, Web of Science and ACM Digital Library electronic databases and used studies from 2018 until November 16, 2022. In total, 16 studies were analyzed in this literature review. The results demonstrate that the integration of game, narrative, and craft in augmented reality mobile applications for cultural heritage is diverse, with narrative being the most prevalent. Regarding how the evaluation phase is conducted, despite using each study using different protocols, the data collection instruments can be patterned, highlighting the use of independent questionnaires and scales. Nevertheless, the findings of this literature review suggest that augmented reality mobile applications with participatory activities can positively influence the touristic experience, constituting a powerful element of engagement and immersion, guaranteeing that some creative and technical aspects are ensured.

1. Introduction

Cultural heritage is an invaluable and irreplaceable resource, and its loss, either through deterioration or disappearance, is an impoverishment of the world's heritage (UNESCO, 2021). In this sense, cultural heritage can be categorized as "a group of resources inherited from the past which people identify, independently of ownership, as a reflection and expression of their constantly evolving values, beliefs, knowledge and traditions. It includes all aspects of the environment resulting from the interaction between people and places through time" (Council of Europe, 2005, p. 2). In other words, it is understood as the generational transmission of unique and irreplaceable customs, practices, places, objects, artistic expressions, and values that form the identity of a community, with the aim of keeping alive the traditions of the past for the benefit of future generations (Devidze & Gigauri, 2015). It is estimated that about 47% of trips are motivated, directly or indirectly, by culture (UNWTO, 2018) and, therefore, cultural heritage can be used for tourism purposes as a strategy to preserve the past, transmit traditions to

future generations and raise awareness of the importance of heritage (Di Pietro et al., 2018). Because of this, cultural tourism becomes particularly relevant as "a type of tourism activity in which the visitor's essential motivation is to learn, discover, experience, and consume the tangible and intangible cultural attractions/products in a tourism destination. These attractions/products relate to a set of distinctive material, intellectual, spiritual and emotional features of a society that encompasses arts and architecture, historical and cultural heritage, culinary heritage, literature, music, creative industries and the living cultures with their lifestyles, value systems, beliefs and traditions" (UNWTO, 2019, p. 30). Cultural tourism aims to develop sustainable economies that protect and preserve natural and cultural resources, improving, in turn the quality of life of locals and enriching the touristic visit (Devidze & Gigauri, 2015). From this perspective, it also becomes a prestigious vehicle for the transmission of knowledge associated with cultural heritage (Rhim et al., 2013) which results in the preservation of local identities that could otherwise disappear (Di Pietro et al., 2018). From another, yet interconnected perspective, heritage education is a

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robust method to raise community awareness about the importance of heritage in a playful way, since it seeks to connect the community with the heritage, and, consequently, lead to its preservation (Bezerra, 2020; Pereira & Cardoso, 2010).

In the cultural tourism panorama, the use of information and communication technologies allow for an innovative way of experiencing heritage, positively reinforcing the touristic experience and increasing the flow of tourists to a place, who unconsciously become vehicles for that place's heritage transmission (Di Pietro et al., 2018). Among the numerous technologies that underlie information and communication technologies, augmented reality – perceived as the superimposition of virtual elements on the real world (Azuma, 1997; Craig, 2013) – presents itself with enormous applicability in the context of cultural tourism (Graziano & Privitera, 2020) since, in addition to enabling preservation and facilitating tourist access to heritage (Krogstie & Haugstvedt, 2015), it can be accessed with a device available to most people, their smartphone (Craig, 2013). By seamlessly merging digital elements within the real world, augmented reality offers a unique way that allow visitors to explore historical sites. What distinguishes augmented reality from conventional information and communication technologies is its capacity to incorporate interactive features into these real-world experiences. This integration holds the potential to captivate diverse audiences, which can subsequently enrich the learning process by promoting an overall engagement with the cultural heritage of the place. With this, given its ability to enhance a continuous learning process (Moorhouse et al., 2017) and to increase the levels of attention, satisfaction and confidence associated with the motivation to learn (Khan et al., 2019), augmented reality is being applied in different educational contexts, namely in heritage education (Luna et al., 2019). Its inclusion in this last context has the capacity not only to bring the visitor closer to the cultural space and promote the site sustainability, but also to provide a good learning moment (Mendoza et al., 2015; Moorhouse et al., 2017), by providing visitors with an overall engaging experience.

Delving further into the concept of engagement, it must be acknowledged that engagement is a complex term which can be defined as a “category of user experience characterized by attributes of challenge, positive affect, endurability, aesthetic and sensory appeal, attention, feedback, variety/novelty, inter-activity, and perceived user control” (O'Brien & Toms, 2008, p. 941). From this perspective, engagement originates from the theory of optimal experience (Csikszentmihalyi, 1990), a psychological theory – also known as flow –, categorized as a state of immersion where attention is solely focused on the task being performed in the present moment, which, in turn, becomes a moment of intense concentration (Nakamura & Csikszentmihalyi, 2002). This moment of immersion is a psychological experience that transports the user to another reality (Murray, 1997), achieving the so-called state of flow. To enter this state, it is crucial to find a balance between the user's abilities and the challenges presented to them. In other words, if the user's abilities are lower than the task's demands, they will feel anxiety and panic. On the other hand, if their abilities are higher, they will become bored. Achieving equilibrium leads to the aforementioned state of flow (Nakamura & Csikszentmihalyi, 2002). Within this context, Zagalo (2020) introduces the Engagement Design Model, draws from the study conducted by Yee (2015). The latter study reveals six distinct motivations for why individuals engage in gaming, based on the responses of 140 000 players. The central aim of Zagalo's Engagement Design Model is to establish “comfortable flows and streams of engagement, supported by the user's motivations and profiles, leaving the content of meaning to each user.” (Zagalo, 2020, p. 123). In essence, the model posits that the potential for engagement of a product depends on the specific user profile. Consequently, in order to effectively engage a user, the product's development must take into account, at the very least, one of the three engagement flows outlined in the model: the flow of progression, which corresponds to the acquisition of knowledge and targets users with an inclination towards abstraction;

the flow of expression, geared towards practical action and preferred by users who enjoy hands-on experimentation; and the flow of relation, which revolves around emotional connection and resonates with users who appreciate dramatized experiences. Upon dissecting each of these engagement flows, it becomes apparent that the flow of progression is tailored for profiles inclined towards mastery and knowledge acquisition. The development of content for this user category necessitates the incorporation of problem-solving patterns rooted in elements that stimulate deductive processes. Regarding the flow of expression, this second dimension is tailored to users who prefer hands-on experiences, propelled by their creative facet and a preference for building and experimenting. Consequently, content created with this profile in mind should empower users to generate and explore diverse possibilities. Lastly, in the flow of relation, users derive motivation from human connections, underscoring the need for content that amplifies emotions and nurtures empathy. As defined by Zagalo (2020) in his model, these engagement flows can be translated into distinct activities: the flow of progression aligns with the realm of gaming; the flow of expression finds its counterpart in craft; and the flow of relation corresponds to narrative experiences (Zagalo, 2020).

In line with this, this paper is part of a research project that aims to develop a human-computer interaction design model to support the design of user experience in participatory activities incorporated in an augmented reality mobile application, applied to the cultural tourism context. We hypothesize that participatory activities based on the three engagement flows, when combined with augmented reality, can improve the touristic experience by endowing tourists with a rich and deep social and emotional engagement while promoting the preservation of cultural heritage, particularly outdoor spaces. The model will be applied in Almeida, a village belonging to the group of Historical Villages of Portugal, which will demonstrate its potential for replication in other locations. The preservation of the cultural heritage of the Portuguese Historical Villages will ensure not only the preservation of the identity of the space, but also, given the territorial context in which they are located, the preservation of their natural environment.

In this review, our first objective is to understand the design principles behind augmented reality mobile applications that integrate elements of gaming, narrative, or craft and have the primary goal of conveying knowledge associated with the cultural heritage of specific locations. Answering this question can provide insights into the various design approaches used in augmented reality mobile applications for cultural heritage. It may reveal trends, best practices, and innovative methods for incorporating game elements, narratives, or craft techniques to enhance user experiences. As such, the findings can help developers and designers understand the challenges and opportunities involved in designing augmented reality mobile applications that blend cultural heritage with interactive elements effectively. Furthermore, our second objective is to comprehend how the evaluation is carried out within this context. By delving into the evaluation protocols, we seek to identify the methodologies and metrics used to assess the user experience of augmented reality mobile applications for cultural heritage. Our interest in this aspect stems from the recognition that evaluating the user experience within this domain can be particularly challenging due to its unique characteristics. Through our work, we aim to contribute to the field by identifying evaluation paths that are tailored to the intricacies of augmented reality in cultural heritage, that can help practitioners and researchers improve future evaluation practices within this specific domain. Our last objective is to ascertain the real-world impact arising from implementing this genre of applications *in loco*. The insights gathered from this analysis can reveal how augmented reality mobile applications enhances visitors' overall experience within cultural heritage sites, artifacts, and stories. In line with the aforementioned objectives, the authors have formulated the subsequent research questions that will guide this literature review:

Q1: How are augmented reality mobile applications for cultural heritage, that integrate game, narrative, or craft, designed?

Q2: How is the evaluation process of an augmented reality mobile application for cultural heritage, that integrate game, narrative, or craft, performed?

Q3: How can augmented reality mobile applications that integrate game, narrative, or craft influence the way cultural heritage is experienced?

2. Method

To ensure the validity and replication of the results of this literature review, the team relied on the guidelines proposed in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). This section will present the search strategy, the selection protocol, which data categories were extracted from the studies included in the analysis, and the studies selection process.

2.1. Search strategy

The literature review was operationalized until November 16, 2022, including results from 2018, in the Scopus, Web of Science and ACM Digital Library databases, considering only the title, abstract and keywords, with the search query ((“AUGMENTED REALITY” OR “AR”) AND (“CULTURAL HERITAGE” OR “HERITAGE EDUCATION” OR “CULTURAL TOURISM” OR “HERITAGE PRESERVATION”) AND (“MOBILE APPLICATION” OR “MOBILE APP” OR “APP” OR “APPLICATION*” OR “MOBILE GAM*”) AND ((“DIGITAL GAM*” OR “SERIOUS GAM*” OR “EDUCATIONAL GAM*” OR “VIDEOGAM*” OR “VIDEO GAM*” OR “PERVASIVE GAM*” OR “LOCATION-BASED GAM*” OR “ALTERNATE REALITY GAM*” OR “MOBILE GAM*” OR “GAMIFICATION”) OR (“NARRATIVE” OR “DIGITAL NARRATIVE” OR “INTERACTIVE NARRATIVE” OR “STORYTELLING” OR “DIGITAL STORYTELLING” OR “INTERACTIVE STORYTELLING”) OR (“CRAFT*” OR “CRAFTWORK” OR “HANDCRAFT” OR “HANDICRAFT” OR “HANDIWORK” OR “TINKER*”)).

The primary terms established for this query encompass augmented reality, cultural heritage, mobile application, digital game, narrative, and craft. These designated keywords were strategically chosen to comprehensively cover the relevant literature pertaining to augmented reality mobile applications within the domain of cultural heritage. This focus is further refined to specifically address activities of game, narrative, and/or craft. Considering the aim of this review and recognizing that various authors might employ diverse terminologies, a set of synonyms and alternate words have been thoughtfully incorporated to ensure inclusivity in the search and capture a broader range of studies. These synonyms or alternate words enhance the ability to encompass studies that might utilize different terminology while still remaining relevant to the core research focus. In relation to the keyword “augmented reality,” the acronym AR (augmented reality) has been adopted. For the term “cultural heritage,” the alternate words heritage education, cultural tourism, and heritage preservation have been incorporated. Similarly, the term “mobile application” is complemented by the alternate words mobile app, app, application, and mobile game. To encompass the diverse dimensions of “digital game,” the terms serious game, educational game, video game, pervasive game, location-based game, alternate reality game, mobile game, and gamification have been employed. For the term “narrative,” the extensions include digital narrative, interactive narrative, storytelling, digital storytelling, and interactive storytelling. Lastly, “craft” is extended to encompass craft-work, handcraft, handicraft, handiwork, and tinker. The wildcard character “*” has been strategically utilized to account for both singular and plural forms of the keywords and their derivatives, thereby enhancing the comprehensiveness of the search strategy.

2.2. Selection protocol

For a study to be included in this literature review, it had to fulfill the following specific criteria:

- Publication Date: The study must have been published within the last five years (2018 or after) to ensure the incorporation of current technology trends.
- Publication Type: The study must fall within the category of a conference paper, journal article, or book chapter.
- Cultural Heritage Domain: The study’s content should primarily focus on mobile applications that effectively convey information about the cultural heritage associated with a specific location.
- Technological Domain: The mobile application under analysis should incorporate augmented reality technology.
- Engagement Design Model Domain: The mobile application should encompass and present, through augmented reality, at least one of the following participatory activities: a game, a narrative, or craft activities.
- Language: The study must be written in the English language.

2.3. Data Extraction

The authors carried out an autonomous process of extracting data from each study included in this review. Subsequently, the data was methodically organized, structured and collaboratively analyzed by all authors using a spreadsheet software. The data extracted encompassed the following aspects:

- Study Goal: The intended objective or purpose of the study.
- Participatory Activities: The engagement activities that the mobile application present through augmented reality.
- Area of Implementation: Whether the mobile application is designed for indoor or outdoor use.
- Augmented Reality Tracking Method: The method utilized to detect the position and orientation of the mobile device within the augmented reality environment.
- Augmented Reality Content Type: The type of content presented through augmented reality.
- Augmented Reality Display: The display that visitors use to interact with augmented reality.
- Software Used for the Application: The software utilized for creating the mobile application.
- Software Used for Augmented Reality: The software employed to develop the augmented reality components.
- Data Collection Protocol: The protocol adopted for collecting data.
- Number of Users: The total of users participating in the evaluation phase of the mobile application.
- Users’ Age: The age range of the users that participate in the evaluation phase of the mobile application.
- General Findings: The overall conclusions and outcomes drawn from the study.

This data enables comparative analysis, offering insights into ludic and technological patterns and variations across studies, contributing to a more informed and thorough review process. Table 1 showcases the coding scheme utilized by the authors.

2.4. Studies selection process

Through the search operationalized in the Scopus, Web of Science and ACM Digital Library electronic databases, our team identified a total of 213 studies – 133 collected from Scopus, 75 obtained from Web of Science and 5 gathered from ACM Digital Library. Before conducting the

Table 1
Data extraction.

Question Contribute	Extracted Data	Dimensions	Objective
–	Publication Information	Authors; Title of the study.	These dimensions will serve to organize, identify, and accurately represent the extracted data from the included studies.
Q1	Participatory Activity Design Augmented Reality Design	Study goal; Participatory activities; Area of implementation. Augmented reality tracking method; Augmented reality content type; Augmented reality display; Software used for the application; Software used for the augmented reality.	By conducting a comprehensive analysis of the information pertaining to these dimensions, our team will gain valuable insights into the design considerations of each mobile application. These insights include the integration strategy of participatory activities, the target site for application use (indoor or outdoor), and relevant technological aspects.
Q2	Data Collection Protocol	Data Collection Protocol; Sample size; User's age.	Collecting information about these aspects will enable researchers to understand the evaluation process of each augmented reality mobile application. Through this verification, it will be confirmed whether a pattern can be outlined in terms of evaluation strategies for mobile applications in this context.
Q3	Outcomes	General findings.	By analyzing the general finding of each study, researchers can gain a broader understanding of how augmented reality mobile applications influence the way cultural heritage is experienced and if it will be possible to identify a trend or if the analyzed results are disparate.

first screening, a total of 124 studies were marked for removal – 77 for being duplicates and 47 for having a publication date prior to 2018. Following this first removal, our team began the screening process, which involved reading each study's title and abstract, resulting in a total of 40 new studies removed: 16 where a mobile application was not discussed, 14 that did not use augmented reality, game, narrative or craft, 8 Book, book conference, book proceedings, thesis, report, or an erratum, and 2 that did not focus in transmitting knowledge related with cultural heritage. Subsequently, 49 studies were sought for retrieval. During this process, our team was unable to obtain the full text of 9 studies, which resulted in their exclusion from this literature review. Hence, with 40 studies remaining, each one was meticulously read, resulting in the exclusion of another 23 studies: 17 that did not apply augmented reality, game, narrative or craft, 5 for not being about mobile applications, 1 whose focus was not transmitting knowledge about cultural heritage and one for being a short version of an extended paper already included (in this case, our team opted by considering the short paper a duplicate of the latter, which was, structurally, more detailed). In the end, 16 studies were considered and analyzed in this literature review. A systematized version of the process detailed in this section can be found in Fig. 1.

3. Results

In this section, we will present the key findings derived from the analysis of the selected articles. Table 2 presents the extracted data, organized according to the first three categories defined in section 2.3, namely the study goal, what participatory activities were implemented, and where the mobile application is intended to be use.

In accordance with what can be observed in Fig. 2, there is a clear predominance of the narrative activity, with 14 studies implementing it in their mobile applications. Regarding game, there were 7 studies that have applied this approach. Lastly, the craft activity was used by 4 studies. It is similarly possible to verify that the combination of activities is frequent: 3 studies combine narrative and game, 1 study resorts to narrative and craft, 1 study uses game and craft, and 2 studies implemented all activities.

In Table 3, we can see the indicators related to the characteristics of augmented reality, namely the tracking method and display, the software that the authors used to develop the mobile application and implement the augmented reality system, as well as the type of content displayed through augmented reality.

It should be noted that three studies (Jakobsen et al., 2018; Liestøl, 2019; Liestøl et al., 2021) use indirect augmented reality, i.e., digital content is not superimposed over real-world live feed. Instead, panoramic images or 360° videos are used in place of the live camera and the

conjugation of the real and virtual happens in the combination of the user's real-time perspective at the location and the perspective provided by the augmented reality equipment (Liestøl, 2019; Wither et al., 2011).

The study by Vanoverschelde (2019) is a proof of concept about an application that is currently being developed and, given that it is still in an embryonic state, without any technological or content aspects defined, will not be considered for analysis in the table and figures below (Table 3, Fig. 3, Figs. 4 and 5).

The analysis revealed a consistent trend regarding the favored context for application development, with outdoor settings being the predominant choice. Furthermore, the analysis of tracking method unveiled a prevalent trend in the use of GPS, followed by Marker-Based tracking (Fig. 3).

In terms of augmented reality display methods across various implementation contexts, the use of smartphones and/or tablets emerged as almost unanimous. Nonetheless, a few studies also incorporated HMDs, more specifically the Microsoft HoloLens (Decker et al., 2021; O'Dwyer et al., 2021) (Fig. 4).

Regarding the content type (Fig. 5), a clear prevalence of 3D modelling is noticeable, which can be of various natures, from animations that recreate traditional local events or activities (Andrade & Dias, 2020; Cesaria et al., 2020; Jakobsen et al., 2018; Liestøl, 2019; Liestøl et al., 2021), to historical, mythical or fictional characters related to the place and that tell something about it (Andrade & Dias, 2020; Decker et al., 2021; Fenu & Pittarello, 2018; Jakobsen et al., 2018; Koutsabasis et al., 2021; Lehto et al., 2020; Sprung & Haxha, 2020), objects or architectural buildings (interactive or static) characteristic of or related to the place or historical character (Fenu & Pittarello, 2018; Jakobsen et al., 2018; Koo et al., 2020; Koutsabasis et al., 2021; Nisi et al., 2019; Sprung & Haxha, 2020; Varinlioglu & Halici, 2019), or even avatars that allow interaction with other users from the application (Sprung & Haxha, 2020). Additionally, most make use of 3D modeling to integrate the characters into the augmented reality environment, with the exception of O'Dwyer et al. (2021) who use volumetric videos.

Concerning the use of real images or videos, these are used in order to show users how the place used to be, through documental content (Liestøl, 2019) or as historical recreation (Calvi, 2020). Furthermore, video is also used as a tutorial for the application (Koo et al., 2020).

Finally, sound and text are used as a complement to the other contents and are never displayed separately.

Of the 16 articles only 9 presented results of the evaluation of the application (Table 4).

In turn, three studies (Liestøl, 2019; Liestøl et al., 2021; Nisi et al., 2019) do not provide significant findings for the context of the present review. If, on the one hand, the results obtained from the tests performed in both studies by Liestøl (2019) and by Liestøl et al. (2021) are very

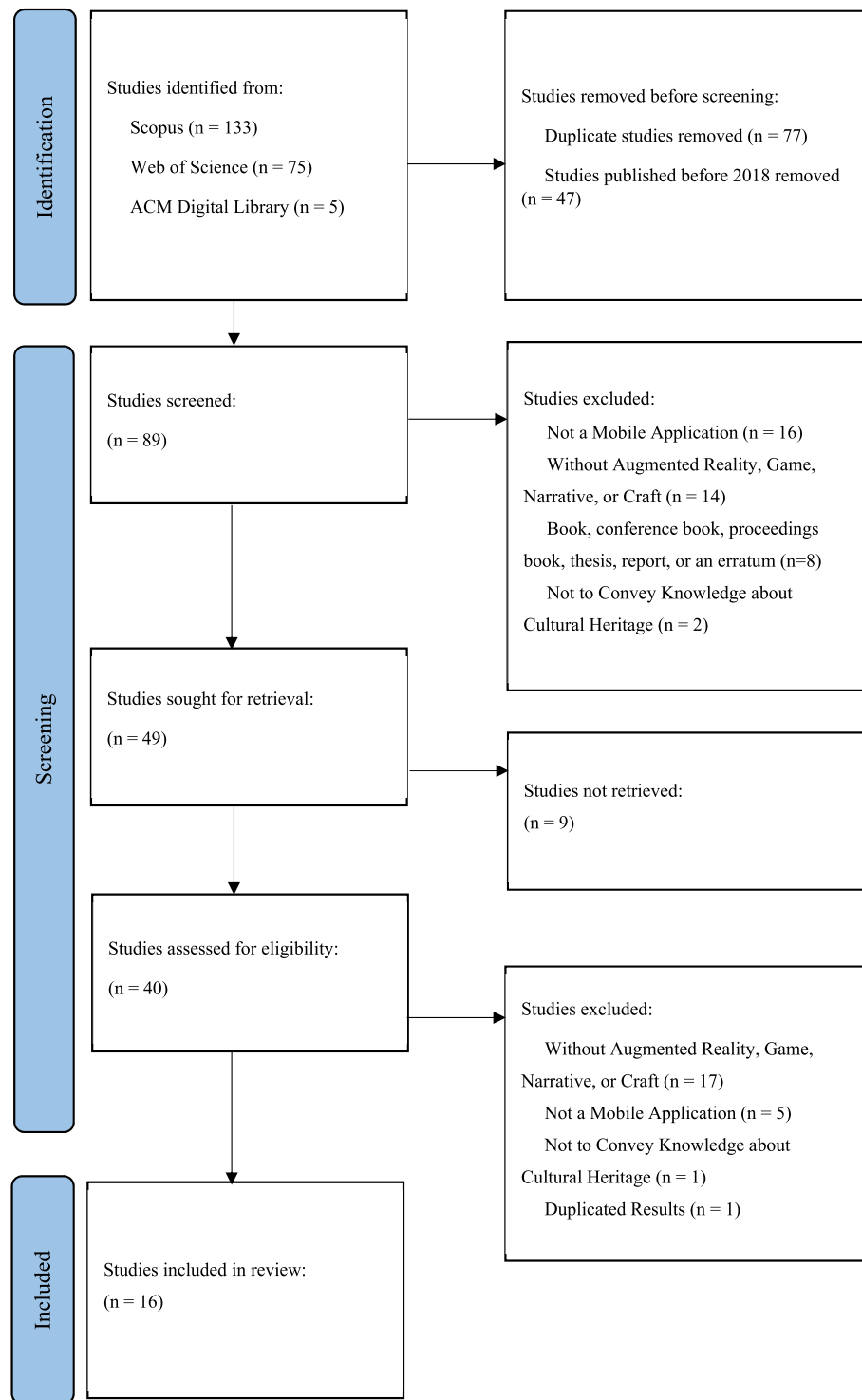


Fig. 1. Studies selection process. Model taken from Page et al. (2021).

specific, pertaining to the usability of the application, having the intent of providing a technical improvement of the application, on the other hand, the one by Nisi et al. (2019) was considered inconclusive by the authors. Such consideration is grounded on the justification that the sample was limited, and the tests were not conducted in a real context, meaning that a deeper analysis should be undertaken to understand if the application can really enhance the museological experience.

4. Discussion

In this literature review, we aim to understand how augmented reality mobile applications that integrate participatory activities and aim to convey knowledge associated with the cultural heritage of a given location are being designed, how they integrate user participation and how they articulate it with augmented reality. Furthermore, it is intended to understand how mobile applications are evaluated in this context, as well as what the impact arising from their implementation *in loco*.

Table 2
Summary of the studies.

Study	Title	Goals	Participatory Activity(ies)	Area
Andrade and Dias (2020)	A phygital approach to cultural heritage: augmented reality at Regaleira	Explore the repercussion of an augmented reality mobile application for Quinta da Regaleira and understand the positive and negative aspects arising from its implementation, providing a path for other heritage locations intending to develop a similar approach. The authors present which steps need to be taken into account during content production and exemplify a narrative model that can help people visit the heritage location and obtain information about it.	Narrative Craft	Outdoor
Lehto et al. (2020)	Augmented Reality Gaming as a Tool for Subjectivizing Visitor Experience at Cultural Heritage Locations—Case Lights On!	Discuss the use of an augmented reality game (Lights On!) as a way to attract people to experience different historical destinations (eight sites rich with cultural history from the Central Baltic Sea region) via a playful attitude, supported by the playability with historical characters to present new perspectives of ancient stories and history.	Game Narrative Craft	Outdoor
Nisi et al. (2019)	Augmented Reality Museum's Gaming for Digital Natives: Haunted Encounters in the Carvalhal's Palace	Describe the design, development, implementation and evaluation process of a treasure hunt experience (Memories of Carvalhal's Palace - Haunted Encounters), deployed at the Natural History Museum of Funchal, that utilizes augmented reality to stimulate teenagers to gather scientific knowledge about museum exhibits.	Game Narrative	Indoor
Liestøl (2019)	Augmented Reality Storytelling – Narrative Design and Reconstruction of a Historical Event in situ	Discuss and present the design and evaluation process of an augmented reality application that recreates the assault at Omaha Beach. The authors start by comparing how the assault is portrayed by pop culture, mainly movies, against how it is documented by photos and written reports, among other media, and follow by presenting the narrative design and how the application was perceived by visitors.	Narrative	Outdoor
Liestøl et al. (2021)	Augmented Reality Storytelling Submerged. Dry Diving to a World War II Wreck at Ancient Phalasarna, Crete	Explore the use of augmented reality storytelling to visually reconstruct the german attack that sunk the Tank Landing Craft A6 and describe the current condition of the site for visitors who cannot dive.	Narrative	Outdoor
Decker et al. (2021)	Bridging Past and Present: Creating and Deploying a Historical Character to Engage Audiences Through AR and VR	Present the creation and implementation of a virtual tour guide for a living history museum, that introduces narrative storytelling from the perspective of a historical character to offer first-person accounts of the past.	Narrative	Outdoor
Koo et al. (2020)	Development of an Augmented Reality Tour Guide for a Cultural Heritage Site	Explore the design, production and evaluation process of an augmented reality mobile application for the cultural heritage of Hwaseong Fortress in South Korea.	Game Craft	Outdoor
Varinlioglu and Halici (2019)	Gamification of Heritage through Augmented Reality	Propose an immersive augmented reality game, based on a mobile application, for the conveyance of information about the architectural heritage of the Teos ancient city.	Game	Outdoor
Sprung and Haxha (2020)	IFAR: MobileAR for cultural heritage	Explore the acceptance and potential of using social interaction in augmented reality to communicate facts and emotions to visitors of cultural heritage sites, implemented in the Graz Castle.	Game Narrative Craft	Outdoor
Jakobsen et al. (2018)	Improving User Experience for Lost Heritage Sites with a User-Centered Indirect Augmented Reality Application	Describe the development and evaluation process of an indirect augmented mobile application focused on increasing the user experience at the fortress of Aggerborg through a treasure hunt experience meant to incentivise the exploration of the site and a virtual guide that combines immersive and narrative elements to convey factual historical information.	Game Narrative	Outdoor
Cesaria et al. (2020)	Interactive Archaeological Storytelling: Using Immersive Technologies to Visit the Ancient Site of Roca Vecchia (Lecce, ITA)	Present the methodological approach employed to develop an augmented reality mobile application as well as a virtual reality application for Roca Vecchia's archaeological location.	Narrative	Outdoor
Koutsabasis et al. (2021)	Location-Based Games for Cultural Heritage: Applying the Design Thinking Process	Describe the approach used to develop a mobile application game about the cultural heritage of olive oil production in Lesvos Island, Greece.	Game Narrative	Indoor Outdoor
Vanoverschelde (2019)	No Story without a Backstory	Present an early-stage project whose aim is to develop an augmented reality mobile application with location-based and transmedia storytelling methods to tell the full story about the béguines and the béguinages, as well as discuss the importance of having a backstory in these types of applications developed for cultural heritage.	Narrative	Outdoor
Fenu and Pittarello (2018)	Svevo tour: The design and the experimentation of an augmented reality application for engaging visitors of a literary museum	Explain the design and evaluation process of an augmented reality mobile application, enhanced with storytelling, focused on the Italo Svevo cultural heritage.	Narrative	Indoor Outdoor
O'Decker et al. (2021)	Volumetric Video in Augmented Reality Applications for Museological Narratives: A User Study for the Long Room in the Library of Trinity College Dublin	Discuss and explore the potential of combining humor, storytelling and augmented reality in cultural heritage contexts using a practical example applied in the Long Room within the Old Library in Trinity College Dublin.	Narrative	Indoor
Calvi (2020)	What do we know about AR Storytelling?	Discuss the use of storytelling and augmented reality for raising awareness around those who fought in World War II, through a mobile application that tells the story of two Jewish children confined in Kamp Vught.	Narrative	Outdoor

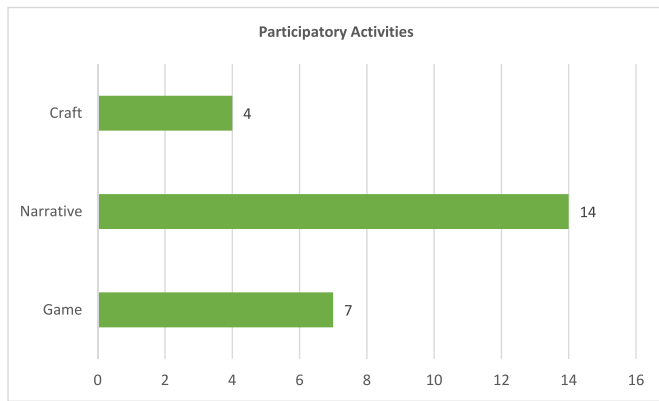


Fig. 2. Participatory activities.

4.1. Q1: How are augmented reality mobile applications for cultural heritage, that integrate game, narrative, or craft, designed?

Analyzing the type of participatory activities, it is evident the predominance of narrative strategies. Moreover, with the exception of the studies by Varinlioglu and Halici (2019), which implemented only game activities, and Koo et al. (2020), which recurs to game and craft strategies, every other study uses narrative, sometimes combined with game or craft techniques. However, one aspect that should be highlighted is the scarcity of craft activities, with only four studies implementing them (Andrade & Dias, 2020; Koo et al., 2020; Lehto et al., 2020; Sprung & Haxha, 2020). Given the low prevalence of studies using craft activities, it is important to understand the reasons why this occurs. One may theorize that craft activities are less common in digital games, leading developers to rely on narrative or game approaches (Trouvé, 2023). Drawing from this data, it also becomes evident that the narrative element plays an essential role in supporting the other activities of game and craft. In essence, these last two elements are rarely implemented separated from a supporting narrative context. This conclusion demonstrates the importance and potential of narratives when applied to augmented reality for cultural heritage. In fact, a story is a robust empathy machine, enabling individuals to experience the memories,

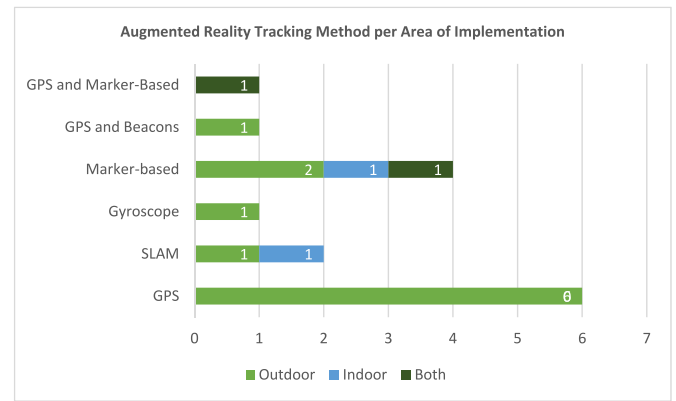


Fig. 3. Augmented reality tracking method per area of implementation.

thoughts, and emotions of others (Pueyo, 2018), ultimately captivating the audience's attention and resulting in a quicker and deeper understanding of events (Núñez, 2009). Allied with this aspect, human brain is unable to distinguish between a story that was told and a lived experience, making stories 2 to 10 times more memorable than factual

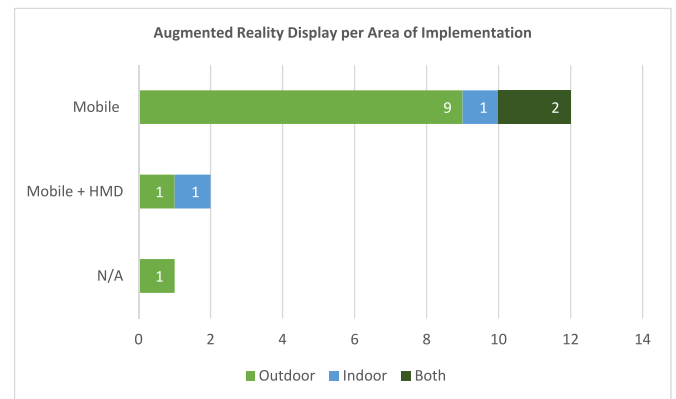


Fig. 4. Augmented reality display per area of implementation.

Table 3

Augmented reality characteristics and software analysis.

Study	Augmented Reality		Software		Type of Content Displayed Through Augmented Reality
	Tracking Method	Display	Application	Augmented Reality	
Andrade and Dias (2020)	GPS and Beacons	Mobile	Unity3D	Vuforia	3D Model, and Text
Lehto et al. (2020)	Marker-based	Mobile	N/A	N/A	3D Model, and Text
Nisi et al. (2019)	Marker-based	Mobile	Unity3D	Vuforia	3D Model
Liestøl (2019)	GPS ^a	Mobile	N/A	N/A	3D Model, Image and Text
Liestøl et al. (2021)	GPS	Mobile	Unity3D	SitSim AR	3D Model, Image, Sound
Decker et al. (2021)	GPS ^b	Mobile and HoloLens	Unity3D	N/A	3D Model
Koo et al. (2020)	GPS	Mobile	Unity3D	Unity ARKit	3D Model, Video, Image and Text
Varinlioglu and Halici (2019)	GPS	Mobile	N/A	N/A	3D Model and Text
Sprung and Haxha (2020)	SLAM	Mobile	Unity3D	ARFoundation	3D Model and Sound
Jakobsen et al. (2018)	Gyroscope	Mobile	N/A	N/A	3D Model, Text and Sound
Cesaria et al. (2020)	Marker-based	Mobile	Unity3D	N/A	3D Model
Koutsabasis et al. (2021)	GPS and Marker-based	Mobile	N/A	N/A	3D Model
Fenu and Pittarello (2018)	Marker-based	Mobile	Wikitude Studio	Wikitude SDK	3D Model, Image, Text and Sound
O'Decker et al. (2021)	SLAM	Mobile and HoloLens	Unity3D	Device API	3D Model, Video and Sound
Calvi (2020)	GPS ²	N/A	N/A	N/A	Video

^a The author of the study mentioned that the application's tracking method is based on location, as it only works when the user is less than 200 m from Omaha Beach, suggesting, although not explicitly cited, that the smartphone's GPS sensor is used for this purpose.

^b Although not explicit, the authors mention that the AR application was developed with the intent of being used onsite, activating as soon the visitor enters the site.

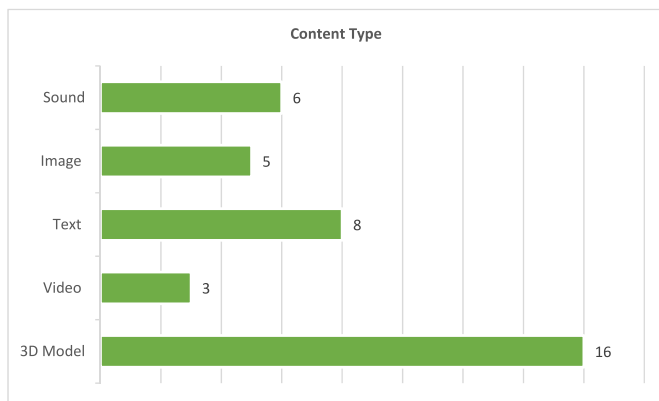


Fig. 5. Content type.

information (Pueyo, 2018). Its combination with games can be seen as a natural tendency, considering that games resort to stories to captivate and engage the player, thereby introducing them to the state of flow (Nakamura & Csikszentmihalyi, 2002). Although they are primarily associated with leisure, the applicability of games to contexts where the transmission of knowledge prevails is another of their strengths. Serious games are believed to have the potential to effectively maintain and communicate tacit knowledge associated with cultural heritage given that empathizing with the character or story can be a powerful tool for perceiving historical events, different cultures, and other people's thoughts and behaviors (Mortara et al., 2014). In the context of craft activities, narratives serve as a supporting structure that allows historical or cultural significance to be intertwined with the artifacts created through crafting, enabling visitors to infuse their creations with an elevated sense of purpose and authenticity by guiding them to understand the context and stories behind the artifact.

Delving deeper into how participatory activities are integrated, it can be noted that one of the most commonly adopted game mechanics, although substantially supported by narrative elements, was the treasure hunt, either as a single main mechanic (Jakobsen et al., 2018), or to complement others (Lehto et al., 2020; Nisi et al., 2019; Varinlioglu & Halici, 2019). In both cases, their implementation is intended to promote exploration of the place being visited. Despite the fact that Nisi et al. (2019) used a strategy of having a single treasure, which could only be found after obtaining the various pieces of the map during the progress of the game, in most cases it was verified that there are several treasures and that each treasure corresponds to an object associated with one of the locations (Jakobsen et al., 2018; Lehto et al., 2020; Varinlioglu & Halici, 2019), with subsequent locations being unlocked through correct answers to quizzes related to what they learned at the location (Varinlioglu & Halici, 2019). In addition, there were several reward strategies used. If on the one hand, the reward is awarded immediately after the treasure is discovered - allowing the user, through augmented reality, to inspect the object in more detail (Jakobsen et al., 2018), acquiring virtual points (Varinlioglu & Halici, 2019) or the traditional treasure hunt approach, where the treasure symbolises the end of the game, providing the user with the information they need to answer the final quiz questions (Nisi et al., 2019) –, on the other hand the reward is awarded solely after the whole process of the search for the missing object, encouraging the user to know all the points and stories of the place (Lehto et al., 2020). Thus, we can observe the presence of quizzes associated with treasure hunts, either to get answers to questions about the location (Nisi et al., 2019), or as a trigger for new hidden treasure locations (Varinlioglu & Halici, 2019).

Besides the quizzes, the treasure hunt is, on one occasion, also complemented with shadow games. With this game, users need to find the correct match of the shadow of a certain element in the museum, unlocking a 3D model of the species in question, and by answering

correctly to a quiz they can interact with the model in more detail and receive the map pieces to find the treasure containing the answers to the final quiz (Nisi et al., 2019).

In another perspective, one of the game mechanics utilized is based on the construction of buildings, in augmented reality, which allows the understanding and/or consolidation of the stories and construction methods. Two approaches are presented here: simple construction and sandbox. In the first one, the user must build following the construction instructions of the architectural buildings, according to the original construction plans, in order to visually understand the architectural information. In this way, there is a scoring system, which is assigned and displayed at each construction stage. In turn, the sandbox approach allows the user to build freely using the different building materials in a limited amount of time (Koo et al., 2020), being this mode the only one among the studies to be identified as craft in the clear sense of the construction concept.

However, using the concept of craft to refer only to physical construction is a reductionist approach, so we believe it can be understood in a wider sense ranging from the creation of new meanings to the discovery of new theories, without prescription. In line with our view, the study by Sprung and Haxha (2020), besides allowing to visualize, through augmented reality, demolished parts of the Graz Castle and to visualize and interact with the objects present in the simulation, the application allows participants to interact with each other. Upon entering the application, users enter a room, where they can view the avatars, dressed in historical clothing, of other users who are on site and work together to accomplish certain tasks and unlock goals (Sprung & Haxha, 2020). In this way, it can be considered as part of the craft activity in the social domain, since it provides a social space that allows for the construction of new meanings, and in the conversational domain, since users can dialog to develop new theories to overcome the challenges that are presented in the game. The social domain is also emphasized by Andrade and Dias (2020), and by Lehto et al. (2020), although with a different applicability from the previous one, by allowing users to take selfies with several historical figures presented in augmented reality, allowing the sharing it in other media (Andrade & Dias, 2020; Lehto et al., 2020). This approach aligns with the creation of new meanings by providing a functionality that allows users to take photographs with historical figures, making it possible to create small elements that belong uniquely to the user. The creation of these small elements is extremely beneficial for the overall tourist experience, which, according to Laws (1995), encompasses three phases: before (intent to visit), during (enjoyment of the destination), and after (memories of the place) (Laws, 1995). Drawing a parallel with the framework proposed by Buoincontri and Marasco (2017), which connects technology with the experience economy (Pine-II & Gilmore, 1999) and the three phases of a tourist experience (Laws, 1995), participatory activities of game and narrative are used with augmented reality solely *in loco*, with the aim of enhancing the on-site visit by providing complementary information, primarily promoting the dimensions of entertainment and education as referred to in the experience economy (Pine-II & Gilmore, 1999). Conversely, craft has the potential to extend beyond the immediate visit, into the after-visit moment and indirectly influence the before-visit phase. In the after-visit phase, crafted artifacts function as elements that enable visitors to re-experience of the journey by allowing them to reminisce about the memories associated with them. Additionally, by being shared on social media, these elements can also indirectly influence the before-visit phase of people who have never visited the location (Buoincontri & Marasco, 2017).

Making a brief analysis of the narrative component, several studies have resorted, through augmented reality, to characters, typically associated with the site, in order to tell its history, stories, or legends. If on the one hand we have characters that only act in the place where the user is (Andrade & Dias, 2020; Fenu & Pittarello, 2018), on the other hand we have a more complex approach, combined with other game

Table 4
Evaluation summary.

Study	Data Collection	Sample	Age	General Findings
Lehto et al. (2020)	The authors applied a post-test questionnaire composed of 28 questions, measured on a 7-point Likert-type scale, not mandatory and delivered through the mobile application itself. The questionnaire focused on six themes: the content and functionality of the game, the comprehensiveness of tasks in the game, emotions the game evoked, immersion into the story, the future of the game and the importance of the place. Some of the participants, in addition to completing the questionnaire, also completed, in groups, learning diaries about their game experience, addressing, necessarily, aspects such as the use of cell phone during the visit, the influence of the game in relation to the place visited and potentials and obstacles that the use of augmented reality can bring to historical sites.	194	9 to 31	The results varied according to the participants age, the youngest (9–11 years old) found the experience to be pleasant, while the older ones found this approach to be childish, as they were expecting factual information instead of historical stories. Notwithstanding, the general results suggest that this approach is capable of improving the visitors' experience at historical sites, enhancing the learning process and interesting towards history.
Nisi et al. (2019)	Prior to formal evaluation, the authors conducted a pilot test with 2 12-year-old participants. In this pilot test, observational techniques and interviews were used to collect the data. The formal evaluation was conducted in a simulated environment. After experiencing the game, two questionnaires were presented: Multimedia Guide Scale (MGS) (Othman et al., 2011), measuring the reactions to the usefulness and usability and AttrakDiff (Hassenzahl et al., 2003), measuring the attractiveness of the experience.	16	17.25 (average)	N/A
Liestøl (2019)	After using the application, the participants completed an individual pen and paper questionnaire.	17	N/A	N/A
Liestøl et al. (2021)	The evaluation starts with a brief contextualization of the application and the evaluation process. As the participant visits the space, a member of the development team accompanies him. After experiencing the application, users received a paper questionnaire focused on assessing the following themes: general experience of using the application, sound quality during the submersion and the historical reconstruction of the attack, and the adaptation of documentary elements.	6	N/A	N/A
Koo et al. (2020)	To conduct the evaluation phase, the authors asked visitors to install the mobile application, providing a hotspot to prevent them from spending their own mobile data. After completing the visit, participants were asked to fill out paper questionnaires. In the case of groups, only one questionnaire was collected. The questionnaire was based on four of the 10 indicators suggested by Hoehle et al. (2016) together with three others chosen by the authors - visual appeal; control obviousness; entry point; transition; usefulness; technology readiness - divided by 19 questions measured on a 7-point Likert-type scale.	169	≤19: 19 20–29: 47 30–39: 37 40–49: 30 50–59: 25 ≥60: 11	The results confirmed that the proposed mobile application is a valid alternative to the traditional guided touristic experience, considering the practical limitations of the guided experience. The authors propose, as future work, that the development of a guided touristic experience for a HMD could be an approach capable of providing a even a higher level of immersion in augmented reality.
Varinlioglu and Halici (2019)	The evaluation was conducted on-site with a group of visitors and experts at the archaeological site. Data were collected using a post-test questionnaire.	N/A	N/A	The results advocate in favor of the use of gamified informative environments in the field of archeology, as it provides an increased immersive experience to visitors.
Jakobsen et al. (2018)	User experience data was collected through post-test questionnaires based on the Intrinsic Motivation Index (IMI) (Center for Self-Determination Theory, n.d.) and questions designed by the authors. Also, the System Usability Scale (SUS) (Usability.gov, n.d.) was applied to evaluate the usability and interface of the application. At the end, a comparative questionnaire was administered to evaluate the experience with and without the application. All questions were measured against a 7-point Likert-type scale.	78	Children: N/A Seniors: 50 to 68	The results demonstrate that the mobile application improved the user experience for school children, but not for seniors, as they already had a positive experience with information boards. However, when directly asked, the latter still preferred the mobile app. As for the children, they considered the application to be more engaging and exciting, by giving them a more complete experience.
Fenu and Pittarello (2018)	Two evaluation phases were conducted, both involving visitors to the Svevo Museum and the city of Trieste. The mobile application was installed on the participants' personal smartphones. After the visit, participants were asked to complete a questionnaire available in the app. In addition to the questionnaire, the authors used observation methods, collecting users' behavior and verbal comments. The questionnaire contained a set of questions on demographics, previous use of AR or other technologies in cultural heritage contexts. To collect user experience, a questionnaire was administered based on O'Brien and Tomss' (2010) indicators: ease of use, degree of interest in the content, emotional engagement of the different types of augmentations, aesthetics and novelty of the experience.	48	N/A	The results indicate that the use of a storytelling-enhanced augmented reality mobile application in the context of the study is a valid approach to engage sensor and emotionally the visitors about the cultural heritage of a place.
O'Decker et al. (2021)	The data collection was based on a pen and paper questionnaire that included open-ended questions and 5-point Likert scales to measure the user experience, addressing the appeal of the application, format of information disclosure, level of interest, as well as the ease of use and comfort between an HMD and a tablet.	17	25 to 65	The results show that the prototype provided enjoyment, fun, and a positive emotional environment, with 94% of the participants advocating expanding the augmented reality application to other cultural heritage contexts. It was also mentioned that less formal approaches (e.g., the use of humor or highlighting the human side of historical figures) could enhance the cultural visit. Regarding the use of HMDs vs tablets, participants preferred the HMD due to the immersion factor, despite the tablet having a higher visual quality.

mechanics. Incorporating characters within games not only fosters players' emotional connections with the game's narrative, but also elevates them from mere observers of in-game events to active participants who genuinely experience the emotions of these characters (Lebowitz & Klug, 2011; Miller, 2004). One of the most prevalent ways characters are connected with game mechanics involves assigning missions, tasks, or challenges to players, encouraging them to explore the location (Koutsabasis et al., 2021; Lehto et al., 2020; Sprung & Haxha, 2020), with these missions being able to be carried out individually (Koutsabasis et al., 2021; Lehto et al., 2020) or in collaboration with another visitor (Sprung & Haxha, 2020). This approach is further coupled with other game mechanics: an object collection system and title progression (novice, helper, and expert) as they accomplish the missions triggered by the characters. Once the game is completed, the augmented reality component can be triggered again, allowing the player to three-dimensionally visualize the collected tools by overlaying them on the floor captured in real time by the mobile camera (Koutsabasis et al., 2021).

On another side, some studies implement a single main character that is solely utilized as a virtual guide to the site, and at each location the same character provides information about the current place (Decker et al., 2021; Jakobsen et al., 2018; O'Dwyer et al., 2021; Vanoverschelde, 2019). Among these, O'Dwyer et al. (2021) differ from the others by assigning human characteristics to the main character (e.g., humor), as does Decker et al. (2021) who allow the user to question the character.

In turn, narrative is also used solely to recreate events that happened at a particular location (Calvi, 2020; Cesaria et al., 2020; Liestøl, 2019; Liestøl et al., 2021). Lastly, the narrative can be secondary, solely implemented as an element of contextualization, being the game the main activity (Nisi et al., 2019).

Finally, in Table 5 we can see a summary of the mechanics of game, narrative and craft used in the studies presented.

Considering the technological aspect, the selection of tracking method is influenced by various factors, one of which is the intended usage area of the application, whether it is indoors or outdoors. In line with this claim and the specific focus on participatory activities in this review, it is unsurprising that outdoor spaces, such as archaeological sites and ancient cities, exhibit a prevailing presence as opposed to indoor spaces like galleries, libraries, archives, and museums, since the outdoors encompasses a larger space than the indoors. Notably, the analysis of tracking methods indicates a recurring trend of using GPS, a technology better suited for outdoor settings (Vairinhos, 2014). In terms of the display technology employed, the number of studies that use smartphones and/or tablets met our expectations. It is undeniable that mobile devices constitute one of the most used tools for experiencing augmented reality due to their widespread ownership – almost every potential user has one (Craig, 2013). Regarding other types of display, the relatively lower adoption of HMDs in outdoor environments, contrasted with a higher prevalence in indoor settings, might be attributed to site configurations. Indoor spaces are often more contained and visit-oriented than outdoor spaces, meaning that the responsible for indoor sites are more prone to provide HMDs to the visitors, considering that they are usually confined spaces with easy environmental variables to control. Conversely, in outdoor spaces visitors can freely roam, being, for this reason, more practical to use their own equipment while visiting the site.

In terms of software preferences, a recurring choice is Unity 3D, likely due to its popularity, versatility, accessibility, and cross-platform support. The availability of a vast community of developers contributing up-to-date documentation, resources, and tutorials could also account for the preference towards this game engine (Dealessandri, 2020). Moreover, its compatibility with the augmented reality platform Vuforia is a natural fit due to its ease of installation and reduced learning curve.

Lastly, regarding the content type, a clear prevalence of 3D modeling is noticeable. We believe that 3D modeling is widely used because of

the ease of recreation, compared to real images/videos, its capacity to faithfully reproduce original models or even because of the lack of real content on what the authors want to portray.

4.2. Q2: How is the evaluation process of an augmented reality mobile application for cultural heritage, that integrate game, narrative, or craft, performed?

The second objective outlined in this review aimed to understand how mobile applications are evaluated in these cultural contexts. First and foremost, each study's evaluation protocol was distinct. The sample size was quite inconsistent, with an average of 65.22 (SD = 69.76) participants. As for the age of the participants, most studies did not set any age limit, and those that defined age limits did so based on the target audience of the application. Regarding the method to collect data, most studies administered questionnaire surveys using Likert-type scales, either applied through the application or traditionally with pen and paper. However, only some studies used predetermined scales or indicators, either based on – Koo et al. (2020) was based on four of the 10 indicators suggested by Hoehle et al. (2016), Fenu and Pittarello (2018) was based on O'Brien and Tomss' (2010) engagement indicators, and Jakobsen et al. (2018) based on the Intrinsic Motivation Index (IMI) (Center for Self-Determination Theory, n.d.) -, or in full – Nisi et al. (Nisi et al., 2019) presented Multimedia Guide Scale (MGS) (Othman et al., 2011) and AttrakDiff (Hassenzahl et al., 2003), and Jakobsen et al. (2018) applied System Usability Scale (SUS) (Usability.gov, n.d.)-, with the remaining designing their own questions. Observational methods and interviews were rarely used (Fenu & Pittarello, 2018; Lehto et al., 2020; Nisi et al., 2019). Learning diaries were only used by Lehto et al. (2020) and one study administered comparative questionnaires to evaluate the experience with and without the application (Jakobsen et al., 2018). Based on these findings, it is observable in most studies that, despite using different protocols in terms of number and age of participants, the data collection instruments can be patterned. There is a transversal use of independent questionnaires and scales, evidencing evaluation processes based on the essence of the work under analysis and of formal experience. Nevertheless, the findings regarding the evaluation protocol underscore the significance of further research in this area, given that it remains challenging to rigorously measure mobile applications of this nature.

4.3. Q3: How can augmented reality mobile applications that integrate game, narrative, or craft influence the way cultural heritage is experienced?

Nonetheless, regarding the findings of each study, we were able to obtain some interesting results regarding the influence that using such applications can have on the cultural heritage experience. According to the results obtained by Lehto et al. (2020), although the integration of narrative was rewarding for the children, who could imagine and experience the characters' stories, the same was not true for the older students, who found the childish approach irrelevant and preferred descriptive historical facts over narratives. Also contributing to this perspective were the unrealistic graphics of the characters and the tasks given by them throughout the story (Lehto et al., 2020), which might be related with the concept of suspension of disbelief (Coleridge, 1906). The findings from Jakobsen et al. (2018) also illustrated similar results, with the children's experience being improved with the mobile application, while for seniors it had no impact as they already had a good experience with informational boards (Jakobsen et al., 2018). O'Dwyer et al. (2021) suggests that one method that can be used to engage these older visitors is the use of humor, considering that it is less formal in comparison with the approaches commonly seen (O'Dwyer et al., 2021), but which allows to maintain the rigor of descriptive historical facts. Indeed, the results show that the prototype was able to provide enjoyment, fun, and a positive emotional environment for visitors (O'Dwyer

et al., 2021). This approach is similarly suggested by Williams et al. (2012) who suggest that incorporating humor into a digital narrative can enhance understanding, alleviate stress and anxiety, and promote a positive attitude (Williams et al., 2012).

Notwithstanding these aspects, the narrative approach used by Lehto et al. (2020) demonstrated to be capable of improving the visitors' experience at historical sites, enhancing the learning process and interesting towards history (Lehto et al., 2020). In line with this perspective Fenu and Pittarello (2018) conclude that narrative can engage sensorially and emotionally the users, which suggests that first-person narrative is a key aspect to increase visitors' emotional engagement (Fenu & Pittarello, 2018). This conclusion aligns with the findings proposed by Williams et al. (2012), who suggest that a first-person narrative is more likely to engage the audience in the story compared to a third-person narrative (Williams et al., 2012).

Regarding the game element, Varinlioglu and Halici (2019) finds supports the use on gamified environments, as they constitute an element capable of increasing user's immersion during the visit. Not disregarding this finding, the study by Lehto et al. (2020) verified a correlation between visitors who already had some degree of interest in games and their interest in the application. That is, those who were already interested in games, evaluated the application more positively, than those who had no interest in games (Lehto et al., 2020).

Concerning craft, no specific results were obtained from most studies. Nevertheless, Andrade and Dias (2020), and Lehto et al. (2020) emphasize that the functionality that allows users to take selfies with several historical figures presented in augmented reality is capable of stimulating an active participation of users, raising the visit experience to a new level by promoting the share of user created content in other media, attracting more and new audiences, which, in turn, extrapolates awareness for the preservation of cultural heritage beyond the visit (Andrade & Dias, 2020; Lehto et al., 2020).

Moreover, the need to include sound effects and a narrator, in lieu of text on the screen, was detected (Lehto et al., 2020). These suggestions are in line with the results obtained by Fenu and Pittarello (2018), which showed that users are much more appreciative of audiovisual content, as well as the importance that Koo et al. (2020) assign to the visual component to improve the application's usability (Koo et al., 2020). However, Andrade and Dias (2020) suggest that the different contents should be combined, considering that video and text are more informative while augmented reality offers greater engagement (Andrade & Dias, 2020). Indeed, apart from the engagement factor, considering that the primary aim of these types of applications is to convey knowledge related to the cultural heritage of various locations, it's worth revisiting the connection Zagalo (2020) draws between Edgar Dale's (1969) "Cone of Experience" and the "Cone of Abstraction" by Baukal et al. (2013). This connection highlights how the diversity of media fosters a range of multimodal discourses, which in turn enhances learning (Zagalo, 2020). However, while diversifying content formats can enhance the overall learning experience, it's crucial for the authors to find a balance, as having more content doesn't necessarily guarantee better results (Williams et al., 2012).

Lastly, Koo et al. (2020) compared the application they developed with independent and guided tours, concluding that the mobile app visit experience has the potential to be a viable alternative to both. Furthermore, they indicate that the app presents itself as more advantageous and flexible since, unlike guided tours, it eliminates the need to schedule the tour in advance, there are no limits on the number of people the tour can take, and it is never insufficient for the demand (Koo et al., 2020). Sprung and Haxha (2020) complete these advantages with the possibility of using personal devices, as it is a way for organizations to avoid excessive costs to acquire devices and, later, to maintain them (Sprung & Haxha, 2020). Nevertheless, in the study by O'Dwyer (2021), participants preferred the use of the HMD in comparison with mobile devices due to the higher immersion factor in the first, despite the latter having greater visual quality (O'Dwyer et al., 2021).

At last, Table 6 summarizes the findings of the evaluation phase and suggestions achieved by the studies analyzed.

5. Challenges and strategies in augmented reality mobile applications for cultural heritage

The development of augmented reality mobile applications encounters significant barriers, primarily centered around the cost associated with producing high-quality content. This financial constraint often leads to the stagnation of numerous products during their early stages (Alexander et al., 2019). Beyond the financial aspect, there are a multitude of other challenges that also warrant consideration, namely the excessive battery consumption that the use of GPS entails, the unpredictability of the weather (Lehto et al., 2020), the difficulty of detecting and stabilizing the augmented reality detection and possible internet network failures (Andrade & Dias, 2020; Fenu & Pittarello, 2018; Liestøl, 2019). In order to avoid possible network failures that would negatively influence the tourist experience, a possible solution, adopted by Koo et al. (2020), is to make the application fully functional offline (Koo et al., 2020). Furthermore, it is necessary to be aware of the location of the augmented reality markers to prevent visitor discomfort during detection (Fenu & Pittarello, 2018). An alternative approach to diminish registration errors in outdoor spaces is exemplified by Jakobsen et al. (2018), Liestøl (2019), and Liestøl et al. (2021), who, aiming for the aforementioned goal, employed indirect augmented reality.

Furthermore, within our investigation, certain studies addressed the potential for personalizing the touristic experience. This customization involves selecting predefined thematic tours, such as architecture (Andrade & Dias, 2020; Koo et al., 2020), mystic caves, paradise, mythology (Andrade & Dias, 2020), land or marine animals (Nisi et al., 2019), or delving into culture and history (Koo et al., 2020). In a related vein, a concept that was not implemented due to time constraints was the creation of a general story that would establish a connection between different locations, and establish a system of choices that would define what kind of "governor" the player wanted to be (Lehto et al., 2020). However, this approach restrains to the path suggested by the application. With this in mind, Fenu and Pittarello (2018) adopted a strategy that grants visitors more autonomy, albeit posing challenges in terms of story implementation. The authors established that each location would feature a distinct narrative connected to an element that held significance for the novelist Italo Svevo (Fenu & Pittarello, 2018).

Last but not least, there are also some considerations that need to be noted at the time of evaluation. The reliance on participants' personal devices may introduce challenges, such as low battery power or the absence of mobile phones, potentially limiting the quantity of obtained responses (Lehto et al., 2020). Moreover, while conducting on-site tests allows to obtain valuable feedback, the resource-intensive nature of this process demands careful planning (Liestøl, 2019). Without stringent time management, it can swiftly deviate from its intended objective (e. g., participants take too long to fill out the survey, taking time away from the visit) (Jakobsen et al., 2018).

6. Conclusions and future work

The use of participatory activities within the context of augmented reality mobile applications for cultural heritage is an emerging area that takes advantage of the wide range of mobile devices available in everyday life. This literature review aimed to explore how augmented reality mobile applications that integrate game, narrative, or craft and that aim to convey knowledge associated with the cultural heritage of a particular place are designed. In addition, it was intended to understand how the evaluation protocol is designed and how the usage of such applications can influence the touristic experience.

In summary, the results of the different studies suggest that the use of participatory activities mediated by mobile augmented reality positively influences the experience of cultural heritage, being the narrative

Table 5
Game, narrative, and craft mechanics.

	Mechanic	Description	Study(ies)
Game	Treasure Hunt	The user must find one or more objects.	Jakobsen et al. (2018); Lehto et al. (2020); Nisi et al. (2019); Varinlioglu and Halici (2019). Koutsabasis et al. (2021); Lehto et al. (2020); Sprung and Haxha (2020).
	Missions or Challenges	The user must correctly complete a series of missions or challenges.	
	Quizz	The user must answer a series of questions correctly.	Nisi et al. (2019); Varinlioglu and Halici (2019).
	Shadowgames	Users must match the pieces with the shadow figures.	Nisi et al. (2019).
	Virtual Points	The game integrates a virtual rating system.	Varinlioglu and Halici (2019).
	Puzzle	The user must reconstruct a certain element by combining different pieces.	Koo et al. (2020).
	Object Collection	The game integrates a system that allows collecting objects.	Koutsabasis et al. (2021).
Narrative	Title Progression	The game integrates a title-based progression system, for example from novice to expert.	Koutsabasis et al. (2021).
	Characters	The application uses characters to tell the history, stories, legends of the place, or to assign missions to the users.	Andrade and Dias (2020); Decker et al. (2021); Fenu and Pittarello (2018); Jakobsen et al. (2018); Koutsabasis et al. (2021); Lehto et al. (2020); O'Decker et al. (2021); Sprung and Haxha (2020); Vanoverschelde (2019).
	World	The application features a narrative that encourages the exploration of the site.	Decker et al. (2021); Jakobsen et al. (2018); Koutsabasis et al. (2021); Lehto et al. (2020); O'Decker et al. (2021); Sprung and Haxha (2020); Vanoverschelde (2019).
	Events	The application uses narrative in order to recreate historical or artistic events.	Calvi (2020); Cesaria et al. (2020); Liestøl (2019); Liestøl et al. (2021).
	Theme	The application applies narrative to exclusively provide context for site or application.	Nisi et al. (2019).
Craft	Social	The application provides social spaces that allow the creation of new meanings.	Andrade and Dias (2020); Lehto et al. (2020); Sprung and Haxha (2020).
	Conversation	The application allows players to engage in a dialog to create new theories.	Sprung and Haxha (2020).
	Building	The application features a mechanic that allows the player to build elements.	Koo et al. (2020).

component indispensable in this context. This strategy appears to be the most widely adopted, as stories have a compelling influence in engaging and immersing users, allowing them to connect with historical events and cultural heritage in a more personalized and memorable manner. From the analysis conducted to the different participatory activities, the treasure hunt mechanics were the most implemented game mechanic. The rationale behind the prevalence of this game mechanic could be attributed to the fact that treasure hunts, as well as missions, are commonly encountered in various playful scenarios. They inherently offer a sense of challenge and reward, which, in a straightforward manner, motivates users to explore the diverse points of interest at the site. As far as narrative is concerned, the use of characters typically associated with the place to contextualize users about history, stories or legends is the most common. In the context of craft activities, a limited number of studies were identified, with the social domain being the most recurrent. The rationale behind the relatively lower occurrence of craft activities might be rooted in developers' inclination to opt for narrative and/or game activities in leisure contexts, driven by resource limitations and a lack of experience in implementing these types of activities. Another plausible reason for crafting being the least implemented activity could be attributed to the alignment of narrative and game elements with the cultural significance of the location, which might occur more naturally.

Concerning the evaluation, each study's evaluation protocol is different, encompassing variations in sample size and participant age, with consensus prevailing on data collection methods. Still, some authors use predefined scales and indicators, while others design their own questions. This variance can be attributed to the fact that research objectives often differ among studies, prompting researchers to tailor their evaluation methods to the specific indicators they aim to measure in each unique context. Regarding participant samples, it's worth highlighting that cultural heritage experiences are typically transgenerational, lacking a specific age limit for engagement, which contributes to the diversity in participant age. Additionally, both age distribution and sample size can be influenced by resource constraints and limited access to a larger pool of participants. However, it's important to note the lack of standardization, which can have both positive and negative

implications. On one hand, the academic landscape allows for experimentation, giving researchers the flexibility to adopt diverse approaches for conducting their studies. On the other hand, the absence of a standardized evaluation protocol may lead to the use of less appropriate techniques that could potentially introduce biases into the evaluation process.

In terms of the effects stemming from the implementation of this type of mobile applications within cultural heritage contexts, it is suggested that the use of participatory activities is capable of enhancing visitors' experience in historical sites, improving the learning process and increasing their interest for the history of the place, providing visitors with an immersive experience, engaging them sensorially, emotionally and actively with the cultural heritage. Effectively, the integration of participatory activities within augmented reality mobile applications has the ability to provide a highly immersive experience, increasing the level of visitors' engagement. However, the acceptance of both the technological implementation and the playful attitude by users is necessary for a joyful immersion to be possible.

Still, designing an augmented reality mobile application, particularly for the context in question, requires caution, either for creative reasons, scarcity of financial and time resources, cultural preservation, and limitations of the current technology. For this reason, the authors enumerate a list of important considerations to take into account while designing an augmented reality mobile application within cultural heritage contexts:

1. User Segmentation: Tailoring experiences in accordance with user profile is imperative, as preferences for narrative, game elements, and craft activities vary among different audiences.
2. Cultural Context: Align participatory activities with historical and symbolic relevance of the site is essential, ensuring contextual cohesion.
3. Humorous Inclusion: Introducing humor emerges as a mechanism to captivate and sustain the interest of older visitors, without compromising the factual integrity of content.

Table 6
Findings and suggestions.

	Finding/Suggestion	Study(ies)
Findings	The integration of narrative was rewarding for the children, while older age groups prefer descriptive historical facts.	Lehto et al. (2020).
	The mobile application was rewarding for the children, while in older participants it had no impact as they already had a good experience with informational boards.	Jakobsen et al. (2018).
	Narrative can engage sensorially and emotionally the users.	Fenu and Pittarello (2018).
	A virtual guide was able to provide enjoyment, fun, and a positive emotional environment for visitors.	O'Decker et al. (2021).
	The visit experience using a mobile application has the potential to be a more advantageous and flexible alternative to guided tours provided by organizations.	Koo et al. (2020); Sprung and Haxha (2020).
	Missions and narrative demonstrated to be capable of improving the visitors' experience at historical sites, enhancing the learning process and interest towards history.	Lehto et al. (2020).
	Gamified environments constitute an element capable of increasing user's immersion during the visit.	Varinlioglu and Halici (2019).
	Visitors who were already interested in games evaluated the application more positively, than those who had no interest in games.	Lehto et al. (2020).
	Participants preferred the use of the HMD in comparison with mobile devices.	O'Decker et al. (2021).
	There is a need to use sound effects and a narrator in this type of applications.	Lehto et al. (2020).
Suggestions	First-person narratives are a key aspect to increase visitors' emotional engagement.	Fenu and Pittarello (2018).
	The functionality that allows users to take selfies with several historical figures presented in augmented reality is capable of stimulating an active participation of users, extrapolating awareness for the preservation of cultural heritage.	Andrade and Dias (2020); Lehto et al. (2020).
	Less formal approaches can enhance the cultural visit.	O'Decker et al. (2021).
	Audiovisual content improves the application's usability.	Fenu Pittarello (2018); Koo et al. (2020).
	Different audiovisual contents should be combined with augmented reality.	Andrade and Dias (2020).

4. Emotional Engagement: Employing first-person narratives fosters emotional engagement by creating a profound link to historical context and characters.
5. Gameplay Immersion: The infusion of game elements, exemplified by treasure hunts, missions and challenges, can heighten the immersion, especially for gaming enthusiasts. This approach serves as a means to encourage visitors to explore multiple points of interest.
6. Active Craft Participation: The facilitation of craft activities fosters visitor engagement, promoting their active involvement and content sharing beyond visits.
7. Content Equilibrium: Striving for equilibrium between different type of content format (e.g., text and video) enhances engagement and learning capabilities.
8. Harmonizing Entertainment and Education: Find a harmonious balance between playful interactions and conveying cultural insights.
9. Technological Optimization: Taking into account factors like network connectivity, battery life, and tracking and registration errors is vital to provide a user-friendly and reliable experience in cultural heritage settings.
10. Visit Harmony: Augmented reality mobile applications should enhance, not overshadow, the cultural touristic visit.

It is worth noting some fragilities found in the present review. Accordingly, we can register a set of improvements in relation to the search strategy in order to try to obtain more results: a) add the terms "Game*", "Gaming", and "Heritage"; b) replace the terms "Narrative" to "Narrativ*", "Digital Narrative" to "Digital Narrativ*", "Interactive Narrative" to "Interactive Narrativ*", "Handicraft" to "Handicraft*", "Handcraft" to "Handcraft*", "Craftwork" to "Craftwork*", and "Handiwork" to "Handiwork*". In addition, it would be essential to include articles prior to 2018, in order to not only have a greater breadth of articles, but also to understand whether there have been significant changes in the use of augmented reality.

Looking from the standpoint of future work, the creation of a model that enables the design of mobile augmented reality applications with participatory activities of game, narrative, and/or craft regardless of the culture site configuration would be a step forward in the field of human-computer interaction. Likewise, further research is needed regarding the development of data collection methods for augmented reality, in terms of building and validating a scale that serves to accurately measure the usability of augmented reality applications with these participatory

activities. As far as the main project mentioned in the introductory chapter is concerned, the information gathered in this review will help in making decisions for the design of user experience and evaluation methods of participatory activities and will be crucial in deciding what will work best considering our objectives.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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