Augmented Reality Development in Museums Leveraging Instagram Filters – Case Study of a Cartographic Heritage Exhibition

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This study aims to provide a discourse of Instagram augmented reality (AR) filter to promote the museum and engage a wide range of audiences to visit the exhibition of "*Kartorupa*: Cartographic Heritage of Java", held by the Jakarta Maritime Museum. With the increasing fashion of social media, particularly Instagram, this research also examines AR development leveraging Instagram filters as an alternative to the expensive possession of AR applications in the heritage sector. The creation of AR filters constitutes three designs: cartographic photo, heritage object "Sextant", and *Da Vinci* room. The visitors review the built filters' performance using a Google form questionnaire consisting of four assessment components: interactivity, enjoyment, learning, and technological affordance. Some improvements in the filter quality are also suggested to support the interactive platform for visitors in the future to create a sustainable digital infrastructure in the museum and cultural heritage sector.

Keywords:
Augmented Reality, Digital Museum, Heritage Imaging, Instagram Filter, Java Island.

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1. INTRODUCTION

Augmented reality (AR) continues to increase as technology develops and is ubiquitous worldwide. Particularly in education, the findings from Samala et al. [2023] highlighted that India and Denmark are the two countries with the most significant fields in developing augmented reality (AR) and

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virtual reality (VR) for learning. Another study conducted by Al-Ansi et al. [2022] revealed that the adoption of AR and VR in education has had exponential growth during recent years where wearable devices have gained much of this development, while Kamińska et al. [2022] showed that AR is considered as a valid and versatile educational technology. This advancement is also part of the Sustainable Development Goals (SDGs) support system that improves the quality of education.

The escalation trend of AR is also experienced in business and economics with an emphasis on several technical aspects such as motivation, domain of application, media characteristics, and displays [Roxo and Brito 2018]. On the other hand, entertainment, and games also contribute considerable implications through this technology since many international game companies have started the design of AR platforms [Duan et al. 2018]. This progression provides insight into AR as a promising tool for visualizing objects or sites in cultural heritage and museum exhibitions. For instance, data visualization methods in archaeological investigation are vastly used in field surveys, computer simulations, GIS modeling, and photogrammetry [Markiewicz 2022].

These achievements for heritage imaging were derived from techniques first pioneered in the field of medical imaging [Gibson 2023]. The digitization of heritage objects also means restoring them virtually by improving the quality of images when they are affected by structural or chromatic pathologies and allowing a wide range of audiences to access the heritage collections without damaging the original document [Stanco et al. 2011]. This technology can also be an opportunity to attract more users to the positive triggering experience in the museum sector [Gong et al. 2022] although the level of acceptance is still controversial in the middle of society [Siang et al. 2019].

The role of a combination of AR and social media in the museum exhibition is to provide various creative visualization platforms for the virtual display of ancient objects such as 3D models utilizing AR experience systems that visitors are able to access through different viewpoints [Purnomo et al. 2018]. This combination allows a new digital journey inside the museum for various categories of visitors to enjoy the exhibition engagingly and interactively [Spadoni et al. 2022]. Increasing heritage dissemination and education through social media is the main challenge nowadays, particularly for AR developers. Social media is considered a collaborative platform that facilitates participatory experiences and interaction of stakeholders and deepens the understanding of the cultural attachment to audiences, reflecting a framework of sustainable cultural heritage management [Liang et al. 2020].

The use of mobile applications as AR filters in museums offers significant advantages, maximizing the potential of this technology. Hence, this research aims to provide insights into the technical side of AR development using Instagram filters, and examines user experience for a museum exhibition entitled "Kartorupa: Cartographic Heritage of Java." This objective is also discussed in a broader sense to improve the collection, use, management, preservation, and dissemination of digital heritage.

2. LITERATURE REVIEW

2.1 Technological Adoption and Social Media Interaction

The issues regarding AR development in various domains are identified as barriers to readiness for technological adoption. Mekni and Lemieux [2014] highlighted that hardware and software failures are the biggest limitations to developing AR to be lighter, smaller, and easier to work with various users. Contreras-Espinosa et al. [2021] pointed out some considerable obstacles are privacy, legacy systems, source requirements, and the most crucial is finance. As an illustration, the latest models of AR glasses are very expensive and reachable only in a narrow-segmented market. On the other hand, technological advancement is still in the developmental stage [Ariso 2017], leading to resistant conditions for people in certain regions. As AR developers attempt to enter the market, progress in implementing AR across various industries has been slow [Zakaria et al. 2022].

Therefore, integrating AR into social media helped patch the problems of technological acquisition. There is a similarity in creating a shared experience within the digital social media platform and a museum exhibition in a public space. Li and Ch'ng [2022] developed a framework where visitors can observe a digital heritage asset inside a museum and share this experience through different devices, in this case, an AR-enabled smartphone and a Head-Mounted Display (HMD). There are three attributes of virtual objects: i.e., visualization, interaction, and presentation. Visualization is the fundamental part where an object comprises different data, from 3D meshes to textures as the digital version. Interaction is considered the most important attribute, influenced by its design for experience, while considering the display and technology affordances. Lastly, presentation is how the extra information about the objects is displayed. Echoing Li and Ch'ng, investigating how to improve the interaction between visitors and the virtual heritage mediated by social media AR filters is our main objective in this research.

Instagram filter utilization is considered essential as an alternative to expensive AR technology and hardware and software failures with heavy and memory-consuming data processing. Past studies have been conducted concerning human behavior when using AR filters. Javornik et al. [2022] outlined nine motivations as potential drivers for AR face filter usage on Instagram, such as self-presentation (true, ideal, and transformed), affiliation, enjoyment, silliness, creative content curation, social interactions, and convenience. In the heritage sector, the research conducted by Cui et al. [2023] highlighted five cores of heritage organizations' engagement through Instagram such as participation, storytelling, sharing user-generated content, relating heritage to popular media or culture, and providing information.

2.2 Instagram Spark AR

Launched in 2010 as a simple image-sharing app, Instagram has evolved into a social media platform that enables users to share photos, videos, and moments wisely. Over time, Instagram has incorporated advanced features, including augmented reality (AR) filters, primarily accessible through the "stories" feature. These filters overlay virtual effects onto the user's face or surroundings, blending digital elements with real-world views through Instagram's camera. Stories, which

disappear after 24 hours, have become a key platform for AR visuals, allowing users to create immersive experiences directly on their smartphones.

The involvement of users in the experiment and the creation of filters is another feature of Instagram filters that can highlight the private preferences of customers [Harika et al. 2022]. Another study shows a significant trend in user experience using Instagram filters such as in the entertainment perspective [Ibáñez-Sánchez et al. 2022], digital learning [Sukmawati et al. 2022], and even heritage mapping leverage crowdsourcing and citizen data [Bai et al. 2023].

Instagram AR filters are developed using Meta Spark Studio, a tool for building, testing, and publishing AR experiences across Meta platforms, including Instagram [Meta Spark d n.d.]. Once published, these filters are accessible to Instagram's extensive user base. Users can discover filters by browsing creator profiles, exploring stories and reels where filters appear, or through direct links shared by creators.

Using these AR filters requires an Instagram account, which could pose a minor barrier for some users. However, given Instagram's popularity in Indonesia, this requirement is unlikely to limit accessibility. As one of the country's most widely used social media platforms, Instagram provides a substantial existing base of users, making access to AR features convenient without additional setup. In 2016, Instagram ranked as the second most visited social media platform by Indonesians, highlighting its sustained popularity [APJII, 2016]. As of October 2024, there were 90,183,200 Instagram users in Indonesia, representing 31.9% of the entire population, further underscoring the platform's widespread reach and familiarity among Indonesians [napoleoncat.com, 2024].

2.3 Cultural Significance in Digital Preservation

Technology is crucial in preserving and making cultural materials more accessible by digitizing heritage objects such as artifacts, architectural forms, arts, manuscripts, etc., so they are available in a virtual environment. However, the focus on technology should not overshadow the cultural and historical significance of the materials themselves. The challenges are to the user experience and its communication, particularly in traditional cultural heritage communication. Popular social media platforms nowadays, such as Instagram filters, have the potential to accommodate such communication workflows. However, there is still a need for perceptual (i.e., visual) carriers to provide a basic sense of existence and balance the ratio of virtual and real content and media.

Jin and Liu [2022] are concerned about the cultural heritage digitization process involving describing, restoring, and presenting artistic and scientific values. Risks and issues in authenticity, historical accuracy, and ethical dilemmas are rising along with the digitization process that needs to be addressed and anticipated. In other words, the technological tools and methods should preserve and share the cultural heritage meaningfully, not distracting from or reducing the importance of the cultural or historical context of the materials. Digitizing cultural objects, for example, should not just be about using cutting-edge technology for its own sake but about respecting and enhancing the experience.

Several main virtualization issues, such as simplifications or inaccuracies in 3D models, might misinterpret the cultural or historical context, potentially resulting in a distorted perception of the

objects [Buragohain et al. 2024]. Hence, to anticipate this issue, the references to create the virtual presence in the case of the cartographic exhibition are collected diligently and ensured through observation and literature studies of the designated heritage objects to present the cultural and historical properties in a proper visualization (e.g., ratio, colors, texture, etc.).

3. MATERIALS AND METHODS

3.1 Museum Exhibition Case

The museum exhibition material in this research is a temporary exhibition entitled "*Kartorupa*: Cartographic Heritage of Java," held for four months from 16 January to 30 April 2024 at the Jakarta Maritime Museum in Jakarta, Indonesia [Silanews 2024]. This exhibition is part of the research output from the Department of Geography, Universitas Indonesia (UI) for the UI International Publication Research Grant 2023 in collaboration with the Jakarta Maritime Museum. Cartography, as the main focus, is a branch of geography that constitutes science, art, and technology related to map-making processes. The heritage map collections were observed on Java Island as the center of a complex civilization explored and inherited in the archipelago [Riyanto 2024].

The *Kartorupa* exhibition not only displays historical maps but also brings together the dimensions of cartography and art, where visual artists are invited to respond to curated cartographic collections and then create works according to their interpretations [Kastara 2024]. Through this exhibition, visitors are invited to enjoy the beauty of cartographic heritage as a combination of science, technology, and art that connects the past, present, and future [Ilyas 2024]. The visitors start their journey from the entry door. They can enjoy the several main segments of the cartographic collections display, as shown in Fig. 1. The layout of this exhibition is generally divided into two main chambers. In this research, we focus on developing AR for the cartographic collections.

3.2 Data Sources and Software

The data used for Instagram filters were 3D heritage models depicting map-making tools, both retrieved from www.sketchfab.com and constructed by the developer. The available free 3D objects with Creative Commons Attribution licenses were browsed on the Sketchfab website using a viewer based on WebGL and WebXR to acquire appropriate objects to be downloaded. This curation step was essential to reduce the file size as determined by Meta Spark. For the objects not available within the file size limit on the website, the AR creator used Blender to create 3D models from many image references of heritage objects [Meta Spark b n.d.]. This open-source application also handled texturing and scene composition before it was exported to the next software, Meta Spark Studio. This platform allowed the creator to adjust the AR experience easily for a wide range of Instagram users. Another software that is leveraged to manipulate graphics is Adobe Photoshop. It was mainly used for composing and editing texture image files before they were exported to Meta Spark Studio.

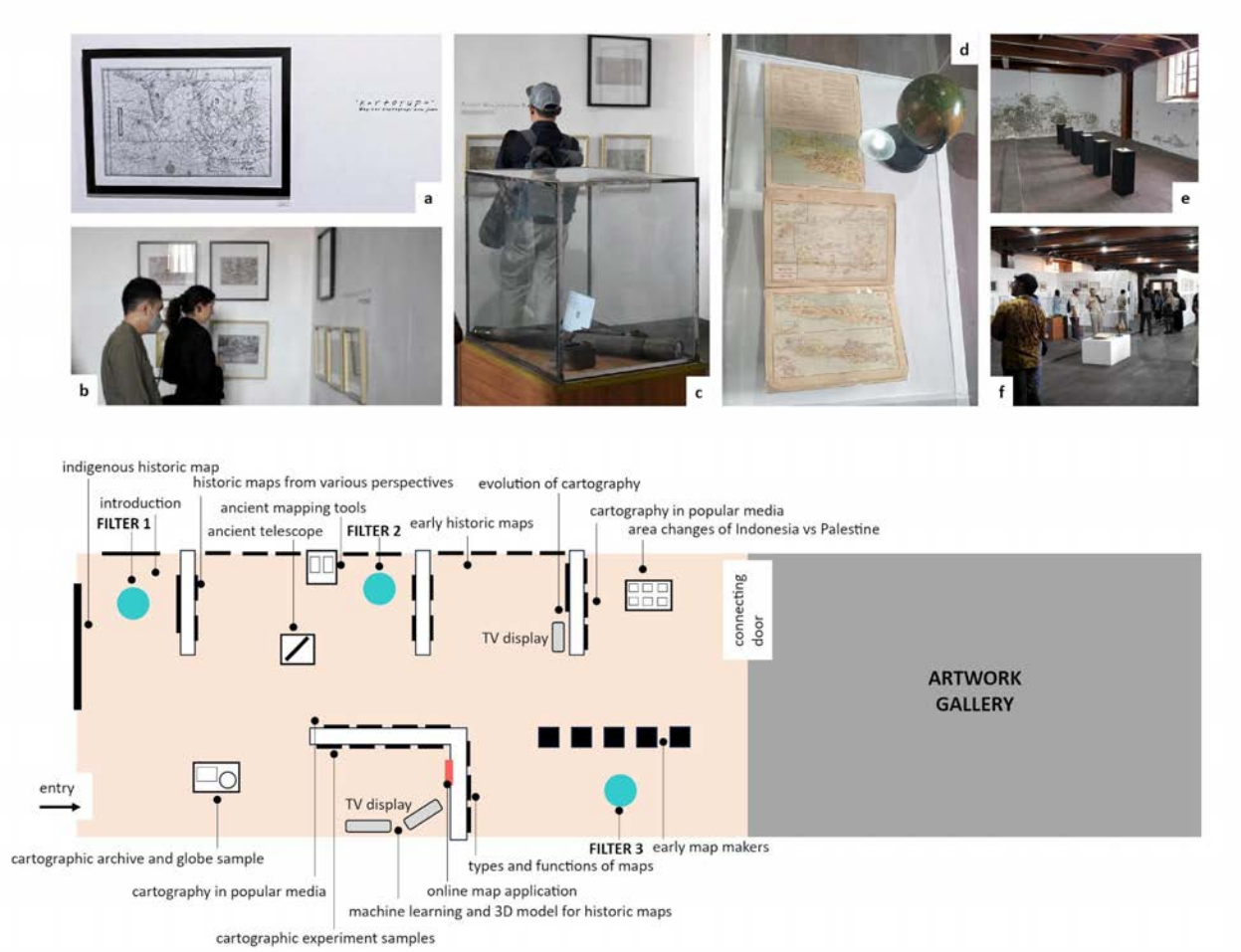

Figure 1. Some documentation of the "Kartorupa" Exhibition (upper): (a) introduction section; (b) people observing the cartographic displays; (c) ancient telescope; (d) cartographic archives and globe; (e) early map makers' section; (f) main space. Exhibition layout (bottom). Some positions are prepared for AR Instagram filter placement: (a) Filter 1; (b) Filter 2; and (e) Filter 3. All the cartographic collections are displayed in digital copy.

3.3 AR Development for Instagram Filters

The development of AR for Instagram filter creation is divided into four main steps, adapted from Spadoni et al. [2022], which include (1) research, (2) design, (3) development, and (4) deployment (shown in Fig. 2). Researchers first observed the exhibition site to understand the visitor flow and exhibition materials before moving on to the next phase, designing. To examine how visitors interact with Instagram AR filters, this study compares three filters with different tracking technologies corresponding to diverse versions of Android and iOS. The first filter is a simple 2D image filter without any trackers. The second one used a target tracker where the assigned image would be a trigger to reveal an animated 3D object. The last AR experience used a plane tracker where the back camera would detect a horizontal surface to place the 3D object.

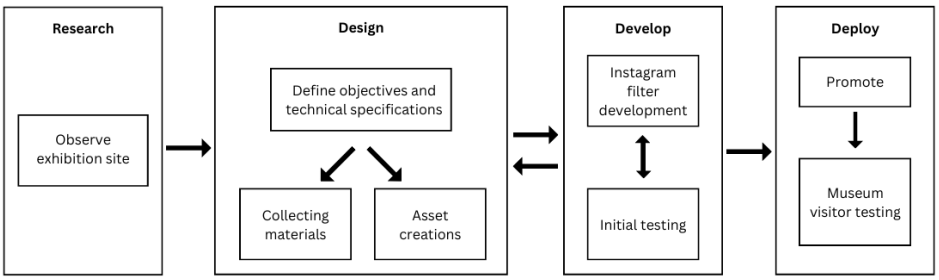

Figure 2. Scheme depicting the processes of AR design and production for Instagram filters adapted from [Spadoni et al. 2022]. The prominent steps constitute research, design, development, and deployment.

To support the educational content from the exhibition, we chose three different themes with different objects (see Table 1). As seen in Fig. 1, the first AR filter's purpose was as an introduction to the exhibition; therefore, it did not present any educational content. The second filter served as a 3D representation of the mapmaking tools in the second area, where all the materials were presented as flat images in frames and objects protected behind glass displays. The 3D objects of the collection can be present and observed more closely in virtual space. It can attract visitors to the exhibition because they should scan the sextant image where the object is exhibited. Lastly, the last filter was placed in the most spacious empty area of the exhibition so it could present a room-scale 3D visualization for visitor interaction.

In the design phase, visual attributes were added to associate the filters with the cartographic exhibition, as shown in Table 1. The assets (see Fig. 3) constitute several images in the public domain downloaded from Wikipedia Commons and then composed in Photoshop as a cartographic-themed photo frame. This will encourage sharing photo results that include the exhibition's name as part of the frame. The second filter used a sextant 3D model by [Larich 2023] (username: @samoval88) on Sketchfab with material alterations on Spark Studio. The real sextant is also displayed in this exhibition inside a glass display. The last filter featured a custom-made *Da Vinci* odometer in low poly made in Blender, based on photogrammetry scanned odometer by [Bandera 2018]. This filter depicted an imaginary *Da Vinci*'s workshop hidden behind a door. The odometer is a historically significant object in cartography, associated with figures like *Da Vinci*. This exhibition aims to recreate Da Vinci's workspace, allowing visitors to virtually engage with elements such as the odometer and various maps inside a virtual space. By enhancing visitor interaction through augmented reality, the exhibition seeks to stimulate curiosity and interest in both the showcased artifacts and the museum's offerings, providing a fresh perspective on cartography.

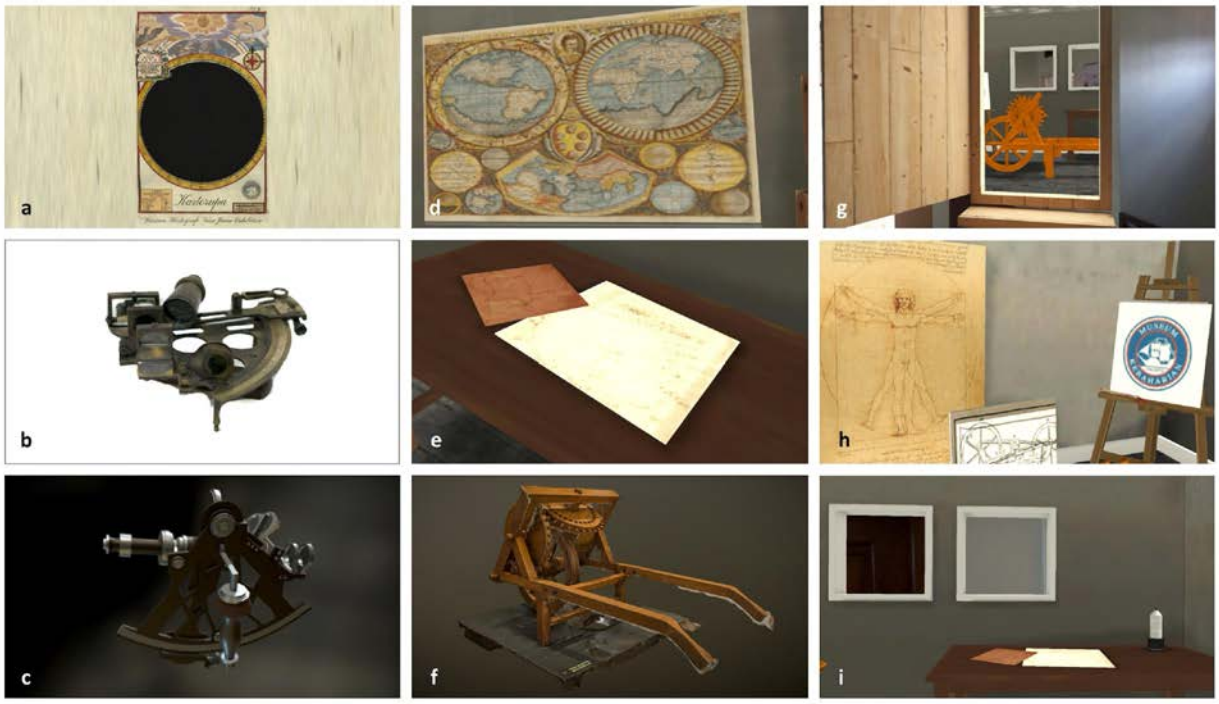

Figure 3. Some raw materials for Filter 1 (a) anonymous cartographic frame ornaments; Filter 2 (b) pointing image and (c) sextant 3D model by [Larich 2023]; Filter 3 (d) anonymous ancient world map, (e) hand-made old maps, (f) scanned odometer by [Bandera 2018], (g) virtual door, (h) Vitruvian man and Jakarta Maritime Museum painting, and (i) windows and table.

Table 1. Visual attributes for each filter design idea

Filter	Purpose	Visual Attribute
Filter 1 – Cartographic photo	Introduction about the exhibition and shareable promotional material	Red listed frame Historic emblem, sun, clouds, and swans at the top Circular ruler for photo window in the middle Map legend and Jakarta Maritime Museum emblem at the bottom Tagline of "*Warisan Kartografi Nusa Jawa* Exhibition"
Filter 2 – Heritage object "sextant"	Add interaction variation of objects presented in the second area	A built 3D model of Sextant An image of the sextant to reveal the 3D model
Filter 3 – *Da Vinci* room (odometer)	A room-scale AR interaction to stimulate curiosity and interest by being virtually present in a virtual space	A wood-framed door with a small staircase A built 3D model of an Odometer Two square windows A table and a chair Two pieces of maps and a candle on the desk A pile of boxes

The development phase consisted of scene arrangements on Meta Spark Studio version 173.0.0.39.372 and testing on Instagram via private test links. After several iterations, the final files were ready to be published on the museum's Instagram account: @museumkebaharianjkt. Each filter had a QR code that would be printed and placed at the exhibition site, where the visitors could scan the codes and interact with the filters. The filters were also accessible from the museum's Instagram profile page.

3.4 Visitor Survey

A survey was conducted to find the visitors' responses to the AR filters created using their smartphones. The assessment includes four main components: interactivity, enjoyment, learning, and technological affordance. This survey was carried out by providing a Google form that tourists could scan via the QR code provided at the exhibition entrance. Museum officers also provide regular assistance to guide the candidates who will fill out the questionnaire. Each of the three Instagram filters is rated on a 1 – 5 Likert scale where 1 is the lowest value (strongly disagree) and 5 is the highest value (strongly agree). Table 2 shows a list of components for assessing Instagram filters by visitors. The calculation of the filters' performance threshold is notated as follows:

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Class Interval:
I = R/K = 100/5 = 20

where
I: Interval
R: Range
K: Number of Likert scale categories

Upper limit = Highest score = 100%
Lower Limit = Upper Limit - Interval = 100% - 20% = 80%

Objective/Interpretation Criteria:
Good = overall score ≥80%
Bad = overall score <80%
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Table 2. List of statements for visitor questionnaire materials based on four assessment components for each Instagram filter adapted from [Sukmawati et al. 2022]

Component	Statement
Interactivity	This filter is very interactive
Enjoyment	I enjoy using this filter
Learning	This filter helps me understand the exhibition materials
Technological affordance	My device can run this filter smoothly

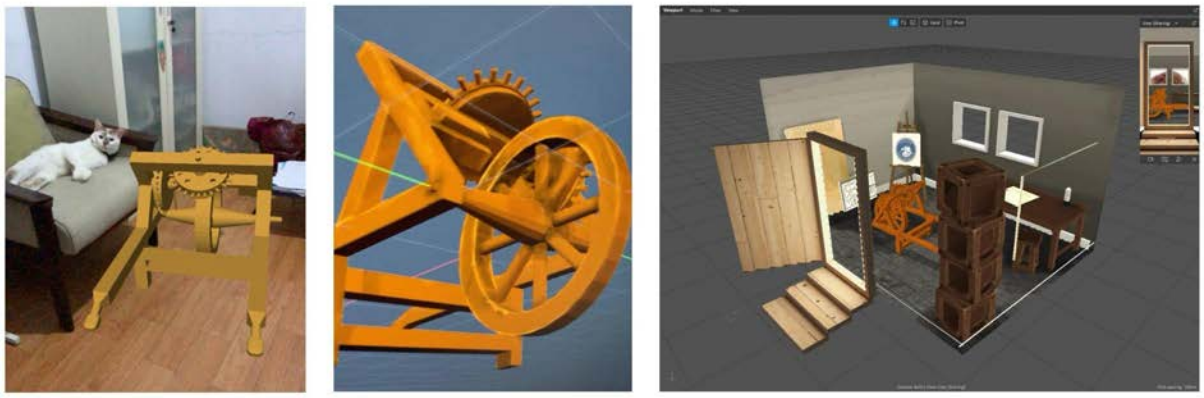


Figure 4. Exhibiting large objects as a digital version in an AR filter provides more benefits, such as convenience in procuring and logistics, while enabling visitors to interact with the object on the actual scale (see left image where the odometer is compared with other objects during a test session). Due to the large file sizes, we found that many of the 3D digital versions of heritage objects in Sketchfab were not optimized for AR filters. As a result, the odometer was reconstructed and hand-painted in Blender (image in the center) before it was finally arranged inside a virtual room by reimagining a small workshop in Spark Studio (right image).

4. RESULTS AND DISCUSSION

4.1 Initial Test

Before publishing filters to Jakarta Maritime Museum's Instagram account, we ran some initial tests via test links provided in the Meta Spark Hub, shown in Fig. 5. To test how the filters appear on different devices, several smartphones with Android and iOS operating systems were used. iPhone XR with iOS 17, iPhone 6s with iOS 15, and Oppo Reno 5G with Android 15 could run all three filters smoothly on Instagram. Several Android devices with older OS, such as Android 13 and below, could not run the third filter with the plane tracker. Failure to experience the filters might occur to the museum visitors as the target tracker only works properly on newer devices with Android AR Class 50 and higher, and iPhone 8 and higher [Meta Spark c n.d.]. Questions about how well the filter runs on their device were included in the survey to evaluate whether the filter can execute smoothly [Gaver 1991].

4.2 User Experience

4.2.1 Demographic Profile

The insights from the Jakarta Maritime Museum's Meta account were fetched and displayed in Fig. 6 (top), highlighting great numbers of engagement and impressions (>1,000). This number represents the accessed filters by the audience worldwide from the museum's Instagram page. Thirty-five responses were collected from Google form respondents who visited the exhibition in person, classified based on age, gender, and device, as illustrated in Fig. 6 (middle). The pie charts reveal the

gender ratio of male to female is 3:2, showing that men (22) are more represented than women (13). The age category constitutes five groups with the primary distribution of 18-24, followed by 25-34, while the age group under 18 is the fewest. The device's operating systems used for the filter testing account for Android (26 users) and iOS (9 users).

4.2.2 General Performance

Fig. 6 (bottom) shows that the overall performance of the filters varied based on the assessment criteria (interactivity, enjoyment, learning, and technological affordance). In general, the performance of Filter 1 was under the threshold (<80%), which was considered Bad in terms of interactivity, enjoyment, and learning while giving the highest rate in technological affordance (≥80%). In contrast, Filter 3 surpassed other filters' performance, giving the highest interactivity score yet with inferior execution in technological affordance. On the other hand, Filter 2 indicated a medium trend of performance. This highlights the opposite trend of Filter 1 and 3 in terms of interactivity and technological affordance.

4.2.3 Suitability

The suitability assessment refers to the demographic profile of the respondents: age, gender, and device (see Fig. 7). It is reported that Filter 1 showed the lowest trend for interactivity among the filters, while enjoyment and learning vary. However, regarding technological operation, Filter 1 was the most convenient among others. Filter 2 provided a high level, but not as high as Filter 3 on interactivity, enjoyment, and learning for most age ranges. At the same time, technological affordance was lower than Filter 1 but higher than Filter 3. On the other hand, Filter 3 surpassed Filter 2 in interactivity, enjoyment, and learning for all age ranges. However, the 35-44 and 45-54 age categories struggled in operating the filter, resulting in a low technological affordance value. In contrast, respondents aged <18 indicated proficiency in using filters. This may depict the generational difference in technological attitude [Shelley et al. 2006], such as the ability to select, interpret, and evaluate information, and technological devices, and create technological content [Cirilli and Nicolini 2019].

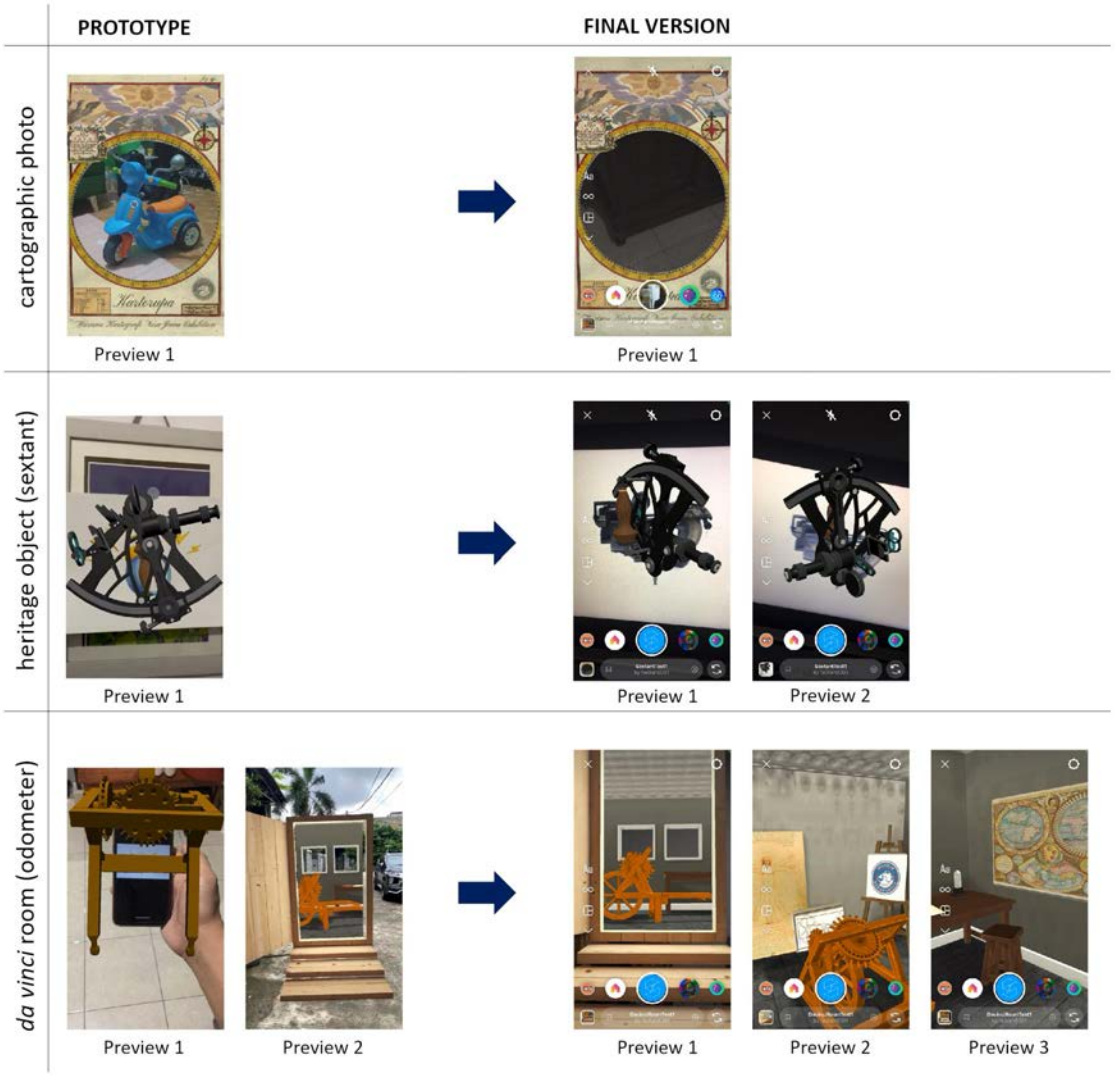
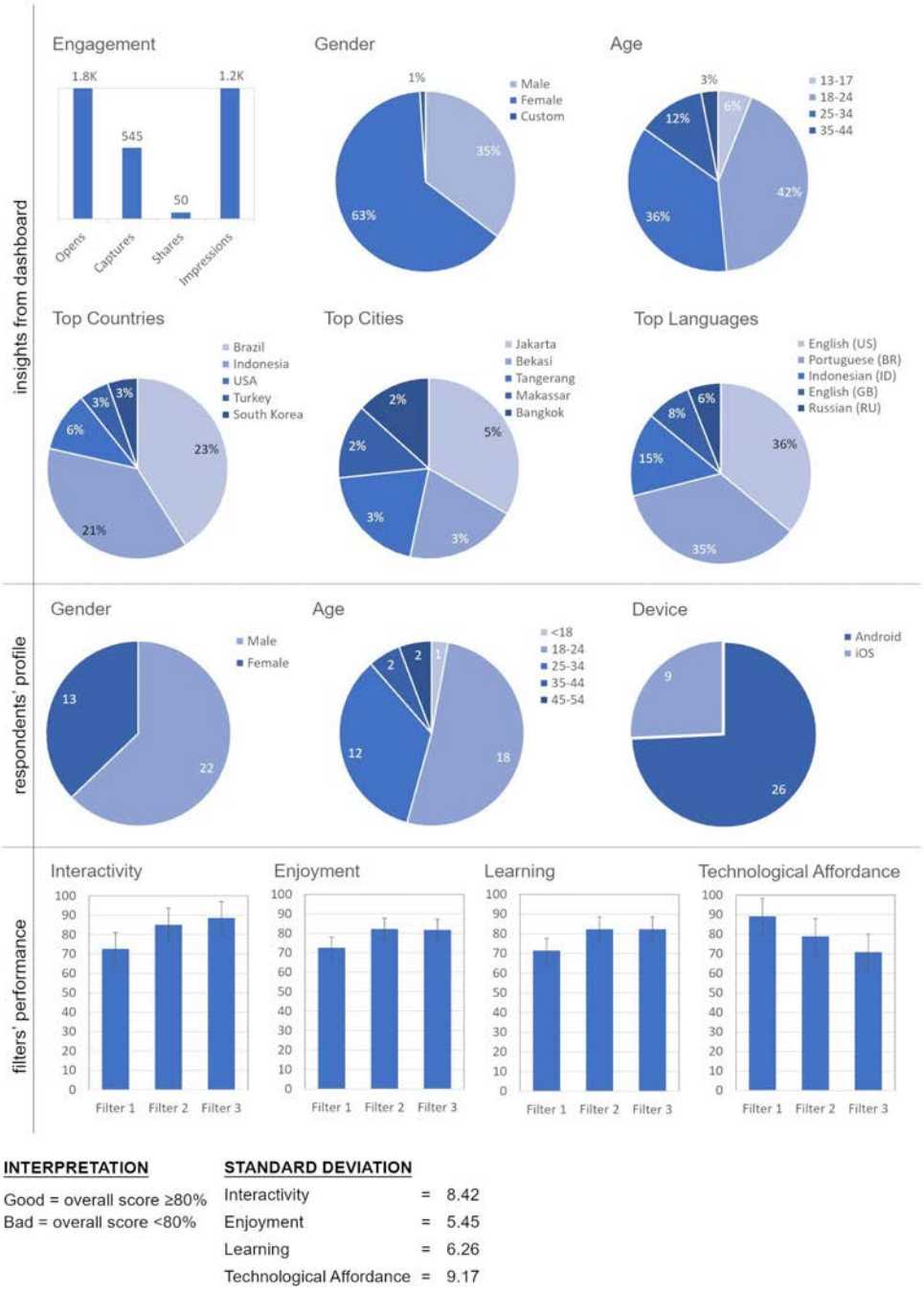


Figure 5. The prototype (left) depicts images and videos taken from the initial testing results. From above to below: Filter 1, Filter 2, Filter 3 before iteration, and Filter 3 with updated scene. The final version (right) is ready to deploy to visitors: Filter 1 (cartographic photo, did not change) (https://www.instagram.com/ar/1336094363767626/); Filter 2 (heritage object "Sextant") with a new marking image and rotating display (https://www.instagram.com/ar/406465928423647/); Filter 3 (Da Vinci room) displays a hidden virtual room with ancient nuance ornaments (https://www.instagram.com/ar/2181549292181037/).



INTERPRETATION

Good = overall score ≥80%
Bad = overall score <80%

STANDARD DEVIATION

Interactivity	=	8.42
Enjoyment	=	5.45
Learning	=	6.26
Technological Affordance	=	9.17

Figure 6. Insights from Meta Dashboard (top); Respondents' profile summary of age, gender, and device used by visitors (middle); The overall performance of filters (bottom). The assessment by respondents is based on four aspects: interactivity, enjoyment, learning, and technological affordance. The overall performance of the filters is divided into two categories: Good (≥80%) and Bad (<80%).

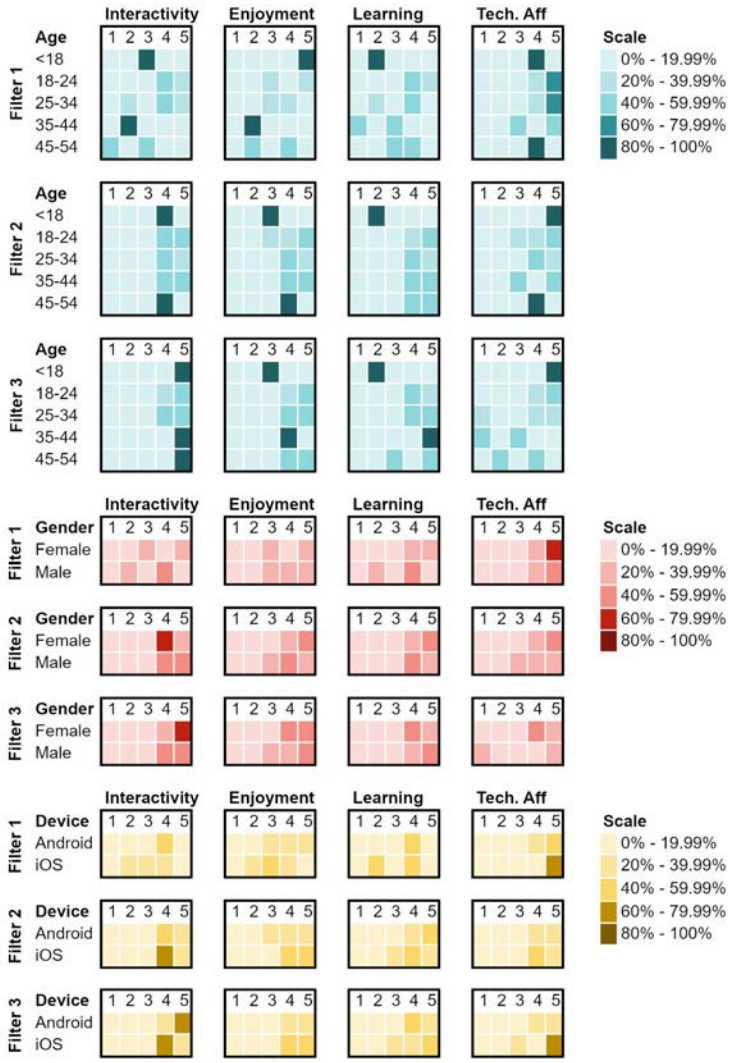


Figure 7. Heat maps visualize the suitability assessment based on groups of age, gender, and operating systems on the respondents' devices. The scale is divided into 5 classes. The scale has been normalized to reduce the bias caused by the unequal number of respondents.

In terms of gender, both male and female users agreed that Filter 1 performed the easiest operation among others while the interactivity, enjoyment, and learning varied. On the other hand, Filter 3 and Filter 2 performed better interactivity sequentially while other criteria (enjoyment, learning, and technological affordance) diverged. This finding did not reveal gender differences in technological use, as strengthened by [Qazi et al. 2022]. The assessment based on the visitor's device highlighted that minor iOS users experienced difficulties when employing Filter 1 and 3. While the interactivity

of Filter 3 contributed the highest rate, followed by Filter 2, other criteria (enjoyment and learning) diverged both for Android and iOS users.

4.2.4 Impression (Sentiment)

Table 3 shows the impression of the respondents towards the tested filters. The comments were clustered based on their sentiment [Aliandu 2014] with emotional involvement, which can be the expression of appreciation or judgment [Taboada 2016] through positive or negative comments [Zhang and Liu 2017]. Some typical positive comments were spotted, such as “interesting”, “cool”, and “satisfactory”. In contrast, some negative opinions, such as “laggy” and “failure in operating the filter” criticized the performance of the filters. However, the negative comments that were collected are also fundamental for improvement.

Table 3. Respondents’ comments for each Instagram filter. The feedback is divided into positive and negative with simplification of statements and clusters

Sentiment	Filter 1	Filter 2	Filter 3
Positive	Cool, fun. Good in providing information. The filter is very good. Spark curiosity in the exhibition. Very easy and interesting. I like it. Very satisfactory. The best. Very innovative.	Very cool. Very exciting with the display. It is amazing. The filter is very good. Easy to understand. Cool. Very satisfactory. The best. Interesting.	The filter is perfect. Looks gorgeous. Can interact virtually. Interesting for art fans. Cool. Very satisfactory. Crazy. The best. Insightful.
Negative	More colorful will be better. Good, but flat.	Failed to load on my device. What is this sextant for?	Laggy. It doesn't work on my device. The image does not stay in place. Cannot use it on my device. Add more objects.

4.3 Future Improvement

Based on the survey results and the scope of this research, which focuses on the AR filter feature on social media mobile applications, we have identified three key issues and their corresponding solutions (see Table 4).

4.3.1 Low interactivity and enjoyment for simple filter

On Filter 1, this issue is caused by implementing a simple filter using the device’s camera with a static image overlay. To improve the interactivity, this type of filter can provide multiple images that can be switched by tap input. A respondent mentioned that the content appeared to be "too flat". Incorporating animated assets is one way to make it more engaging without adding extra trackers

for low-end devices. This way adds more interest without increasing the minimum phone requirements.

4.3.2 Low technological affordance with image and world trackers

Creating a high-end filter with more complex trackers comes with the cost of excluding users with low-end devices. Our findings in the field revealed that some users could not run the filters because their devices could not support one or more trackers, as mentioned by several respondents as "failed to load on my device", laggy, and the 3D objects failed to anchor. The lowest technological affordance was reported for Filter 3, where a smartphone model that can recognize a world tracker is needed. We recommend two approaches to address this problem. Firstly, informing the device requirements beforehand is important to help manage users' expectations. This could be written in the filter description section and the museum's exhibition area. Secondly, an alternative filter that showcases the same exhibit but uses a simpler tracker could be provided. This would help to ensure a smooth user experience and reduce frustration.

4.3.3 Improve learning experience

As an educational tool, AR can give a better context according to the user's condition [MacCallum and Jamieson 2017]. For example, an overlaying text can provide contextual information imposed inside the AR that appears only when there is touch input. The text could be presented as a 2D or 3D object or disguised as part of the world objects such as floating visual effects with text or an opened book. Beyond text, audio files or short videos can also be added with a limited duration. This would increase immersion and interactivity while the user is experiencing AR through their phone screens.

Table 4. The identified issues on the Instagram filters and the possible solutions to improve filters' performance

Issue	Solution
Low interactivity and enjoyment for simple filter	Add more overlay image options and provide interaction using tap input to switch images.
Low technological affordance for AR filter with image and world trackers	Provide information beforehand about minimum requirements to manage user's expectations. Provide an alternative filter using more simple trackers that can cover low-end devices.
Improve learning experience	Incorporate context and information inside the AR filter as part of the narrative.

4.4 Limitations

This study was only tested for a temporary exhibition, where the marketing effort by the museum staff was more extensive than that of a permanent exhibition. The design improvements stated above have not been implemented yet due to the limited exhibition duration. The Instagram filters were also part of the marketing campaign to attract and engage museum visitors to the museum's social media account. However, the reliance on specific platforms can pose risks, particularly in light of recent developments.

Meta shared an update to close Meta Spark's platform in January 2025. As a result, any creators' AR filters will no longer be available on any Meta platform, including Instagram [Meta Spark a n.d.]. However, other platforms like Snapchat and TikTok are still open for external creators to develop and publish AR filters. A safer option is to utilize webXR, which can be available outside these social media platforms, such as Niantic's 8thwall. By being independent of the platforms, there is less dependence and precarity in any decision made by the platform makers that could eliminate access to the AR filters.

4.5 Opportunities

It is important to note that providing an AR experience through a social media platform should not compromise the quality of the museum's learning experience. Given this research's limitation to comparing three different types of AR filters, there is another opportunity to explore narrative-based AR experiences [Shilkrot et al. 2014]. This could be done from the first stage of exhibition planning with the museum stakeholders, during which the AR experience is presented as part of the exhibition's narrative.

Another opportunity is coming from a younger audience, where only one participant was under 18 in this research. AR filters have become increasingly popular among children, often called "digital natives" due to their early exposure to digital technology. As a result, they are more familiar with interactivity and have higher expectations for technology-based experiences. This is particularly true for those exposed to AR filters from a young age. Given their familiarity with this technology, they are likely to understand better how it works and what it can do, which can result in higher expectations for AR experiences.

With more new devices in the mainstream market, such as Meta Quest 3 and Apple Vision Pro, which have good camera quality for passthrough features, experiencing AR with head-mounted devices is becoming more popular. This will open more possibilities for previously limited interaction with hand-held devices, including tablets and smartphones.

5. RECOMMENDATION FOR MUSEUM AND VIRTUAL HERITAGE

5.1 The future of AR filters in museums

The future of augmented reality in museums promises to bring significant changes to how these institutions educate, entertain, and engage visitors. With AR, museums can offer a more interactive experience, encouraging visitors to actively participate and immerse themselves in what they see. This technology has the potential to transform the way we experience art and history, making visits to museums not just informative but also truly engaging.

The presence of AR also makes exhibitions in museums that previously only displayed collection objects as a physical display, now starting to transform into museum exhibitions that utilize digital space and technology to display collections interactively. In addition, collections that are in vulnerable conditions when exhibited can be anticipated through 3D model examples of museum

collections, these collections can still be enjoyed and viewed without worrying about the safety of the collection.

5.2 Integrating museum promotions with social media with AR

Using augmented reality (AR) in museums, combined with social media, has incredible potential to attract more visitors and enhance their engagement with the exhibits. With the right strategy, social media can serve as a powerful marketing tool while also boosting education and promoting exhibitions or the museum as a whole.

6. CONCLUSION

The increasing fashion of augmented reality has expanded into many sectors, including museums and cultural heritage. On the other hand, the expensive foundation of supporting infrastructure leads to the creation of alternative platforms, particularly social media AR filters as a prominent creative medium for dissemination and engagement to the public. Three filters were created and tested for museum visitors during the cartographic heritage exhibition. Overall, Filter 1 gave poor performance regarding interactivity, enjoyment, and learning, although this rate was the opposite of technological affordance. In contrast, Filter 3 surpassed other filters' performance, giving the highest score of interactivities yet the lowest performance in technological affordance, while Filter 2 did not give any outstanding impression.

The generational disparity was reported using the filters, while gender and device did not contribute to significant suitability differences. Several positive and negative responses were identified regarding the filter examination, and some possible solutions are suggested to improve the performance of the filters in the future. This research underscores the potential of augmented reality as a filtering tool within the museum sector, even in the absence of dedicated mobile applications. However, further research is needed to examine how certain age groups respond to AR filters by getting more participants per age group and more structured research to evaluate usability and learning experiences. Such research can significantly contribute to the development of AR technology to enhance visitors' engagement and learning outcomes in the museum sector.

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