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Augmenting the intangible: an intervention through an AR mobile app and an installation to foster a local cultural phenomenon

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Introduction: In the context of preserving and promoting Intangible Cultural Heritage (ICH), we propose a technology-driven approach to transmit cultural and social phenomena to new generations. As a case study, we explored the *umarell* phenomenon, a deeply rooted tradition in the Emilia Romagna region, where retired men spend their time observing construction sites and offering unsolicited advice.

Methods: Our intervention was designed using Human-Computer Interaction (HCI) methods, involving 15 young adults in a focus group and 73 participants in a survey. To engage digital natives in urban spaces, we developed an *in-situ* experience that combines tangible artifacts with interactive 3D digital content accessible through Augmented Reality (AR) on a mobile application. Our approach leverages smartphone sensors, including GPS and gyroscopes, to dynamically adjust and contextualize the 3D building model within the real environment, enhancing spatial awareness and immersion. To assess the effectiveness of our solution, we involved approximately 125 teenagers and young adults in a public demonstration.

Results: The findings show that the umarell concept is more familiar to adults, who also recognize its territorial value, whereas younger participants were drawn primarily to the app's digital features (AR function and 3D model).

Discussion: This study extends existing research by showing how hybrid strategies, combining mobile AR with tangible elements, enhance engagement with cultural heritage among younger audiences. The intergenerational co-design process helped identify meaningful features while mitigating risks of cultural flattening and commodification. Overall, technology emerges not as a substitute but as a bridge for intergenerational cultural transmission.

KEYWORDS

heritage, intangible cultural heritage, augmented reality, public installation, 3D digital content

1 Introduction

Cultural heritage plays a crucial role in shaping future societies by preserving collective memory and fostering cultural awareness among citizens (Siountri and Vergados, 2018; Plaza-Hernández and Rodríguez, 2022). While urban digital transformation often overlooks the unique cultural characteristics of different communities, the integration

of Smart Cultural Heritage presents a unique opportunity to enhance and safeguard local identity through innovative technologies and participatory processes (Siountri and Vergados, 2018).

Cultural Heritage encompasses the ways of living passed down through generations, including traditions, practices, places, objects, art, and values (ICOMOS International Cultural Tourism Charter, 2002). Tylor (1871) defines it as "that complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities acquired by man as a member of society." This definition highlights the relevance of both tangible heritage (e.g., buildings and monuments) and Intangible Cultural Heritage (ICH) (Vecco, 2010). ICH refers to cultural expressions that lack a physical form, such as traditions, performances, knowledge, and skills recognized by communities as part of their identity (Kurin, 2004). It includes oral traditions, social practices, craftsmanship, gastronomy, and other living cultural expressions (Ruggles and Silverman, 2009). Often referred to as living cultural heritage, ICH is continuously recreated within social ecosystems and deeply rooted in territories and communities (Cominelli and Greffe, 2012), ensuring a sense of identity and continuity across generations (Lenzerini, 2011). Communities play a crucial role in its preservation and transmission, contributing to cultural diversity and human creativity, as recognized by the 2003 UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (UNESCO, 2003).

In the broader field of Human-Computer Interaction (HCI), ICH has become a key area of research. Studies in this domain explore how interactive technologies, such as virtual and augmented reality, sensors, and digital platforms, can document and share cultural practices, preserving traditions while actively engaging communities (Liu et al., 2023; Rao et al., 2024). Moreover, revitalizing cultural heritage within smart cities enhances quality of life (smart living) and generates economic value for local cultural industries (Pouryousefzadeh et al., 2021; Siountri and Vergados, 2018). Smart heritage management platforms facilitate data-driven decision-making, improving conservation efforts and fostering new forms of knowledge creation and public engagement (Plaza-Hernández and Rodríguez, 2022). Additionally, digital technologies enable the reinterpretation of urban history, offering fresh perspectives on the city's built past and challenging traditional narratives through creative, automated processes (Batchelor et al., 2021). Cultural heritage innovation is becoming an essential component, integrating preservation, community participation, and technological advancement into a unified, forward-thinking approach (Batchelor et al., 2021).

In this context, we propose an intervention aimed at preserving and promoting cultural phenomena tied to specific communities and territories. As a case study, we examine the Italian cultural phenomenon known as *umarell*. The term, derived from the Bolognese dialect word *umarèl*, refers to retired men who spend their time observing construction sites–often with hands clasped behind their backs–while offering unsolicited yet thoughtful advice (Figure 1a). Originally a slang term in Bologna, umarell has spread across Italy, becoming a recognized social phenomenon (Andrea Mazzucchi, 2018; Urban Dictionary, 2015). It resonates particularly with the people of Emilia Romagna, as it evokes a familiar and endearing image. The concept gained further popularity thanks to Danilo Masotti (Masotti, 2005–2025), a Bolognese urban anthropologist who reintroduced it in 2007 through his book, sparking various creative initiatives. For instance, the cultural association *Succede solo a Bologna* launched the *Umarell card* as a fundraiser for the restoration of San Petronio Church (solo a Bologna APS, 2016). The term even inspired a Burger King social media campaign, which humorously recruited umarells to oversee restaurant construction sites (Jardine, 2016). More recently, a board game was developed, allowing players to experience the daily life of an umarell, a creative response to COVID-19 lockdown restrictions.[1] Although often treated as a humorous or nostalgic trope, the umarell figure can also be interpreted as embodying a specific relationship with urban space, one that aligns with Lefebvre's notion of the production of space (Lefebvre, 1991), wherein their behaviors contribute to the everyday shaping and social meaning of the city, transforming construction sites into arenas of informal observation, everyday sociability, and even grassroots surveillance. Despite its cultural significance and widespread recognition, we observed that younger generations are largely unaware of the umarell concept and its role in local traditions and society.

In this paper, we address a broader research question: *Can emerging technologies be leveraged to engage young adults with a local cultural phenomenon?*. To explore this, we design and evaluate an intervention intended to spark curiosity about the umarell phenomenon, with the added benefit of passing it down to younger generations. To make this intangible cultural concept more tangible, we adopted a mixed approach that combines an *in situ* physical installation with a mobile application, drawing inspiration from previous studies (Häkkilä et al., 2014; Valkanova et al., 2014; Hu et al., 2013; Zheng, 2024). The physical installation serves as a tangible user interface, capturing users' curiosity and providing a contextualized space for interaction with the cultural landmark (Figure 1). Complementing this, the mobile application leverages smartphone sensors, including GPS and gyroscopes, to dynamically align and visualize 3D models of construction sites in Augmented Reality (AR). This integration enhances spatial awareness and immersion, allowing users to experience the umarell perspective firsthand while engaging with the historical and cultural context in an interactive way.

The rest of the paper is organized as follows. Section 2 details some examples of emerging technologies used to promote ICH. In Section 3, we present the design process applied to implement our approach, including the results of a focus group with 15 young adults and a survey with 73 participants. Then, the resulting intervention, composed of the tangible artifact and the mobile application, is described in Section 3.2, and the outcome of a public session evaluation with about 125 participants is presented in Section 4. Finally, Section 6 concludes the paper with final remarks and future work.

2 Related work

Involving young people, particularly students, in the upkeep of archaeological sites, museums, and libraries, as well as local

1 https://dominionilibri.it/prodotto/la-giornata-dellumarell/

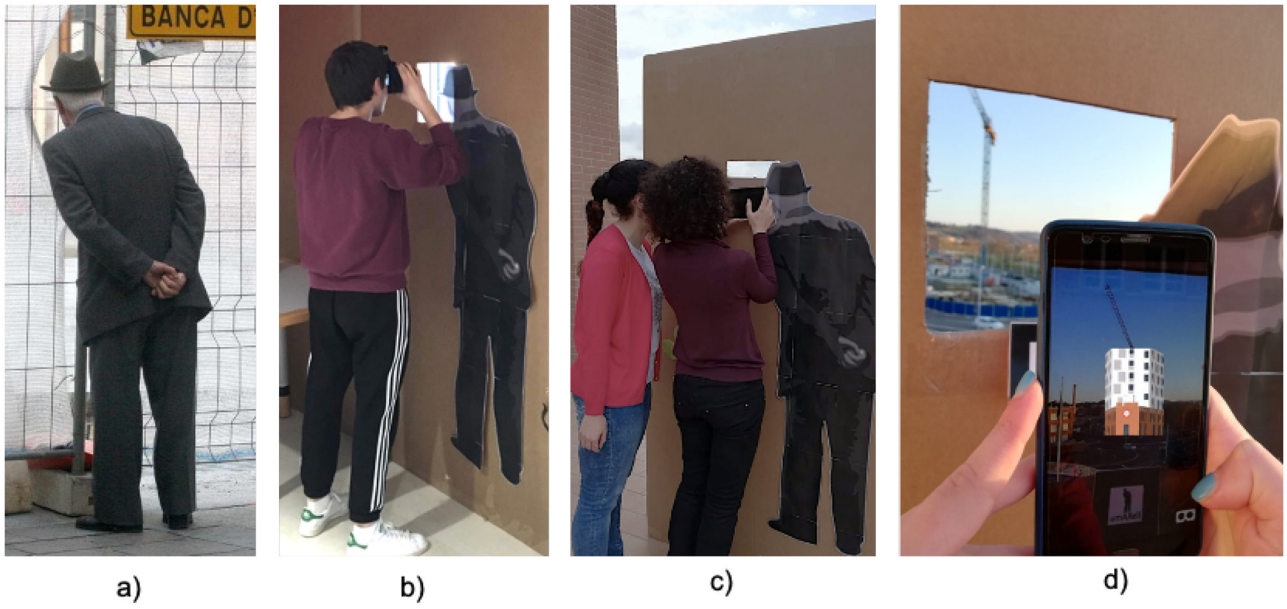

FIGURE 1
The UMARELL concept: **(a)** a typical image showing an umarell peering at a construction site [credit: Masotti (2005–2025)]; **(b)** our installation where the users are interacting through an AR/VR headset and **(c)** with an Android tablet; **(d)** the outcome of the AR function (3D model) in the *in situ* installation scenario.

heritage projects, not only raises their awareness of heritage values but also contributes to the preservation and promotion of these cultural assets, as proven by the study proposed in Menkshi et al. (2021). Looking at the literature, one way to engage young adults is by exploiting mobile applications combined with 3D User Interfaces (3D UI), which have gained significant traction in recent years due to advancements in interactive technologies and the growing demand for immersive experiences. These interfaces are crucial for enhancing user interaction within Virtual Reality (VR) and Augmented Reality (AR) environments, where the third dimension plays a pivotal role in improving spatial understanding and user engagement (LaViola et al., 2017; Ceccarini and Prandi, 2022). AR has emerged as a powerful tool for enhancing the accessibility and understanding of cultural heritage, both tangible and intangible (Sun and Wang, 2024; Boboc et al., 2022). By overlaying digital information onto the physical world, AR allows users to experience historical artifacts, monuments, or traditions in new and engaging ways (Nikolarakis and Koutsabasis, 2024), while having in mind the potential to educate on cultural heritage (Dordio et al., 2024). For example, "MuseumEye" has integrated AR with museum tours, offering rich, layered information about exhibits through smartphones. It exploited markerless tracking and the simultaneous localization and mapping method through the smartphone camera. These applications provide educational value and engage users in more meaningful interactions with cultural heritage (Hammady et al., 2018). In line with this, the study proposed in Galani and Vosinakis (2024) introduces a mobile augmented reality installation that recreates the stages of the leather tanning process by overlaying 3D content onto a physical scale model of an old tannery. The approach aims to convey the cultural significance of traditional craftsmanship to visitors, linking the building's architectural features to its historical context and former usage. The educational angle is also considered in Arias-Espinoza et al. (2018), where authors created a mobile app to preserve the heritage of the Cañari and Inca indigenous cultures. The app, meant to be used by children at home or in a museum in Ecuador, exploited QR codes and AR to increase their interest in the museum's material. The use of mobile applications for cultural heritage is extensively discussed, in combination with extended reality technologies, in the systematic literature review by Marques et al. (2023), which examines their effectiveness in cultural engagement and education. The authors delve into gamification, revealing how game-like elements are integrated to enhance user motivation and engagement, especially in historical, architectural, and archaeological heritage contexts. Another way to increase engagement is by creating tangible experiences. For example, the study proposed by Krumpen et al. (2021) analyzed the use of haptic feedback to enrich VR-based object inspection in the context of cultural heritage. Following this branch, the study proposed in Nofal et al. (2018) investigated the tangible characteristics of an interactive prototype museum installation to understand how it influences the visitors' perception of a story about tacit heritage knowledge. The museum experience is also taken into account in Chu and Mazalek (2019), where tangible and embodied interaction with cultural heritage artifacts was the means for visitors to understand the cultural context. On the same page, Duranti et al. (2016) investigated the potential of tangible interaction in order to give shape to intangible contents. Interestingly, the study classified as tangible all bodily experiences during interaction with digital content, such as manipulating physical objects or using gestures.

Analyzing the existing literature, we observed that both Location-based AR and Marker-based AR have been widely used

in cultural heritage applications, each offering distinct advantages. Location-based AR enables geographical targeting in specific hotspots by just relying on device sensors, without the need for costly outdoor markers, and provides practical applications for navigation and wayfinding. However, due to the limited accuracy of smartphone sensors (GPS, gyroscope, accelerometer, and magnetometer) in certain scenarios, achieving precise geo-located experiences on mobile devices remains a challenge (Dargan et al., 2023). On the other hand, Marker-based AR ensures greater positional accuracy and stable content placement, making it a reliable alternative when GPS accuracy is insufficient. However, Marker-based AR also has its limitations. In certain situations and weather conditions, markers may fail to be scanned if they reflect light, affecting usability in outdoor settings. Additionally, AR experiences disappear when the mobile camera moves away from the marker, requiring users to repeatedly scan the trigger image to re-access the content (Dargan et al., 2023). To leverage the strengths of both approaches, we adopted a mixed AR strategy, combining Location-based AR for contextualized, large-scale experiences and Marker-based AR as a fallback solution to ensure accurate and seamless interactions in case of sensor inaccuracies.

Building on insights from related works, we chose to focus on a mobile application, complementing it with a tangible installation. However, our approach differs from traditional methods, typically centered around museums or indoor spaces. Instead, we explore outdoor settings, encouraging participants to experience the life of an *umarell* by engaging with urban surroundings and navigating construction sites. To ensure that this outdoor, exploratory experience was both captivating and meaningful, we actively involved our target users during the design phase. This participatory approach enabled us to assess the effectiveness and relevance of specific design elements in enhancing engagement within an open, mobile environment. Additionally, drawing inspiration from previous studies, we integrated an *in-situ* installation to further ground the experience and make it more tangible.

In summary, our contribution lies in the hybrid use of both location-based and marker-based AR, applied in the context of live construction sites. What further distinguishes our approach is the integration of a tangible, on-site installation designed to be clearly visible and spark curiosity among passersby. This physical presence not only acts as a visual anchor for AR content but also serves as an entry point for engagement, drawing attention to the experience and increasing the likelihood of interaction, particularly among audiences unfamiliar with the concept of *umarell*.

3 Materials and methods

3.1 Methodology

Our approach, as visible in Figure 2, was composed of four steps: (i) analysis of related work on cultural heritage; (ii) a design process involving a focus group with young adults and a survey; (iii) a development phase where the app and an *in-situ* installation were created; and (iv) an evaluation phase to assess our approach and collect reactions, where we made the installation available to the public during a University open day, an attractive event for young adults and teenagers (usually, students attending the last two years of high school)—as described in Section 4.

The design process was composed of two steps: (i) a focus group with young adults (the target community), and (ii) a survey, employing a user-driven innovation approach (Chang and Kaasinen, 2011; Holmquist, 2004; Roccetti et al., 2020).

3.1.1 Focus group

To collect ideas, we conducted a focus group involving 15 young adults (according to our primary target audience), ranging from 19 to 26 years old, nine males and six females. The group comprised ten people from Emilia Romagna (where the concept of umarell was coined) and five from nearby regions. The participants were students enrolled in the Computer Science Bachelor's Degree who voluntarily answered our call for participation.

The focus group lasted one hour. After a short introduction to the project, we presented the umarell concept and the project brief: "In the context of bringing the umarell concept closer to young people, which functionalities should a mobile application have?", and we opened the discussion. The session was recorded with the consent of the participants, according to the GDPR EU law, for later analysis.

The first interesting outcome was related to the concept of umarell: just three participants were familiar with the term; five recognized it as an intangible value once visualizing the image representing a umarell in his typical environment (Figure 1a); for the remaining seven, it was the first time they heard about it.

After the session, we analyzed the recorded discussion and sketched some features the application should have according to the participants, which we formalized into the low-fidelity mockups visible in Figure 3. The application should provide three features:

1. A list of construction sites and the possibility of visualizing them in a map-based interface (Figure 3a);
2. An augmented reality (AR) function to see and interact with a 3D preview of the resulting construction (Figure 3b);
3. Gamification mechanisms to engage users, like leaderboards, badges, etc. [already proved to be successful in urban contexts (Prandi et al., 2019; Arakawa and Matsuda, 2016)] (Figure 3c).

In particular, the second feature that emerged is in line with the findings from the related works (Hammady et al., 2018; Galani and Vosinakis, 2024).

3.1.2 Survey

To understand the pervasiveness of the umarell concept and have some feedback on the features resulting from the focus group, we conducted a survey, sharing an online questionnaire on two-course units (Web Technologies and Mobile Programming) web pages. Moreover, we asked participants to share with friends and family [exploiting the snowball sampling strategy (Handcock and Gile, 2011)].

As visible in Table 1, the questionnaire was composed of 15 items:

- *Demographic section*: three questions related to personal information (i.e., age, gender, birthplace);

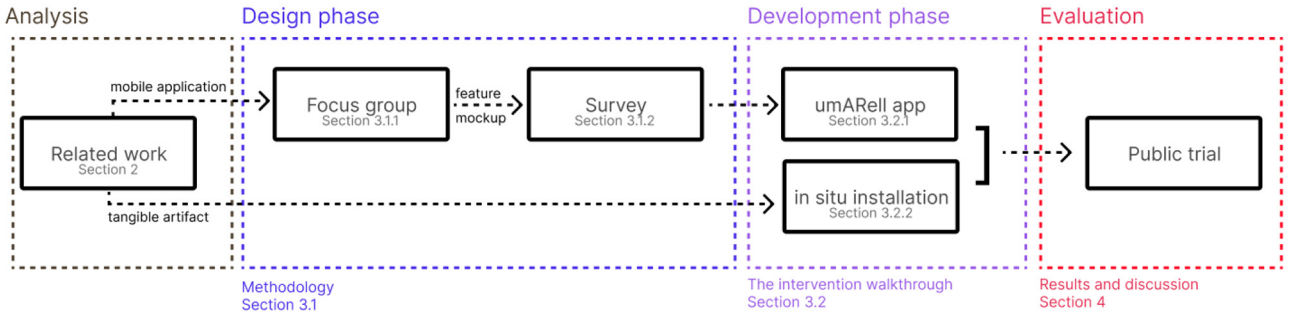

FIGURE 2
The methodology composed of four steps: (i) analysis of related work on cultural heritage; (ii) a design phase involving a focus group with young adults to gain insights on the feature that an app should have in the context of spreading knowledge on the umarell concept and a survey to receive feedback on the findings; (iii) a development phase where the app and an *in situ* installation were put in place; and (iv) an evaluation phase.

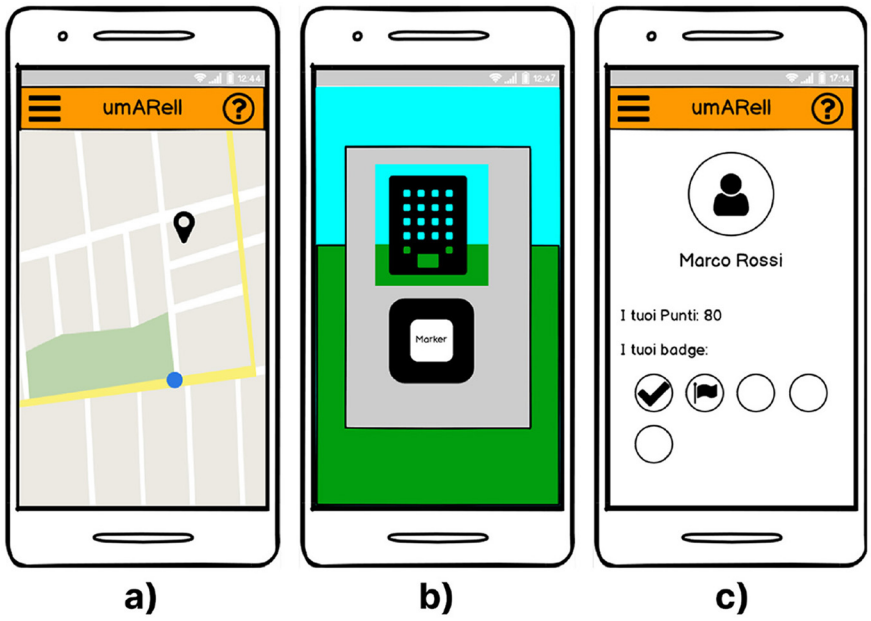

FIGURE 3
Mockups presented in the survey to explain the mobile app features: **(a)** a map-based interface with construction sites as Points of Interest (PoIs); **(b)** the AR function to see a 3D preview of the resulting construction; **(c)** gamification mechanisms to engage users (i.e., badges and points).

- *Umarell section*: two questions related to the umarell concept, particularly concerning its meaning;
- *App's features section*: seven 5-point Likert-scale questions to rate the interest in the app's features (e.g., 3D model of the construction sites, gamification elements, AR)—to note that low-fidelity mockups (visible in Figure 3) were used to represent the mentioned features;
- *App usage*: two questions regarding the possibility of installing the app once available, and an open question to explain the previous answer;
- *Feedback section*: an open question to integrate the previous answers with comments or feedback on the project.

We received 73 responses, with 54 males (74%), 17 females (23%), and two respondents who preferred not to indicate their gender. Their ages ranged from 16 to 61. As anticipated, most respondents (65 individuals, 89%) fell within the 18–24 age range, which aligns with our target demographic. In terms of awareness of the "umarell" concept, 41 users (56.2%) indicated that they were not familiar with it, while 32 users (43.8%) reported that they were aware of it. We verified the correct knowledge by analyzing the answers to question Q5. In particular, all the answers were correct, analyzing different aspects of the umarell, named age, polemic mood, body position, and origin. For example, P12 said that umarell is "the old man from Emilia Romagna watching the construction sites" or P18: "The typical old man/retired man who watches the construction site and pontificates about the work of the laborers, because "that is not how it is done.." Also, their body position is famous, as stated by P32: "They are used to do with their hands placed behind their backs and with constant negative comments about the organization and progress of the work, regardless of how it is actually proceeding." The activity can

TABLE 1 Questions asked in the survey to understand the pervasiveness of the umarell concept and have some feedback on the features resulting from the focus group.

Section	ID	Questions	Type
Demographic	Q1	How old are you?	Choice
	Q2	What gender do you identify with?	Choice
	Q3	What is your birthplace?	Open
Umarell	Q4	Do you know the meaning of umarell?	Yes/no
	Q5	If yes, write a brief description	Open
App's features	Q6	How interesting do you find the information about the construction site?	5-point Likert Scale
	Q7	How much do you think the badges encourage app usage?	5-point Likert Scale
	Q8	How motivating do you find the leaderboard?	5-point Likert Scale
	Q9	Would you like to play without a leaderboard?	Yes/no
	Q10	Would you like to appear on the leaderboard without your username?	Yes/no
	Q11	Do you find the 3D model interesting?	5-point Likert Scale
	Q12	How interested are you in the AR component?	5-point Likert Scale
App usage	Q13	Would you use the app?	yes/no
	Q14	If you want, justify your previous answer.	open
Feedback	Q15	Do you have any comments?	open

also be taken on their own or in small groups, highlighting also the social aspect, as emerged from the answer of P22, who mentioned "a group of old man."

Concerning the birthplace (visible in Figure 4), we had 35 participants from the Emilia-Romagna region and 38 from other Italian regions. To understand if a relationship exists between the birthplace of the participants and the knowledge of the "umarell" term, we employed the Chi-Square (X^2) Test of Independence, which is a nonparametric test used to determine the eventual relationship of two categorical variables. In particular, we wanted to test the null hypothesis H0: "Knowledge of the "umarell" is independent of birthplace." However, from the results (X^2 = 2.22, df = 1, p-value = 0.14), we were not able to reject the null hypothesis, since the p-value is greater than our chosen significance level (α = 0.05). Rather, we conclude that there is not enough evidence to suggest an association between knowledge of the concept and birthplace.

Looking at the ages of the participants (visible in Figure 4), most of them were in the range 18–24 years old (56%–76.6%), followed by the ones in the range 25–35 (12%–16.4%), one under 18, one in the age between 36–50 and the last 3 with an age above 50 years old. To understand if a relationship exists between the age of the participants and the knowledge of the "umarell" term, we employed the Fisher's Exact Test, which is a nonparametric test used as an alternative to Chi-Square (X^2) when the expected frequency of one or more cells in the contingency table is <5. We test the null hypothesis that knowledge about the "umarell" concept is independent of age. The findings are statistically significant since the p-value (0.03) is less than our chosen significance level (α = 0.05). We exploited Cramer's V to investigate the substantive significance. In particular, Cramer's V measures the effect size in terms of how strongly two categorical variables are associated. We saw a moderate correlation between age and knowledge of the concept (effect size = 0.33), which led us to reject the null hypothesis. Moreover, we computed Goodman and Kruskal's lambda (λ) to capture how this relationship manifests. Particularly, Goodman and Kruskal's lambda is a measure of association for categorical variables, exploited to quantify the strength of the relationship by assessing how much knowledge of one variable improves the prediction of the other. Our findings proved that knowledge of the "umarell" concept can be predicted from the age group, but with a low lambda [λ = 0.22, CI (0.00, 0.59)]. The presence of a moderate correlation between age and awareness of the concept of "umarell" highlights the importance of designing applications with a focus on younger generations, who are generally less familiar with the term. As such, the features and content included in the app should specifically target this demographic, with the goal of increasing their engagement and understanding of the phenomenon.

Focusing on our app, we received positive feedback on the clarity of the mockups, and the three features identified in the focus group were generally well-received by the participants. In particular, the gamification and AR features, which are the main components of the application, were carefully analyzed.

Regarding the gamification feature, most liked the badges to incentivize the app's usage (μ = 3.6, σ = 1.0). At the same time, the leaderboard was considered motivating (μ = 3.7, σ = 1.0), and, consequently, 60.8% of the participants wanted to include it in the app. Moreover, interestingly enough, 67% declared to prefer to have the leaderboard showing the users' name (in contrast with the strategy of providing the user with his/her current position in the leaderboard). Given these results, we decided to keep the badges on the user's profile page and create a leaderboard with the players' usernames. Moreover, P54 stated: "The idea (of the app) is nice, the gamification component intriguing."

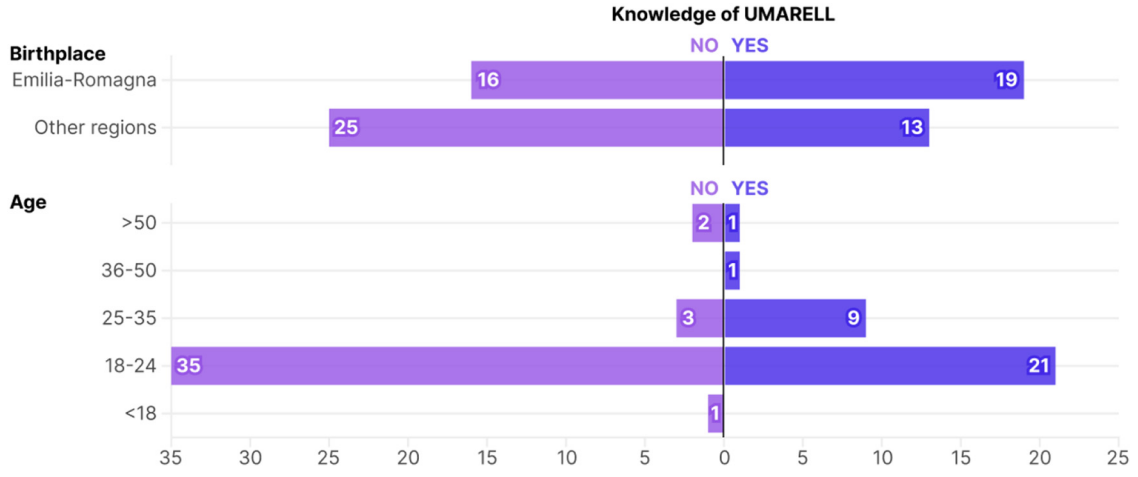

FIGURE 4
The distribution of the knowledge of the umarell concept by age and birthplace. Considering the birthplace, the division was made between Emilia-Romagna (the Italian region where the concept was born) and the rest of Italy.

Regarding the AR, 78% of participants liked having such a function. As proof of this, the AR functionality was considered interesting ($\mu = 4.2$, $\sigma = 0.9$) and the participants liked the 3D model of the building ($\mu = 4.0$, $\sigma = 1.0$). Despite that, one participant wrote: *"Augmented reality cannot make my lack of interest in construction sites a passion, even if done well and intuitively"*, while another claimed: *"I would like to see 3D models of hypothetical constructions"*. Considering this, we decided to keep the AR functionality as one of the main focuses of the application.

As a relevant result, 67% of the participants declared that they would like to download such an app.

3.2 The intervention walkthrough

Our approach to stimulate reactions about the intangible umarell concept was composed of two main components: the UMARELL mobile app and the *in situ* installation.

3.2.1 The mobile application

We developed the application based on insights gathered from the focus group and survey. The final version consisted of three main sections, each serving a distinct purpose as defined by the mockups in Figure 3. In the first screen (feature 1), users can browse construction sites in two ways: as a textual list or as points of interest on a map (Figure 5a). Selecting a construction site from either interface provides users with details about the project, including its address, should they want to reach it, and its future purpose (Figure 5b). The second section (feature 2) enables users to experience an AR representation of the construction site. Upon reaching the site, users can point their phone's camera at it to visualize and interact with a 3D model of the completed building, experiencing an immersive visualization of the future construction outcome (Figure 1d). Finally, the third section (feature 3) is a screen with the user's profile, including their username, badges they earned through gamification, and a leaderboard (Figure 5c).

Regarding the system architecture, we developed the mobile application using Apache Cordova,[2] an open-source framework that supports cross-platform development with standard web technologies. The application reads and writes data to a web server implemented in PHP with the Slim micro-framework,[3] relying on a MySQL database for persistence. The interactive map component for viewing construction sites is powered by Google Maps.[4]

For the AR functionality, we leveraged the AR.js library,[5] which offers support for both marker-based and location-based augmented reality experiences. Inspired by Sánchez Berriel et al. (2023); Kleftodimos et al. (2023), we chose location-based AR to dynamically place the 3D model correctly in relation to the user's location and device rotation. As shown in Figure 6, this technique relies on multiple sensors to accurately position AR objects in the real world. The onboard GPS determines the user's coordinates (Figure 6a), providing a reference point for AR placement. To correctly orient virtual objects, the magnetometer (compass) identifies the direction the user is facing, while the gyroscope tracks rotational movements and changes in orientation. Additionally, the accelerometer detects movement and tilt, ensuring a stable AR experience (Figure 6b). AR.js processes this geolocation and orientation data to position virtual objects at specific real-world coordinates (Figure 6b). In particular, the difference between the user's GPS location (Figure 6a) and the target AR object's coordinates (Figure 6c) dictates the object's placement and scale on the screen, ensuring accurate alignment within the user's environment. In addition to the location-based solution, we also used a personalized marker as (i) a fallback trigger for AR content when GPS data is unreliable or unavailable and (ii)

2 https://cordova.apache.org/
3 http://www.slimframework.com/
4 https://mapsplatform.google.com/
5 https://github.com/AR-js-org/AR.js

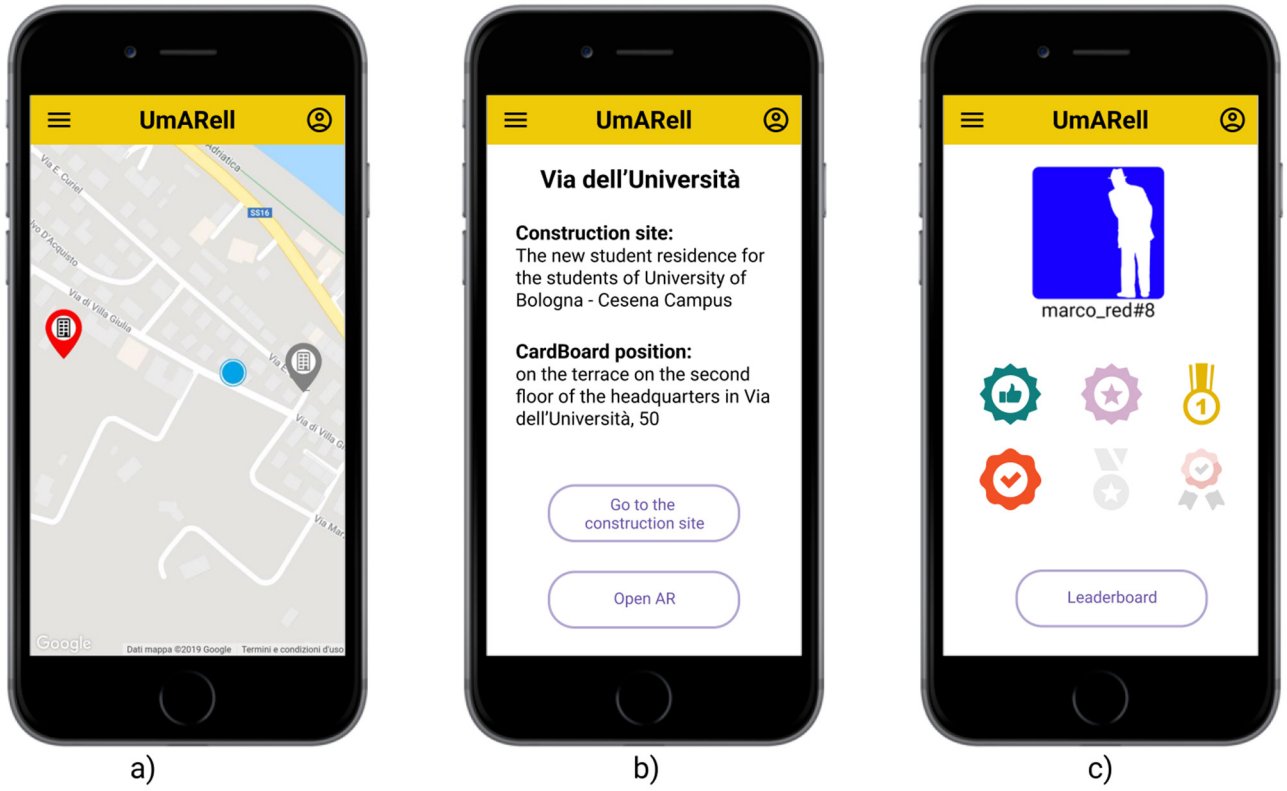

FIGURE 5
The intervention walkthrough: **(a)** the map-based interface (feature 1) of the application; **(b)** information on the selected construction site; **(c)** the profile of a user with the badges (feature 3).

a visual reference (logo) for our intervention. The AR feature is accessible on smartphone-based AR/VR headsets (Figure 1b), tablets (Figure 1c), and smartphones (Figure 1d).

3.2.2 The *in situ* installation

Inspired by pictures portraying the umarells (such as the one in Figure 1a), we constructed a cardboard installation featuring the characteristic opening through which onlookers peer at construction sites. Such an aperture has a two-fold goal: (i) covering the visual of the landscape surrounding the aperture, creating curiosity regarding what is possible to see from there; (ii) creating a physical marker for the user to frame with the camera, assuring a good overlap of the 3D model and the real landscape. Since the focus group and survey showed that users more readily recognize the image of the umarell than the name, we added a visual representation of the umarell to the cardboard installation. This should also make the umarell experience more imprinted on users' minds, since, in this way, it is possible to associate a tangible aspect with the intangible concept. The tangible installation is visible in Figure 7.

4 Results

After the implementation phase, we wanted to evaluate the impact of our intervention in order to answer our RQ. Specifically, we sought to explore whether the app's features and the tangible installation could spark interest and foster discussion among teenagers and young adults around the concept of the umarell. Through this evaluation, we aimed to understand the potential of our approach to engage younger audiences in provoking curiosity about this cultural phenomenon in a contemporary context.

Particularly, we collected observations (reactions and feedback) during a public trial organized during the Open Day of the Computer Science Department of the University of Bologna. On that day, more than one hundred students (mostly attending the last two years of high school) came to visit the campus, some accompanied by parents. During the Open Day, several groups of students (about 25 per hour), accompanied by a member of the university staff, can tour the university facilities and the different labs, where researchers are available to show demos. Our exhibition was one of those demos.

We staged the installation both outside, taking advantage of a large terrace (see Figure 1c), and inside, covering some large windows with cardboard (see Figure 1b). Both locations overlook a construction site where a new University building is being built. In fact, for this demo, we created the 3D model representing the future University building, including the official textures (colors and materials) and dimensions. To make the application immediately available to users (avoiding forcing them to install a new application to enjoy the installation), we provided them with two Android tablets, four Android smartphones,

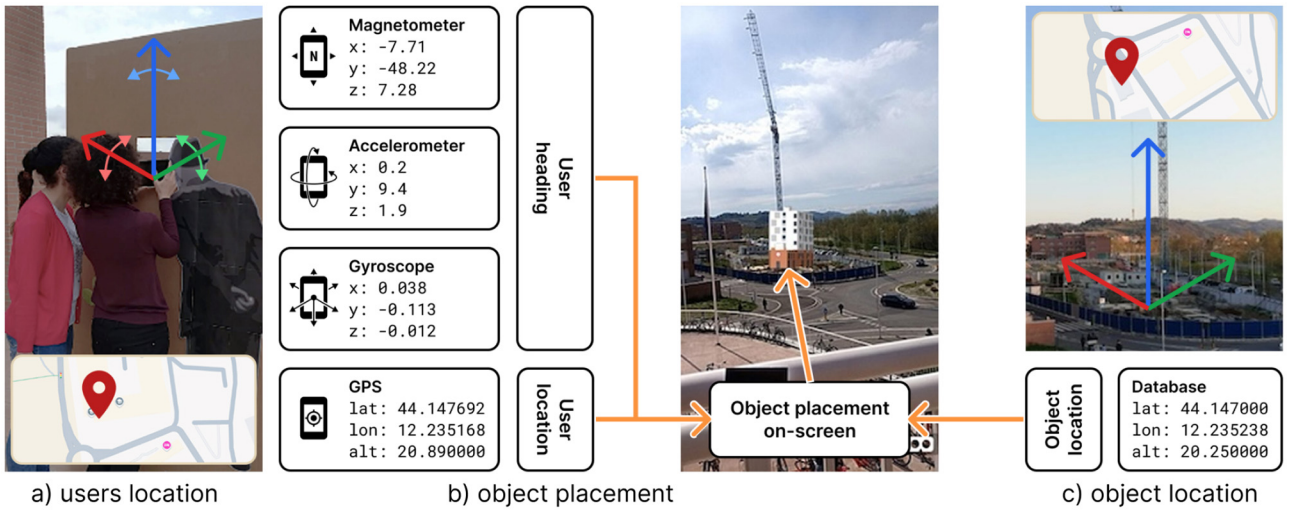

FIGURE 6
(a) Usage of smartphone sensors to perform object placement with location-based AR. **(b)** In particular, the GPS is used to geolocate the user, while the magnetometer, accelerometer, and gyroscope enable detecting the direction the user is facing. **(c)** This data, combined with the virtual object location fetched from the database and the camera feed, is used to compute the placement of the object on the screen.

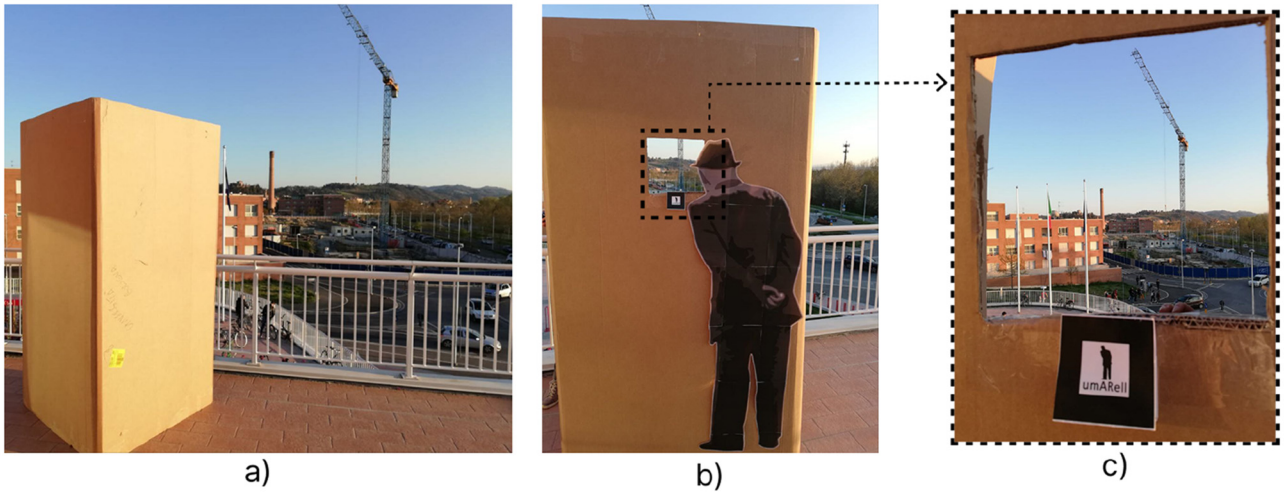

FIGURE 7
The *in situ* installation: starting from a simple cardboard structure **(a)**, it evolved into its final version featuring the iconic silhouette of the umarell **(b)** and a peephole oriented toward the construction site **(c)**.

and two AR/VR smartphone-based headsets. The two AR/VR smartphone-based headsets were positioned next to the tangible installation so that participants could choose whether to enjoy the AR directly from their phones or to place their phones inside the headsets to see the 3D of the building. We divided the group into two smaller groups to allow them to enjoy the system easily from the two demo stations. During the day, we counted more than one hundred users (circa 125) stopping by the installation and enjoying the demonstration. During the trial, the researchers (one for each site) entertained the participants, explaining the research idea behind the installation and asking a few questions (followed by an observer who took notes to document the users' reactions, affirmations, and expressions). As a confirmation of the survey data, most students were unaware of the umarell concept, with particular respect to those coming from outside Emilia Romagna. Instead, the few parents who were there to accompany their sons/daughters immediately answered affirmatively when the researcher asked who the man pictured in the cardboard was.

Most of the users visibly enjoyed the installation. Some of them (11) asked the researchers if the application was available on the App Store and if different construction sites were mapped into it. Two students also asked if it was possible to contribute to the system by adding more construction sites, following a crowdsourcing approach (also considering that we already have the GPS position of the users to trigger the AR content).

Another intriguing result was that some students (5) took a selfie with the umarell at the end of the demo. This is a clear sign of the cultural and social phenomenon of the umarell. One student claimed: *"I can't wait to retire to be able to take full advantage of it. In this way, I can optimize the time spent looking at the construction sites."*

At the end of the public installation, we realized that, nonetheless, young adults enjoyed the system; we gathered more enthusiastic reactions from adults (students' parents, but also University staff and faculty passing by). In fact, teenagers and young adults enjoyed most the novel digital functions provided by the application (e.g., the AR content) while adults, who already were familiar with the concept, showed strong interest in the umarell project, confirming that the umarell is "a (intangible) thing" that makes the native community of Bologna and surroundings feeling part of the territory.

5 Discussion

It is well established that digital technologies can play a key role in raising awareness and enhancing the knowledge of cultural heritage (Neglia et al., 2024; Quiroz-Fabra et al., 2022). However, our study goes beyond this premise by exploring how the combination of digital tools with tangible, real-world elements can further strengthen user engagement and curiosity. In particular, it highlights how this hybrid approach not only creates more immersive experiences but also fosters deeper connections with cultural content. By combining mobile AR experiences with a tangible cardboard installation, we adopted a hybrid strategy aimed at engaging younger generations through the digital language they are most familiar with, while maintaining a material anchor that evokes the physical context of the tradition. This approach allowed us to investigate the use of innovative methodologies that can be exploited for the future of cultural heritage in the digital age, *Digital Heritage Futures*, focusing specifically on the dynamic relationship between humans and digital media in the context of intangible cultural heritage.

The divergence of our approach from the purely traditional experience, where engagement with a construction site occurs directly and without digital mediation, highlights the value of hybrid heritage experiences that combine digital media with local knowledge to bridge generational gaps and expand the reach of cultural narratives. The tangible installation, which mimicked the typical construction-site peephole, provided an entry point into the umarell mindset, while the AR app projected the site's future in a way that appealed to teenagers and young adults.

However, one reflection should also be made regarding the potential cultural implications of digitizing and gamifying a phenomenon that is inherently observational and non-digital. Turning the umarell into a gamified or digital character, if not carefully reasoned, may result in the risk of stripping the phenomenon of its local flavor and cultural richness, resulting in cultural flattening (Khaled, 2011). Spontaneously observing a construction site in person involves a sensory, relational, and temporal experience, by watching progress, interacting with workers, or simply "being there." In contrast, a gamified version might reward check-ins or progress tracking, which might shift the focus from presence to performance. Moreover, digitization often brings with it a layer of irony or commercialization (Yeo, 2018). The umarell, already bordering on self-parody, risks becoming a commodified stereotype, consumed for entertainment rather than appreciated as a reflection of a broader cultural behavior.

To address these risks, we propose community-engaged co-design as a key component in our approach. Involving both experts in the traditions regarding the umarell and target users, particularly young adults, can foster mutual learning: young users can discover the cultural depth of the umarell, while experts can help shape a translation of the phenomenon that remains authentic, yet relatable. Focus groups, like the one conducted in the early phase of our study, provide a valuable space for this exchange. Through these dialogic processes, younger participants not only understand the heritage better but also contribute actively to imagining ways of communicating it to their peers in a manner that respects the tradition's origins while adapting its expression to contemporary media and sensibilities.

Following on this, the study's contribution also lies in its intergenerational design process: by involving both those with contextual and cultural knowledge and representatives of the app's target audience, the research uncovered valuable insights that informed the identification of the most meaningful and engaging features for young people. This approach suggests a promising direction for participatory design practices within the field of digital cultural heritage, supporting an intergenerational reinterpretation, where technology acts as a bridge and not a substitute for cultural transmission. Moreover, the intergenerational approach aligns with positive outcomes observed in other domains, such as infrastructure design and the development of public spaces (Nelischer et al., 2024; van Aalderen et al., 2024).

5.1 Limitations and future work

The study presented a mixed approach to engage young adults with a local cultural phenomenon. As with every empirical investigation, this study does not come without limitations. First, the evaluation was conducted as a preliminary assessment during a single, structured event, the Open Day of the University of Bologna. As such, the findings reflect short-term user engagement in a controlled setting and may not be representative of how the system would be received in more naturalistic or long-term deployments. Following this, participants engaged with the system for only a few minutes during the scheduled visit, and no follow-up was conducted to assess long-term engagement, retention, or deeper understanding of the cultural content. Second, the interaction with the installation occurred in a highly mediated context. Users were guided by university staff and researchers who explained the concept and facilitated the experience. This setting, while helpful for introducing the project, may have influenced user behavior and the nature of the feedback, introducing a degree of observer bias. Third, a further point of consideration relates to the cultural specificity of the umarell figure. While well-known in the Emilia-Romagna region, the umarell may not be immediately understood by individuals from other cultural contexts. This limits the direct transferability of the concept, unless additional contextualization is provided.

Future studies should aim to address these limitations by deploying the system in less structured, real-world contexts over longer periods, involving more diverse user groups. For example, the system could be deployed in public spaces such as urban parks or city centers for extended periods, allowing for spontaneous and unmediated interaction. Additionally, testing the installation in different cultural regions could help assess how the umarell concept is interpreted beyond its original geographic and social context. Another promising direction is to integrate user-generated content through crowdsourcing features, enabling a living, evolving digital archive shaped by community input. Additionally, other strategies, such as storytelling and shared virtual environment/metaverse, could be explored to investigate if and how they affect the study output. Finally, incorporating follow-up interviews or surveys after longer-term use could provide deeper insights into user engagement and the cultural impact of the intervention over time.

6 Conclusion

This paper presents a case study investigating how intangible cultural heritage can be propagated to younger generations, exploiting a mixed approach composed of digital technologies and tangible artifacts. We focused on the umarell Italian cultural phenomenon as a specific case study. The intervention was driven by a design process involving different generations of users, taking advantage of the user-driven innovation method. To collect reactions, we staged an *in situ* installation open to the public during the University Open Day, mostly engaging young adults and teenagers (our selected target).

The findings highlight that the umarell concept is more familiar and meaningful to adults, who tend to recognize its intrinsic and territorial cultural value. In contrast, young people were primarily drawn to the digital and novel aspects, particularly the AR features and 3D model. Nonetheless, based on the students' engagement and responses, we can affirmatively answer our research question: *Can emerging technologies be leveraged to engage young adults with a local cultural phenomenon?*. This study extends existing research by showing how hybrid strategies, combining mobile AR with tangible elements, enhance engagement with cultural heritage among younger audiences. The intergenerational co-design process helped identify meaningful features while mitigating risks of cultural flattening and commodification. Overall, technology emerges not as a substitute but as a bridge for intergenerational cultural transmission.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval were waived for this study due to the anonymized nature of the collected data. The study was conducted in accordance with the General Data Protection Regulation (GDPR). The participants provided their written informed consent to participate in this study.

Author contributions

CP: Writing – review & editing, Validation, Writing – original draft, Data curation, Methodology, Conceptualization. CC: Validation, Data curation, Visualization, Writing – review & editing, Software. GT: Visualization, Software, Writing – review & editing. PS: Conceptualization, Writing – review & editing, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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