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Virtual Reality in Samarkand's Silk Road Museums

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Abstract
This study explores the potential of Virtual Reality (VR) technologies to extend the reach of museum exhibitions in Samarkand, Uzbekistan, by developing virtual exhibits through collaboration between Lublin University of Technology and local museums. The study involved creating a virtual exhibition of 3D-scanned artefacts from three Samarkand museums. An exploratory survey was conducted with museum professionals and Generation Z individuals to assess VR's complementary role to traditional exhibitions. Findings. The survey revealed broad acceptance of VR as a supplementary tool, with 79% of professionals endorsing it. Generation Z participants showed high engagement, with VR enhancing their interest in traditional visits. VR technologies significantly improve access to Silk Road heritage, providing an immersive, interactive experience that traditional methods cannot offer alone. The findings underscore VR's potential to attract diverse audiences, particularly tech-savvy younger generations. Integrating VR into museum exhibitions can enhance cultural heritage dissemination, support educational initiatives, and foster a greater global appreciation for Silk Road artifacts. Future research should explore long-term impacts on visitor behavior and museum attendance.

INTRODUCTION

The Silk Road, an ancient network of trade routes connecting the East and West, has long fascinated historians, archaeologists, and travelers. One of the important cities on this route was Samarkand, known for its rich culture and historic value. With the progress of modern technology, there is an increasing interest in preserving and displaying this heritage in newer ways. Enter VR (Virtual Reality), an amazing new medium that brings a different experience. What better way than experiencing history in virtual reality? This study investigates how VR may enhance the story-telling experience in Silk Road museums around Samarkand.

Although Virtual Reality was conceived in the mid-20th century, it has recently become available and affordable for mass consumption. Virtual reality can be either similar to the real world or completely different, marginalized by VR technology. How one interacts with this environment gives an illusion of it being real or physical, typically involving technology like VR headsets. In museums, VR can give an incredibly immersive and interactive experience like no traditional display could provide, such as showing visitors a historical setting or presenting artifacts/events in situ.

Virtual reality (VR) and related technologies offer promising solutions to challenges faced by traditional museum exhibitions, particularly for geographically dispersed heritage sites like the Silk Road. The applications of VR may bring the museum to a broader audience in terms of an immersive and interactive experience from wherever one is located (Żyła et al., 2020). This approach helps build virtual museums where anyone can easily explore digital figurines without being at the physical location (Ariello et al., 2019). Virtual exhibitions can make inaccessible works visible and interconnect content, enhancing the learning experience (Aiello et al., 2019). While technologies like photogrammetry and 3D scanning have simplified the virtualization process, challenges remain in lighting, texturing, and topology (Esmaeili et al., 2017). Regardless, virtual exhibitions provide a perfect platform for museums

to represent their collections in informative and interactive ways, with broader audiences such as the disabled or students (Walczak et al., 2006).

In the past decade, however, research on VR in museums has gained much interest from researchers. Żyła et al. (2020) argued that VR could broaden the Silk Road museums' repertoire, emphasizing its attraction among audiences and fit for enriching traditional exhibitions Comes et al. Comes et al. (2020) mention combining digital technologies with traditional exhibition techniques for an interactive display at the Sarmizegetusa Regia UNESCO site to appeal to the younger audience. Vishwanath (2023) presents a case study of using VR in museums for Senior Citizens to interact with cultural heritage artifacts. Walczak et al. (2006) argue that VR has the potential to create enjoyable and accessible interactive virtual exhibitions for a range of audiences, including disabled individuals and young students at every level.

Several museums worldwide have conducted VR exhibitions, including the National Museum of Singapore and the State Hermitage Museum in Russia. The implementation of VR has provided alternative resources to increase engagement and education compared to traditional exhibitions. Yes, some aspects have not been fully described, especially the impact of VR on visitor behavior. This study aims to fill the gap by exploring the potential of Virtual Reality (VR) to enhance traditional museum exhibitions in Samarkand and assessing its acceptance among Museum professionals and young adults from different cultural backgrounds.

The main objective of the present study is to evaluate the acceptance and performance of VR by museum professionals or visitors, intended as a supplementary tool for traditional exhibitions in museums. This involves knowing how VR can address issues of accessibility, gain more attention from visitors, and provide means for cultural heritage preservation. While several studies have looked at VR for museums along the Silk Road trade routes, there is relatively less research on such a populous region with deep historical and cultural roots like Samarkand. This research showcases the practical implementation and impact of VR through a collaboration between Lublin University of Technology using local museums in an economically disadvantaged region that is also culturally rich but geographically dispersed. The results of this research are expected to improve VR's acceptance as a supplement to traditional museum exhibits, elevate visitor interaction rates with the Silk Road's legacy, and enhance the availability of the museum's collections. Moreover, it is expected that the findings of this study will create a guide that can be used for integrating VR into other museums situated on the Silk Road, consequently fitting into digital cultural heritage preservation.

METHODS

Source of data

The data for this study were sourced from two primary groups: museum professionals and Generation Z individuals. The museum professionals, experts employed at museums located in Samarkand, Uzbekistan, involved in the administration of the Silk Road legacy, provided insights through interviews. The Generation Z participants, young adults born between 1995 and 2001 interested in cultural heritage and novel approaches to its presentation, were all university students from diverse backgrounds and fields of study.

Data collection and analysis

The current research data is collected in two stages: interview and experimental observation. The first stage is in-person interviews at the 2023 and 2004 Silk Road heritage events and included museum professionals. The interviews involved demonstrations of VR technologies in informal, solitary scenarios. Questions included characteristics of participants, the likelihood that virtual exhibits could someday replace traditional ones or augment them, whether internet technology could help make museum resources more accessible to everyone, and opportunities for increasing public interest in museums through this technology.

The controlled experiment was conducted with Generation Z. The experiment split into two halves, as seen in the first part, where they toured a virtual exhibit displaying 3D-scanned artifacts from Samarkand. This exhibition worked in Unity graphics engine and Google VR SDK for Android using VR BOX for Android devices with Redmi Note 5 and controlled by a Mocute-050 Bluetooth controller. The experiment was conducted in various places, including computer labs and classrooms where possible, sitting or standing, moving freely, and free from distractions (such as noise and crowd). The virtual exhibition offered a playground for participants to look around within the VR space and three other rooms designed as part of the main sightseeing experience. During this phase, the researcher observed participant engagement and behaviors.

Figure 1. The test setup: VR frame, Bluetooth controller with a joystick, Android mobile device

After experiencing the VR, participants were surveyed in which they participated in an experiment. Demographic information of the survey included age, gender, the country of origin where people did their field of study and/or lived, what they studied or were studying at the time, and if anyone had previous experience with VR, interest in cultural heritage was another question. Questions pertained to the extent to which participants found immersive VR an effective complement to conventional exhibitions, whether any believed VR could serve as a replacement for showing museum resources conventionally, if virtual exhibits may attract interest in physical exhibits (or vice-versa) and factors contributing towards visits of museums/ attendance at those using interactive displays. Each answer was rated on a scale from 1 to 5, and we also left open text boxes for comments. Data analysis was based on descriptive statistics, while histograms and box plot diagrams were employed to visualize data distribution of quartiles, median, and outliers

RESULTS

The use of VR exhibits in the Silk Road museums within Samarkand made it highly probable that visitor participation and accessibility would be greatly increased. The VR exhibition, produced in partnership with Lublin University of Technology, uses 3D digitization technology for advice access. Results of the survey and interviews with museum professionals can furnish useful data on their acceptance and the effectiveness of VR in this quarter. The survey involved 200 participants, primarily university students from various countries. Key findings are summarized in Figure 2.

Results from the study of VR technology integration at Silk Road museums in Samarkand shed some light on visitor engagement and access. Results of the 200-participant survey, most being university students and including interviews from twenty museum professionals revealed acceptance for VR as an addition in support to regular exhibitions. Overall, 60% of survey respondents strongly agreed and another 30% agreed that VR was a useful addition to traditional museum exhibits; the number jumps up slightly further when boosting accessibility (90%) or engagement with contents (85%).

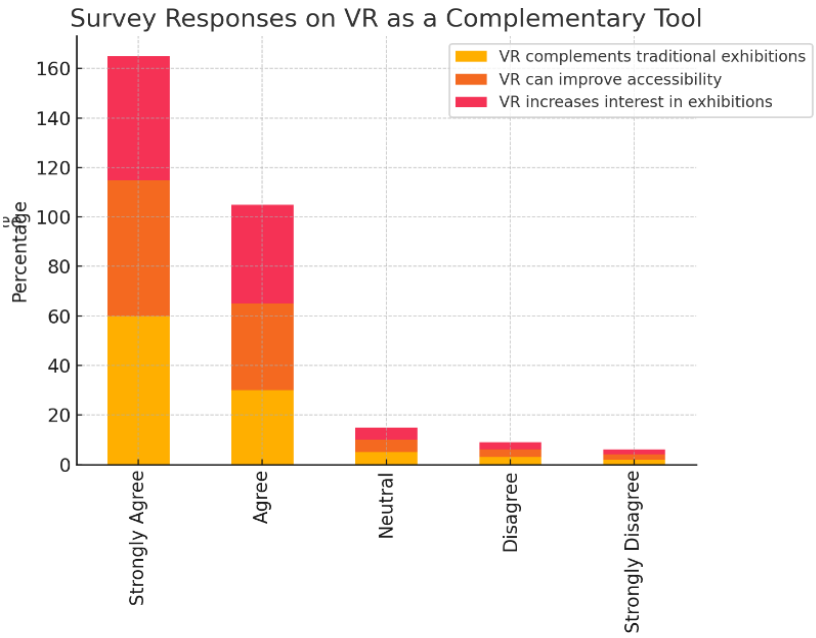

Figure 2. Figure 1: Satisfaction Levels with VR Exhibitions

The museum professionals, hailing from diverse regions, including Poland, Japan, Uzbekistan, Kazakhstan, and Kyrgyzstan, provided substantial qualitative insights. They viewed VR as a beneficial complement, particularly in terms of accessibility. One professional noted, "VR bridges the gap for those who cannot visit due to physical or financial constraints, making our exhibits more inclusive." This sentiment underscores VR's potential to democratize access to cultural heritage, allowing a broader audience to experience the richness of Silk Road artifacts regardless of their physical location or economic situation. Another professional emphasized the role of VR in enhancing educational initiatives, stating, "VR can turn a passive viewing experience into an interactive learning session, especially for younger audiences." This highlights VR's capacity to transform traditional museum education by engaging visitors in a more dynamic and participatory manner.

Generation Z participants expressed high engagement with the VR experience. Comments included, "The VR exhibition made me feel like I was there; it was immersive and exciting," and "This technology could make museums more appealing to people my age." These reactions illustrate VR's potential to attract younger demographics to museums, a critical aspect for cultural institutions' sustainability and future relevance. The ability of VR to spark interest in traditional visits was a recurring theme, with one participant mentioning, "After the VR tour, I wanted to visit the actual museum to see the artifacts in person." This indicates that VR serves as a standalone attraction and a gateway, encouraging physical museum visits by providing a tantalizing preview of what visitors can expect.

Diving deeper into the survey data, more specific preferences and expectations for VR experiences in a museum environment were also identified. Participants rated their overall satisfaction with VR exhibitions highly, with an average score of 4.5 out of 5. This high satisfaction rate suggests that the immersive nature of VR is well-received and valued by visitors. Survey data also suggested that those with greater experience with VR technology in the past believed VR to be a significantly successful tool for enhancing museum-going experiences. The results suggest that familiarity with VR may influence the understanding and acceptance of this new technology in a cultural context.

The interviews with museum professionals featured on the microsite provide helpful information about best practices in VR's operational and strategic integration. Importance of technological infrastructure and staff training to implement VR exhibitions and keep them running smoothly - Several

professionals mentioned the need for proper technological planning when designing a building to support future VR (and AR) exhibition spaces. Though the upfront outlay may be high, this shed led them to wonder whether, in the long term, engaging better with visitors and penetrating further markets was worth it. Professionals also stressed that technologists and curators would have to work together for VR content made on these collections to be both cutting edge from a technical perspective, historically correct, and culturally sensitive.

In terms of access, the research also concluded that VR dramatically reduced barriers for disabled people - or those living in remote places. For instance, VR also opens the possibility of visitors with mobility challenges that prevent them from entering some areas in a real museum to see all there is without necessarily leaving their homes. This inclusive strategy aligns with larger trends across the museum field for more accessibility and social accountability.

DISCUSSION

The results from our investigation of incorporating VR technologies into the Silk Road museums found at Samarkand could represent a great potential for museum visitors to experience digital thinking. Incidentally, the broad-based acceptance of VR as a complementary tool to traditional exhibitions, supported by both survey results and expert interviews, further alludes to what Virtual Reality may bring in terms of disruption to the museum world.

The scale of agreement regarding VR as well as complementing traditional exhibitions for the match (60% strongly agree and 30% sign agreeing), with an overall 90 percent indicating better accessibility and engagement, providing an extraordinary ability to make discovery trips more interactive and make sure everyone will participate. This is congruent with previous research showing the positive potential of VR in educational environments, generally noting that immersion improves learning and engages students (Loureiro et al., 2020).

These qualitative insights by museum professionals are a strong indicator to corroborate the quantitative results. The professionals' observations that VR bridges gaps for those unable to visit due to physical or financial constraints emphasize the democratizing potential of this technology. Museum professionals recognize VR's potential to bridge physical and financial barriers, democratizing access to cultural heritage (Shehade & Stylianou-Lambert, 2020). Overall, visitors are positive in their attitudes toward the application of VR in museums, and factors such as perceived usefulness and ease are offered to explain acceptance (YiFei & Othman, 2024). For example, younger generations show a higher readiness to preserve cultural heritage through VR regardless of their prior knowledge about history (Ch'ng et al., 2020). VR experiences can remotely deliver visual data, enhance site comprehension, and be used for analytical research (Paladini et al., 2019), especially in inaccessible heritage sites. The broader aim of cultural heritage for all is echoed in these insights into VR, which supports greater access and inclusion in the museum space. More research, however, is required to delve into the generational distinctions more deeply and make the best use of VR in museums.

Virtual reality illustrates that it can be an enticing attraction for young museum visitors. Museums struggle to engage younger audiences that increasingly favor digital and interactive media. Many institutions are adopting innovative digital strategies to remedy this. To address this, many institutions are adopting innovative digital strategies. These include creating game-based digital layers to enhance visitor experiences (Doran et al., 2012) and developing online platforms that extend engagement beyond physical visits (Li & Zhong, 2023). Digital museums have emerged as effective tools for attracting youth and interpreting cultural heritage (Novaković, 2021). The expectation to engage in participatory experiences comes from the rise of smartphones and social media, influencing cultural consumption patterns amongst Millennials and Generation Z (Black, 2020). By embracing digital technologies, museums can remain relevant and appealing to younger demographics in the 21st century (Li & Zhong, 2023). The study demonstrates the potential of VR in bettering educational efforts as well. This result supports previous

research advocating that learning in VR is more engaging and interactive, creating cognitive and affective learning effects (Makransky & Lilleholt, 2018).

A notable outcome of the study is VR's ability to spark interest in traditional museum visits. Comments from participants such as, "After the VR tour, I wanted to visit the actual museum to see the artifacts in person," illustrate VR's role as a gateway to physical museum visits. This further implies that, instead of substituting conventional visits for members of the public and consumers alike, it allows broader audiences an attractive glimpse, which can inspire more diligent visitation in person. While this selection may be artifact-dependent, it suggests that VR is not a replacement technology for the traditional museum experience (Carrozzino & Bergamasco, 2010).

The interviews with museum professionals also signaled several working and strategic issues for introducing VR into museum exhibitions. However, the drums to invest in assets (including equipment and staffing) have been beaten before implementation. This aligns with the best practices in integrating new technologies into educational and cultural institutions based on more comprehensive training and support, which stresses its importance (Ross et al., 2003). This underscores the imperative nature of creating interdisciplinary practices for VR content creation, including facilitating collaboration between technologists and curators. It is important to preserve VR museum exhibits' integrity and educational value by ensuring their technological advancement while being historically correct and culturally sensitive (Shehade & Stylianou-Lambert, 2020).

The study identifies several areas for future research and development. One significant gap is the need for longitudinal studies to assess the long-term impact of VR on visitor behavior and museum attendance. Understanding how VR influences repeat visits, learning retention, and overall visitor satisfaction over time will provide deeper insights into its effectiveness as an engagement tool. Additionally, exploring augmented reality (AR) as a complementary technology to VR could enhance museum experiences. AR offers a blend of physical and digital interactions, allowing visitors to engage with exhibits innovatively. This dual approach could provide a more holistic and engaging experience, combining the immersive qualities of VR with the interactive possibilities of AR.

CONCLUSION

The use of VR technologies for the purposes of the integrated museum exhibition in the Silk Road museums of Samarkand is an innovation of substantial importance. The study revealed that VR is well-received among museum professionals and Generation Z visitors, with 90% of survey participants affirming its role in complementing traditional exhibits. The study shows that VR was effectively used in the museum and was well-received by museum professionals and visitors of Generation Z who participated in the survey. The primary implication that can be made is that museums can use VR for two purposes: first, the technology can be used to attract younger visitors interested in experiments that integrate new technologies, and second, VR can be used to facilitate remote visits of visitors who do not have geographical or temporal opportunities to visit the museum. This trend corresponds to the principles of the experiential learning theory and supports the concepts of the multi-sensory visit. Despite the identified implications, it may be critical to investigate further how the presence of VR technology may affect long-term changes in visitor behavior and museum learning outcomes. In addition, it is critical to consider whether this experience may be improved by integrating AR as it has been done for other digital applications. More practically, the findings can be used for future research investigating the cost-benefit analysis of integrating VR into museums and making cross-cultural generalizations about the given technology.

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