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USABILITY EVALUATION OF A PERSONALIZED AUGMENTED REALITY APPLICATION FOR MUSEUM TOURISM: EVIDENCE FROM GENERATION Z VISITORS

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Abstract: This study aims to evaluate the usability of a personalized Augmented Reality (AR) application in a museum tourism context and to examine how such digital tools support Generation Z (Gen Z) visitors' interaction with cultural exhibits. Specifically, it seeks to assess whether personalized AR can deliver consistent and positive user experiences across different visitor groups. A personalized museum AR application, "Explore Muse", was developed and implemented in a museum setting. Usability evaluation was conducted using the System Usability Scale (SUS) with 52 Gen Z participants. Descriptive statistics, reliability analysis, and factorial ANOVA were employed to examine overall usability performance and the influence of demographic variables. The findings indicate that the personalized AR application demonstrates a good level of perceived usability among Gen Z visitors. Reliability analysis confirms the internal consistency of the usability measurement, supporting the robustness of the evaluation results. Further analysis reveals no significant differences in usability perceptions across demographic characteristics or prior AR experience, suggesting that the system delivers a stable and consistent user experience for diverse visitor groups. These results underscore the effectiveness of personalization in supporting inclusive and engaging digital interactions within museum tourism contexts. From a tourism and heritage management perspective, the findings provide empirical evidence supporting the integration of personalized AR technologies to enhance visitor engagement and experience quality in cultural tourism settings.

Keywords: Augmented Reality, museum tourism, visitor experience, usability evaluation, personalization, Generation Z

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INTRODUCTION

Museums play a central role in cultural tourism by functioning not only as repositories of heritage but also as key destinations for learning, interpretation, and experiential consumption. As important nodes of cultural communication and knowledge dissemination, museums are rich in historical content; however, traditional display media often struggle to meet the evolving experiential expectations of contemporary museum visitors (King et al., 2025). In response to broader shifts in smart tourism and visitor behavior, museums have increasingly turned to digital technologies to enhance cultural communication and enrich the quality of the visitor experience. Among these technologies, Augmented Reality (AR) has emerged as a prominent innovation in museum tourism and digital heritage interpretation (Cipparrone et al., 2025). AR technologies enable the overlay of digital content onto physical spaces, allowing museums to design interactive and immersive environments that transform visitors from passive observers into active participants (Hatami & Rashidi, 2025). Beyond improving access to cultural assets, AR facilitates digital reconstruction, simulated historical settings, and immersive storytelling, thereby strengthening interactive communication between museums and visitors (Kefi et al., 2024; Shu, 2025). As museums increasingly compete within the cultural tourism market, AR technologies are becoming strategic tools for improving visitor satisfaction, engagement, and overall experience quality.

Within diverse museum visitor groups, the Generation Z (Gen Z) who are born between the mid-1990s and early 2010s, exhibits obvious technological behavior and a high level of digital engagement expectations (Benítez-Márquez et al., 2022). As digital natives, Gen Z museum visitors value interactivity, personalization, and ease of use in technology-mediated experiences, and they tend to evaluate cultural offerings through both experiential and functional lenses (Chang & Chang, 2023; Peter et al., 2025). This specific profile gives both chances and difficulties to the museums that want to implement new technologies because they should go beyond being able to engage with visitors at a personal level, and need to ensure usability and visitor's long-term cultural engagement. In the context of smart tourism, these

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considerations are particularly critical in museum tourism settings, where visitor satisfaction and experience quality directly influence revisit intention and cultural value creation (Li et al., 2024; Pimentel et al., 2025).

Despite the growing body of research on AR applications in museums, empirical evidence examining how personalized AR applications support visitor engagement and experience remains limited. Existing studies have largely focused on technical development or conceptual discussions of AR's advantages, offering comparatively fewer insights into systematic approaches for evaluating design effectiveness and usability from a visitor-centered perspective (Dargan et al., 2023; Li et al., 2025). Moreover, while the System Usability Scale (SUS) is a well-established and widely validated instrument within Human-Computer Interaction (HCI) research, its systematic application in evaluating AR-based interpretive tools in museum tourism contexts remains underexplored (Genc et al., 2023; Graser et al., 2024). This gap highlights the need for empirical studies that bridge technological evaluation with museum tourism research.

In this context, the present study develops a personalized museum AR application, "Explore Muse", and evaluates its usability among Gen Z museum visitors, a key group within contemporary cultural tourism. By employing the SUS as a standardized assessment tool and examining the influence of demographic factors, the study aims to generate empirical insights into visitor interaction with personalized AR technologies and to assess the applicability of usability evaluation methods in museum tourism environments. Accordingly, the study addresses the following research questions (RQ):

- RQ1: How do Gen Z museum visitors perceive the overall usability of a personalized AR application in a museum tourism context?
- RQ2: To what extent does the SUS serve as an effective instrument for evaluating usability in interactive AR-based tourism settings?
- RQ3: Do usability evaluations differ significantly across visitor demographic characteristics?

Beyond addressing methodological gaps, this study contributes to museum tourism literature by providing empirical evidence on the usability of personalized AR applications and by enhancing understanding of how Gen Z visitors engage with digitally mediated cultural experiences. By combining standardized usability evaluation with demographic analysis, the study offers a replicable framework for assessing personalization digital tools in cultural tourism contexts (Mahajan & Taggar, 2025). From a practical perspective, the findings aim to inform museum managers and designers in developing AR experiences that are not only technologically functional but also meaningful, inclusive, and aligned with contemporary museum tourism strategies (Zhang et al., 2024).

LITERATURE REVIEW

AR Development in Museum Tourism

AR enables more interactive and immersive experiences because it provides viewers with superimposition of the virtual world on the real one (Arena et al., 2022). Nowadays, AR has found extensive application in the museum tourism to assist in preserving cultural heritage sustainably and communicating through the effective representation of cultural heritage (Logan, 2025) The more recent projects on AR use in museum tourism have touched upon its application in exhibits and interactive screens and cultural communications by use of various technologies that optimize the experience of the visitors (Hsieh et al., 2025; Khor & Mubin, 2024). These attempts are useful practical examples of the digital communication of museums and reflect the great potential of AR in the cultural interaction and engagement.

An example of this is (Ahmed et al., 2025) designed and planned a mobile application called MUSEON referring to the ontological theory of gamification learning, and tested the perception of 86 discriminatory visitors about the effectiveness of the MUSEON based on a 3-tiered evaluation model (M3). Gozali et al., 2024 developed a mobile application using Immersal software development kit (SDK), which helps users to use the surroundings of the Bandung Geological Museum. (Xu et al., 2024) presented two physical AR prototypes, which are meant to be used in the display of cultural objects, named Postcard AR and CubeMuseum AR, and conducted three user tests that helped to optimize the overall design quality. Another paper by (Jung et al., 2020) showed a VR/AR-powered visualization platform called JejuView that is intended to provide the visitors with an immersive and intuitive experience of the cultural heritage of the Jeju Island.

AR Usability Evaluation

In the ISO 9241-11 framework, the concept of usability is defined as the level of effectiveness, efficiency, and overall contentment with which the assigned users can complete certain tasks through the system (ISO, 1998). Usability testing is a methodology inherent in HCI research, and is mainly preoccupied with the degree to which the users can use and interact with a system (Nielsen, 2010). It points out the need to study real users since they perform real work to identify any problem of usability, determine their level of satisfaction and guide future design evolution (Meyer et al., 2021). The significance of usability testing in the context of AR research is supported by the extensive use of methods of this type over time, which streamlines the user-centered design and enhances the quality of the interaction in general (De Paolis et al., 2023).

In museum tourism settings, usability evaluation is essential in determining the role of AR technologies in helping visitors to engage in the situation, understand information, and experience interaction (Bekele et al., 2018). Standardized usability measurement tools have also been used in the past to assess usability and this includes the following: heuristic evaluation checklists (Nielsen, 1993), the System Usability Scale (Jordan et al., 1996), and the User Experience Questionnaire (UEQ) (Laugwitz et al., 2008). Although these methods have produced meaningful findings into the AR interface performance, most of the studies focus on overall users, ignoring the unique digital behaviors and user expectation of the Gen Z. As a result, the literature regarding the empirical studies of AR usability evaluation in museums is limited to be specific to Gen Z, which is a prime opportunity to be filled via further research.

Generation Z Visitor Engagement Studies

Gen Z visitors have grown up within digital environments, which shapes their expectations for interactivity, immersion, and personalized engagement when encountering cultural content (Onjewu et al., 2025). In response the new expectations, museums have increasingly introduced AR-based storytelling, interactive installations, and visually distinctive spaces designed to encourage social sharing and active participation, particularly among younger visitors (Diez, 2021).

These practices are not merely aesthetic enhancements; rather, they reflect a broader shift in museum tourism toward experience-oriented interpretation, where visitors co-construct meaning through digital interaction rather than passively consuming information (Zhu et al., 2025). Despite this growing adoption of AR-driven experiences, empirical research remains limited in explaining how such technologies shape Gen Z visitors' usability perceptions and subsequent engagement with museum tourism content. Existing studies have tended to emphasize technological affordances or experiential appeal, while paying comparatively less attention to how usability influences interaction quality, learning processes, and sustained cultural involvement among digitally native visitors (Škola et al., 2024).

Addressing this gap is critical for aligning AR innovation with visitor-centered museum tourism strategies. Accordingly, further empirical research is needed to systematically examine the relationship between AR usability, Gen Z visitor responses, and cultural engagement within museum tourism settings (Hwang et al., 2024; Singh & Ahmad, 2024).

MATERIALS AND METHODS

Research Design

This study develops a virtual AR application named "Explore Muse" to create 3D artifacts animation through Unity with C# programming language. The main design idea is to transform traditional museum visits into self-directed journeys, which enables users to explore digital artifacts overlaid on the physical environment through their smartphone cameras.

It is compatible with Android devices which have OS version 7.0 (API Level 24) or above, and includes AR Foundation and Vuforia SDK to enable marker-based tracking, real-time rendering, and touch to AR response (Linowes & Babilinski, 2017). The AR portal is based on a looped workflow consisting of: (1) camera initialization, (2) marker detection, (3) target-image matching, (4) 3D model rendering, and (5) continuous tracking and it repeats itself until the user leaves the session. As illustrated in Figure 1, when any target is identified, the system triggers real time rendering and constant tracking, which means that the virtual objects can be maintained in visual consistency and live responsive as the user renders his device. This AR application aims to provide a fast and dependable user experience by reducing latency and jitter causes by being lightweight on asset management, and dynamically modulating performance. Subsequently, this study adopts a quantitative cross-sectional design to evaluate the usability of the "Explore Muse" among Gen Z visitors at the Yanshi museum in China. The study design is a mixture of structured usability testing with post-experience surveys of SUS, which would be followed by reliability testing and a factorial ANOVA (Barnum, 2021). After the AR app is developed, there is a one-group post-test study where the subjects go through the "Explore Muse", followed by a standardized SUS questionnaire. Based on a previous study that uses the SUS scale, a target population size of 50 will be selected to provide adequate statistical power to perform a descriptive and inductive analysis (Lacoche et al., 2022). The objective of this design aims to collect direct user perceptions of the AR application's usability without the influence of a control group or pre-test bias.

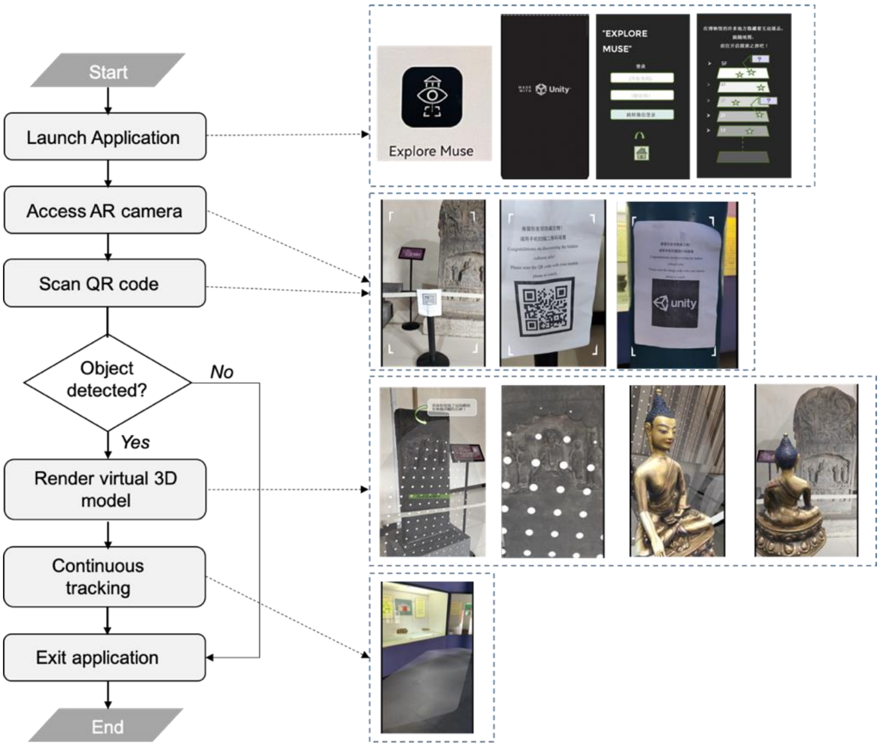

Figure 1. Flow chart of AR portal and usage demonstration (Source: Authors' own work)

Participants

The target participants in this study are members of Gen Z who belong to the cohort born roughly from 1995 to 2010. Participants are randomly recruited from a sampling pool that integrated both online and offline channels, including university forums, social media platforms (e.g., WeChat and QQ), and onsite promotion during visits to the Yanshi Museum in China. The inclusion criteria required participants to be between 15 and 30 years old and have basic proficiency in smartphone usage. Additionally, the sample selection is balanced in terms of gender and educational background to reflect the diversity of Gen Z. Prior experience to AR technology is recorded for reference but is not a requirement for participation. This sampling strategy ensured that participants are representative of typical Gen Z museum visitors, making the results more reliable and meaningful for understanding emerging generation visitors usability perceptions of AR technologies.

Instrument

This study uses the standardized SUS questionnaire as the primary tool for usability testing. The questionnaire is divided into two sections. The first section consists of ten SUS items rated on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) (Likert, 1932). Odd-numbered items express positive statements about the AR application, whereas even-numbered items are negatively worded. The second section collects demographic information, including participants' age, gender, education level, and prior experience with AR. These data are used to contextualize the SUS results and to examine whether individual characteristics influence perceived usability. Each response is scored using the conventional SUS calculation method (Brooke, 1996), as shown in following Equation 1.

$$\text{SUS Score} = 2.5 * \{ \sum(5 - P) + \sum(N - 1) \} \tag{1}$$

Where P = positive statement score, N = negative statement score.

In the case of positively expressed statements, the determination of each item score is in the form of subtracting 1 of the rating chosen. The value of negatively phrased statements is determined by subtraction of the selected rating and 5. A sum of item scores divided by 2.5 is used to get the total score and the final value is obtained as the multiplication of the result by 2.5 a final SUS value. The score less than 50 means there is a bad system usability and is usually unacceptable. The values between 50 and 70 will be moderate usability whereas the values over the 70 will be good usability with a higher value indicating greater perceived ease of use (Orfanou et al., 2015).

Data Collection and Analysis

Before the experiment, all eligible participants were provided with an ethical statement and signed consent form to ensure voluntary participation and confidentiality. Participants were then invited to install the "Explore Muse" AR application on their mobile phone. Subsequently, they were encouraged to freely explore the AR content for approximately 10-15 minutes, allowing for a natural and self-directed journey. Upon completing the exploration, participants are invited to completed an online questionnaire via Wen Juanxing, a widely used online survey platform in China. During the session, researchers remained available to assist with technical issues and provide non-intrusive support without influencing participants' responses. After completing the survey, participants were thanked for their contribution, marking the end of the testing session. All collected data are exported to Microsoft Excel for preliminary cleaning, including the removal of incomplete or invalid responses. Four approaches of data analysis are performed: (1) Descriptive statistics. The central tendency (mean) and Standard Deviation (SD) analyses are computed mainly using Statistical Package for the Social Sciences (SPSS) software 31.0. (2) SUS scores are calculated according to standard method, resulting in usability scores ranging from 0 to 100. (3) To assess the internal consistency of SUS items, Cronbach's alpha (Cronbach's α) is computed using Python. (4) A factorial ANOVA is conducted in SPSS software 31.0 to examine whether participants' demographic variables had significant effects on usability score.

All four variables are treated as between-subjects factors, and interaction effects are included in the model. A significance threshold of $p < .05$ is applied for all statistical tests (Lacoche et al., 2022).

Table 1. Demographic information of Gen Z participants (Source: Authors' own work)

Demographic Variable		Number (n)	Percentage (%)
Gender	Male	25	48.08
	Female	27	51.92
Age	15-18 years old	4	7.69
	19-25 years old	24	46.15
	26-30 years old	24	46.15
Education Level	High school education or below	4	7.69
	College or bachelor's degree	25	48.08
	Master's degree	19	36.54
	Doctoral degree	4	7.69
Prior AR experience	Have used	30	57.69
	Not used	22	42.31

RESULTS AND DISCUSSION

Demographic Descriptive Statistics

A total of 60 participants completed the survey, of which 52 valid responses were retained after excluding invalid questionnaires. As shown in Table 1, among the 52 Gen Z participants, 48.08% identified as male (n = 25) and 51.92%

as female (n = 27). The majority were between the ages of 19 and 30. Specifically, 7.69% were aged 15-18 (n = 4), 46.15% were aged 19-25 (n = 24), and another 46.15% were aged 26-30 (n = 24). The average age of all participants was approximately 24.35 years with a standard deviation of 3.66 (SD = 3.66), suggesting a relatively moderate variation in age distribution and indicating a representative sample of Gen Z visitors. Regarding educational level variable, 7.69% had a high school education or below (n = 4), 48.08% hold a college or bachelor's degree (n = 25), 36.54% hold a master's degree (n = 19), and 7.69% hold a doctoral degree (n = 4). In addition, 57.69% participants (n = 30) have used AR applications before, 42.31% participants (n = 22) have not used any AR applications before this survey. The demographic distribution of participants are illustrated in Figure 2. Those demographic characteristics indicate that the sample was diverse in terms of gender, age, education level, and prior AR experience, providing a balanced foundation for subsequent analyses.

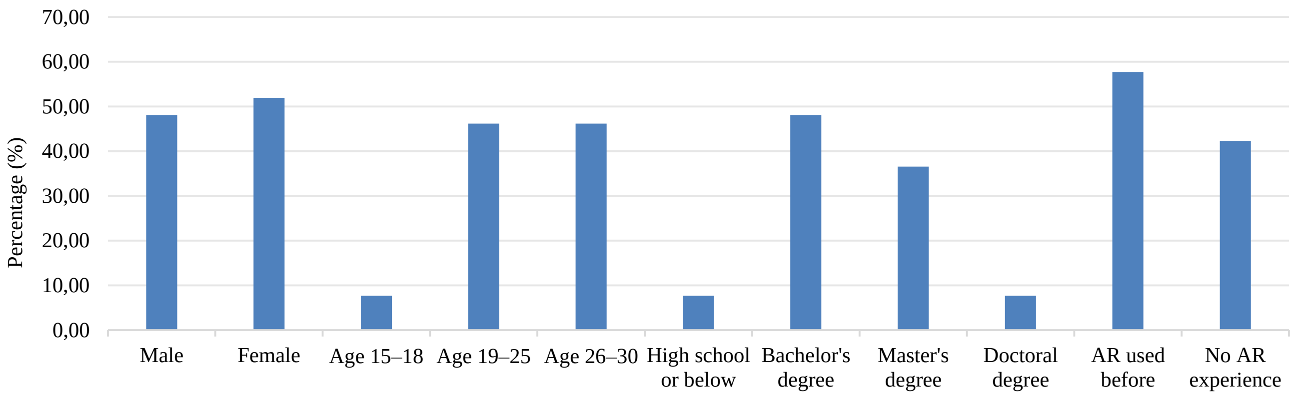

Figure 2. Demographic distribution of 52 participants (Source: Authors' own work)

SUS Score Analysis

As shown in Table 2, The total SUS score reached 3707.5, with an average score of 71.30. According to established SUS interpretation benchmarks, a score above 70 generally indicates acceptable usability and is considered "good" in terms of user experience (Bangor et al., 2008). This suggests that Gen Z participants perceived the application system as usable and functionally coherent. The standard deviation of SUS scores was 10.10, indicating a moderate level of variability in participants responses. While the average usability score suggested a generally positive perception, the distribution of scores reflects a degree of subtle inconsistency among 52 participants. As illustrated in Figure 3, the majority of scores fell between 60 and 80, with a peak around the mean value of 71.30. The distribution closely resembles a normal curve, indicating consistent usability perceptions across overall users. The red dashed line represents the overall mean, suggesting that most users rated the system within the "acceptable" to "good" usability range according to standard SUS interpretation benchmarks.

Table 2. Overall SUS scores analysis (Source: Authors' own work)

Participant Number	SUS Score	Mean	SD	Category
1-5	62.5/67.5/67.5/75/60	66.5	5.76	Acceptable
6-10	55/80/62.5/65/75	67.5	10	Acceptable
11-15	80/55/72.5/62.5/85	71	12.33	Good
16-20	82.5/55/67.5/65/55	65	11.32	Acceptable
21-25	67.5/67.5/75/67.5/55	66.5	7.20	Acceptable
26-30	52.5/55/57.5/60/60	57	3.26	Acceptable
31-35	85/80/82.5/75/82.5	81	3.79	Good
36-40	80/72.5/70/75/72.5	74	3.79	Good
41-45	80/82.5/82.5/80/72.5	79.5	4.11	Good
46-50	82.5/80/80/75/80	79.5	2.74	Good
51-52	87.5/82.5	85	3.54	Excellent
Average Score in Usability Testing		71.30		Good
Standard Deviation		10.10		variability

Table 3. Internal consistency and reliability test result (Source: Authors' own work)

SUS Item	CITC	Cronbach's α if Item Deleted	Cronbach's α	SUS Item	CITC	Cronbach's α if Item Deleted	Cronbach's α
1	0.481	0.718	0.749	6	0.424	0.727	0.749
2	0.694	0.692		7	0.445	0.724	
3	0.144	0.773		8	0.434	0.727	
4	0.396	0.731		9	0.396	0.731	
5	0.422	0.727		10	0.37	0.735	

Internal Consistency and Reliability Test

To assess the internal consistency and reliability of the SUS questionnaire, Cronbach's α was calculated. As shown in Table 3, the resulting reliability coefficient was 0.749, which is above the commonly accepted threshold of 0.7, indicating that the SUS evaluation instrument in this study has acceptable reliability and good internal consistency (DeVellis & Thorpe, 2022). The result supporting its suitability for further data analysis.

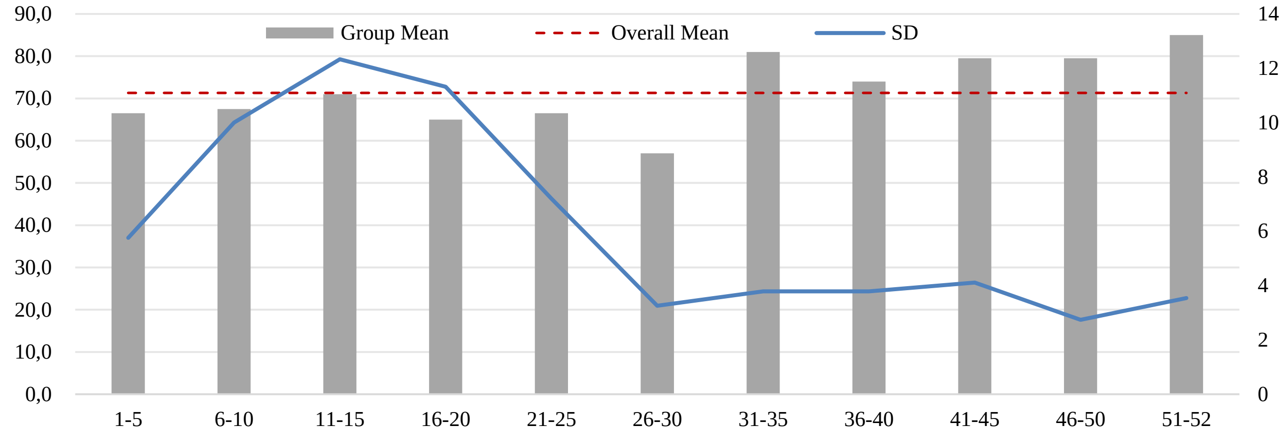

Figure 3. Distribution of SUS score among 52 participants (Source: Authors' own work)

The Corrected Item-Total Correlation (CITC) analysis further supported the reliability of the instrument, with most items showing moderate to strong correlations with the overall SUS score (ranging from 0.37 to 0.69). Among them, Items 2, 5, 6, and 7 exhibited particularly robust correlations (CITC > 0.40), indicating that participants' responses were generally coherent and consistent across different usability dimensions (Nunnally & Bernstein, 2010).

Demographic Variables Factorial ANOVA

A factorial ANOVA was conducted to examine whether gender, age, education, and prior AR experience had significant effects on perceived usability scores, as measured by the SUS scale. The analysis included both main effects and two-way interaction effects among the four demographic variables. As shown in Table 4, the results of the main effects are summarized as follows: (1) Gender, $F(1, 34) = 0.049$, $p = 0.826$; (2) Age, $F(1, 34) = 0.504$, $p = 0.483$; (3) Education, $F(1, 34) = 0.222$, $p = 0.802$; (4) Prior AR experience, $F(1, 34) = 0.125$, $p = 0.726$. Additionally, the model explained approximately 22.0% of the variance in SUS scores, suggesting that demographic attributes such as gender, age, educational level, and prior AR experience contributed marginally to variations in usability perceptions.

Similarly, the interaction terms showed no notable variations across conditions (all $p > 0.05$), indicating that the combined effects among these factors were limited in shaping usability ratings. These results demonstrated that Gen Z participants across different demographic profiles evaluated the AR application in a relatively consistent manner.

Table 4. Tests of demographic variables and between-subjects effects (Source: Authors' own work)

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.
Gender	5.842	1	5.842	0.049	0.826
Age	60.233	1	60.233	0.504	0.483
Education	53.138	2	26.569	0.222	0.802
AR_Experience	14.921	1	14.921	0.125	0.726
Interaction Effects Test					
Gender * Age	75.630	1	75.630	0.633	0.432
Gender * Education	91.629	1	91.629	0.767	0.387
Gender * AR_Experience	48.481	1	48.481	0.406	0.528
Age * Education	96.004	1	96.004	0.804	0.376
Age * AR_Experience	39.880	1	39.880	0.334	0.567
Education * AR_Experience	284.527	1	284.527	2.382	0.132
Gender * Age * Education	11.208	1	11.208	0.094	0.761
Gender * Age * AR_Experience	3.604	1	3.604	0.030	0.863
Gender * Education * AR_Experience	3.500	1	3.500	0.029	0.865
Age * Education * AR_Experience	7.607	1	7.607	0.064	0.802
Gender * Age * Education * AR_Experience	0.000	0			
Error	4061.771	34	119.464		
Total	269543.750	52			

DISCUSSION

In response to RQ1, the findings indicate that Gen Z visitors generally perceive the personalized AR application as usable and supportive of their museum visit experience. The average SUS score of the 52 participants was 71.30 that falls within the standard interpretation rule of being considered as "Good" level. Most of the scores were in the range of 60-80 with the highest point in the range of 71.30. The curve is highly similar to a normal curve meaning that the results were consistently done with equal perspectives of usability by the participants. The overall usability evaluation suggests that "Explore Muse" functions as an accessible and intuitive interpretive tool, enabling visitors to engage with cultural content without cognitive or operational barriers. The relatively concentrated distribution of usability perceptions further indicates that visitors shared comparable experiences when interacting with the application, reflecting a stable level of interaction quality across the sample. Consistent with prior museum tourism research, these findings indicate that usability is closely linked to visitors' sense of involvement and perceived cultural engagement when digital technologies are embedded into exhibition environments (Pentescu, 2023). Regarding RQ2, the results demonstrate that a standardized usability evaluation approach can effectively capture visitor interaction quality in AR-based museum environments. The internal consistency resulted in Cronbach 0.749 level, which showed that the SUS scale is acceptable. Most of the items were found to have moderate to strong correlations with the overall SUS score (all between 0.37 and 0.69), as the values reported by CITC. Echoing previous findings (DeVellis & Thorpe, 2022; Deshmukh & Chalmeta, 2024; Ntoa, 2024), the internal consistency of the usability assessment indicates that visitors responded coherently across different dimensions of system interaction, such as learnability, efficiency, and confidence during use. This consistency suggests that usability perceptions among museum visitors are not fragmented impressions, but rather reflect an integrated evaluation of their overall experience with the digital interpretive tool. From a museum tourism perspective, these findings are particularly relevant because they show that usability evaluation instruments originally developed in HCI research can be meaningfully applied to cultural and tourism settings.

When adapted to interpretive technologies, such tools offer a structured way to assess how visitors experience digital mediation during their visits. This contributes to bridging the methodological gap between technical evaluation and experiential assessment in museum tourism research, where systematic evaluation of digital tools remains relatively limited.

With respect to RQ3, the absence of significant differences in usability perceptions across demographic variables suggests that the personalized AR application delivered a relatively homogeneous experience among Gen Z visitors. Factors such as gender ($F(1, 44) = 0.45$, $p = 0.507$), age ($F(2, 44) = 0.38$, $p = 0.685$), educational level ($F(2, 44) = 0.54$, $p = 0.588$), and prior AR experience ($F(1, 44) = 0.07$, $p = 0.791$) did not substantially influence how visitors evaluated the AR system. This finding implies that personalization within the AR application may have mitigated potential disparities in digital familiarity or prior exposure, resulting in a more inclusive and balanced visitor experience. These results align with earlier studies in immersive digital media and tourism contexts, which similarly reported limited demographic effects on perceived usability and experience quality (Othman et al., 2022; Mohamad Rosman et al., 2023). From a museum tourism management perspective, this suggests that well-designed personalized AR applications can support equitable access to digital interpretation, reducing the risk of excluding certain visitor segments. Such inclusivity is particularly important for museums seeking to engage younger visitors while maintaining broad accessibility and experience consistency.

CONCLUSION

This study examined the usability of a personalized AR application within a museum tourism context, with a specific focus on Gen Z visitors. By developing and empirically evaluating the "Explore Muse" application, the research contributes to a growing body of literature exploring how digital interpretation tools shape visitor experiences in contemporary museums (Almashyakhi, 2022; Trivedi, 2024; Schapsis et al., 2025). The findings indicate that personalized AR applications can deliver consistently positive usability experiences among Gen Z visitors, regardless of demographic characteristics or prior exposure to AR technology. This suggests that usability perceptions within this digitally native generation tend to be relatively homogeneous, highlighting the potential of personalization to support inclusive and accessible digital experiences in museum tourism settings (Tang & Zhou, 2025). Rather than acting as a technical constraint, usability functions as an enabling condition that allows visitors to engage more meaningfully with cultural content. From a methodological perspective, the study demonstrates the applicability of standardized usability evaluation approaches in museum tourism research.

By combining the System Usability Scale with demographic analysis, the research offers a replicable framework for assessing visitor interaction quality with AR-based interpretive tools. This approach extends traditional usability testing into three-dimensional cultural environments and provides empirical grounding for evaluating digital heritage applications beyond purely technical performance (Zhang et al., 2024). The study also carries practical implications for museum managers and designers. The results emphasize that effective AR implementation should prioritize usability and personalization as core design principles, particularly when targeting younger visitor segments. Well-designed AR systems can support engagement without creating digital barriers, thereby enhancing overall visitor experience quality and contributing to sustainable museum tourism development (Mahajan & Taggar, 2025). Despite these contributions, the study is subject to certain limitations. The sample size and focus on a single generational group may limit the generalizability of the findings.

Future research should extend the analysis to broader visitor segments and employ multi-method evaluation approaches, combining standardized usability measures with behavioral or qualitative data to capture more nuanced interaction processes.

Further studies could also examine how advanced AR features (e.g., personalization, gamification, or multimodal interaction) influence visitor engagement and usability, as well as explore longitudinal effects of AR use on learning and sustained cultural interest (Cheng et al., 2025). Such efforts would deepen understanding of how AR technologies can be sustainably integrated into museum tourism and cultural heritage interpretation.

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Use of Generative AI: During the preparation of this work, the authors used ChatGPT in order to refine the structure of the text and enhance its academic clarity while strictly preserving the original content without Al-generated writing. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the published article. All figures and tables presented in this article were originally created by the authors.

Glossary

AR – Augmented Reality; Gen Z – Generation Z; SUS – System Usability Scale; HCI – Human-Computer Interaction; RQ – Research Questions; M3 – 3-tiered evaluation model; SDK – Software Development Kit; VR – Virtual Reality; ISO – International Organization for Standardization; UEQ – User Experience Questionnaire; 3D – Three-Dimensional; OS – Operating System; API – Application Programming Interface; ANOVA – Analysis of Variance; SD – Standard Deviation; SPSS – Statistical Package for the Social Sciences; CITC – Corrected Item-Total Correlation.

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