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RESEARCH ARTICLE

Digital Archives and Sustainability: Strategies for Preserving Cultural Heritage in Virtual Museums

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ABSTRACT

The modern development of mixed reality technologies and the effective use of AI in various domains of everyday social experience is a rising matter of concern, especially when applied within the field of academic. The paper studies how the use of mixed reality technologies such as AR, VR, and AI can help to create an inclusive learning environment when applied in the context of museums and their digital archives for the virtual presentation and communication of information. The results identify that these technological applications are guided by the perspectives and understanding these users and visitors have about technology that determines their use of it in the knowledge gaining process. Accordingly, when applied efficiently to created simulated and augmented learning environments, these technologies help to promote cultural sustainability and user inclusivity.

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1. INTRODUCTION

1.1 Background

In the recent times, artificial intelligence and simulated reality has gained an utmost signifincance in the media culture where it allows visual assisstance to users as well as provide access to global media and information through the use of technology. Museum industry has included AR and VR technologies significantly in their inclusion of cultural heritage and artefacts for the sake of educational information exchange in the public education sphere by communicating verifiable and accurate data through these technologies to the viewers (Lowman & Kress, 2017). Accordingly, Shehade and Stylianou-Lambert (2020) and Errichiello et al. (2019) note that the use of VR technologies has significnatly emerged in the museum industry in the recent times as a means of imparting public education and promoting awareness about history and heritage and thus enhance visitor engagement. Such an integration of the mixed reality technologies to promote visual assisstance and democratisation of information accessibility is essentially performed in the museum industry. This presents a framework for the evaluation of role of mixed reality technologies and AI in creating a sustainable and inclusive leaning environment for visitors in the public education domain.

On that note, the VR industry allows the simulated construction of the historical environments for the visitors to interpret and experience the knowledge-based environment in both on-side and off-side settings (López-Martínez et al., 2020). The use of AR and VR technologies, therefore, allow the users of various social backgrounds to engage immersively with the artefacts in the virtual space.

This presents the need to promote the legal policies and regulations for the protection and preservation of the intangible cultural heritage (ICH). Notably, there are several legal basis and conventions that provide the legal protect for ICH that apply to both the national and international ICH protection standards (Hariri, 2021). Some of these include "UNESCO Convention 2003" for the protection of ICH, "Law Number 28 of 2014 concerning Copyrights", "Law Number 5 of 2017" for the "Advancement of Culture", "Regulation of the President of the Republic of Indonesia Number 78 of 2007" aimed at the "ratification of the Convention for the Safeguarding" of ICH, and "Regulation of the Minister of Education and Culture Number 106 of 2013 for "Indonesian ICH" (p.153). Furthermore, such an approach can be seen in museums of other nations having a colonial history such as the Salar Jung Museum in Hyderabad, India which introduced a VR gallergy for the remote global visitors while aiming to promote the decorative arts by presetrving the collections through exhibitions, oublications, programmes, and other media approaches that educate people about the rich cultural heritage of Salar Jung III (Salar Jung Museum, n.d.). To that end, these museums aiming to promote the ICH standards of their artefacts and their motto to engage with the global audience participate effectively in the promotion of these artefacts through the various ICH preservations policies and regulation through the virtual space.

The inclusion of the mixed reality technologies such as AR and VR alongside AI can create democratisation of the information that can promote inclusivity and cultural sustainability among the visitors. The modern museum education system in the public learning industry is important for creating a collaborating learning approach that can boost the cognitive interpretations of the learners in the virtual setup that can improve the problem-solving abilities and boost student motivation (Geris & Özdener 2020). Museums conduct elaborative displays of historic and cultural artefacts and participate in public engagement through place-based windows that allow visitors from a wide benchmark of age and class to gain information through scientific discoveries and identifications which also enhances the scope of community engagement (Bakker et al. 2020). Museums perform public engagement together with expert and non-expert members to promote scientific education for the visitors by indulging in an upstream model of community participation that allows a dialogic exchange in a mutual and non-hierarchical process (Watermeyer, 2016, p.72). To that end, these museums are often termed as virtual museums, which Chang et al. (2018) identifies as the presentation of digitised museum exhibits and making it widely accessible by public. These are often collections of digital photos, texts, and sounds associated with scientific and cultural interests that are made easily accessible to people using digital technologies (Jun & Bin, 2011). These observations frame an effective premises for the evaluation of the the mixed reality technologies that are used by museums to promote democratisation and sustainability of cultural and historical knowledge.

1.2 Research aim, objectives, and questions

The paper aims to study the importance and benefits of digital archives paired with the mixed reality technologies of augmented reality and virtual reality in museums to enhance inclusivity, accessibility, and cultural sustainability of the visitors and the museum knowledge communication process. The paper asks:

1. How are the storage and accessibility of cultural information increased through digital archives?
2. How can VR and AR promote democratisation of educational and cultural information?
3. How can Artificial Intelligence improve user interaction with the digital and virtual displays of musuem artefacts for all users?
4. How can AR, VR, and AI promote educational outreach and community engagement with diverse communities through educational programmes and collaborative projects?

Accordingly, the paper has the following objectives:

1. To study the increase of storage and accessibility of cultural information through digital archives.
2. To study the importance of AR, VR, and AI in promoting democratisation of educational and cultural information.
3. To study how AI can improve interactive engagement with VR museum artefacts for users.

4. To study how AR, VR, and AI can promote educational outreach and community engagement with diverse communities through educational programmes and collaborative projects

1.3 Significance of the research

The significance of the research paper lies in understanding the academic relevance that museum studies have through the inclusion of mixed reality technologies of AR, VR, and AI to promote cultural sustainability and inclusivity among the museum goers and promote inclusivity among museum displays and visitors. The use of these digital technologies as well as digital archive for the storage of the virtual cultural data on museum artefects allows the democratisation of the visitors by allowing them equal access to all displays through integrated AI guidance so that any visitor with any form of disability or remotely located visitors can have equal access to the museum artefacts for equal acess to educational information. The integration of these technologies helps the visitors to experience personalised interation with the AI and thus gain information that may not be physically accessible to them. Further, the inclusion of digital archives in museums can also potentially reduce the spatiotemporal barriers as a higher nuber of cultural artefacts can be stored and displayed in virtual archives which can be accessed virtually through the AR and VR technologies. Consequently, the visitors gain equality in accessing information through collaborative learning and projects. This boosts the cultural inclusivity of the people and maintains sustainability for both, the museum authorities and the visitors. Accordingly, conducting a qualitative case study on the Palace Museum of the Forbidden City in Bejing presents a cope for the evaluation of the cultural heritage of China and thus spread this information for educational purposes to visitors from all corners fo the world. Identifying these aspects, therefore, allows this paper to conduct a thematic analysis of the kind of artefacts the museum holds and the various aspects such as its inclusive accessibility and sustainability by breaking spatiotemporal and geographic barriers.

2.0 METHODOLOGY

For the current research, the paper undertakes qualitative approach of performing a case study that is supported by the existing literature on the use of AR, VR, and AI by musuems for public education. Case studies can help to investigate any scientific phenomenon in the social setting through intensive systematic analysis of the selected entity as the case to gather observational data that are qualitative by nature and leads to the development of themes for analysis (Heale & Twycross, 2018). As Hammarberg et al. (2015) identified, qualitative forms of analysis helps to perform an experiential analysis that studies the perspectives and experiences of the research participants and those involved with the phenomenon being studied. To that end, the paper applies the knowledge of qualitative case study analysis research method to the selected case of National Museum China and the Palace Museum (Forbidden City) to study how the application of mixed reality technologies can lead to the democratisation of the historical and cultural information in museums and allow a sustainable and inclusive public educational engagement. Accordingly, the paper studies the philosophical underpinnings of qualitative case study method that guides the research process through the sampling, data collection, and data analysis measures.

2.1 Philosophical underpinnings: Interpretivism

The research approach of conducting qualitative case study on National Museum China and the Palace Museum is guided by the philosiphical underpinnings of interpretivism which requires the understanding of the phenomenon under investigation as a socially constructed reality that may be subjective and open to interpretation. Interpretivism is often considered as an opposition to positivism and notes that "truth and knowledge are subjective, as well as culturally and historically situated" that is guided by individual understanding and experiences (Ryan, 2018, p.8). This philosophical understanding of interpretivist research approach is rooted in the works of the 18th century philosopher Giambattista Vico, who had challenged the ideas of Descartes noting how the social world is different from the natural world because of which the perception and understanding of truth and reality is formed by the social experiences of the people. Interpretivism in a socioscientific research functions through the larger aspects of the governmentality and social constructivism along with philosophical factors of humanism and historicism (Bevir & Rhodes, 2012). The philosophy of interpretivism in applied to the case study analysis of the current research

paper to study the implications of the use of digital technology such as AR, VR, and AI in promoting growth and sustainability of the visitors as well as the historical and cultural heritage by imparting information to visitors from all social backgrounds and promoting sustainability and inclusivity. Therefore, the paper appplies the philosophy of interpretivism to conduct thematic analysis of the observational coded themes from the selected cases of National Museum China and the Palace Museum to study how these museums aid the visitors sustainably through its mixed reality and digital technologies. The paper therefore studies how inclusivity is maintained in imparting public education by the museum industry so that technologies like AI can create an immersive and interactive environment simulated by AR and VR which does not discriminate among the visitors with disability or those located remotely and allows equal accessibility in an inclusive way.

2.2 Data collection and sampling

Collection and sampling of data in an essential step in performing a systematic research that is guided by academic standards and is grounded in primary data and research methods. For that reason, sampling the data sources and varied range of datasets becomes essential to acquire the required and essential data that provides grounding to the research. For this paper, the data is collected through purposive sampling to generate results from the data in alignment with the research objective. Identified also as judgemental or selective sampling, purposive sampling is a form of non-probability sampling that is guided by the judgement and understanding of the researcher (Rai & Thapa, 2015). This allows the researchers to select the data sample for evaluation based on their scientific expertise which is guided by the demands of the respective research objectives, making it different from the probability sampling techniques, by selecting samples which are best suited for the research question. For that reason, in the current paper, purposive sampling has been used to select the specific museums such as the National Museum of China and the Palace Museum based on the viability of physical accessibility as well as online and virtual data gathering of the collections and exhibits by both of the museums. Hence, the data collection from these museums is performed based on the specific aspects of visitor access, remote accessibility, the simulation of virtual artefacts and exhibits, as well as interactive AI integration that can guide the viewers to gather information from the museums.

2.3 Data analysis: thematic analysis

For the current research, the paper performs thematic analysis of the gathered data that is presented in the form of themes. These themes are coded based on the onservation of the data from these two selected museums against the set research objectives to study how these musems promote inclusivity and sustainability using the mixed reality and AI technologies. Thematic analysis is a usual canon in qualitative reearch such as those based on case studies where the themes are analysed by coding for the interpretation of meanings through its groundedness with the theoretical frameworks to present a flexible research approach (Clarke & Braun, 2017). As noted by Neuendorf (2018), thematic analysis presents the ways of seeing and interpreting meanings from seamingly unrelated objects which may often occur in the form of interpreting patterns from dataset to acquire the acceptable meaning from socioscientific perspective. To that end, this research performs thematic analysis on the observed themes from these museums to study how these museums break the spatiotemporal limitation in visitor engagement through the inclusion of simulated environments and mixed reality technologies and how the interactive nature creates an interpersonal experience that can allow the visitors to engage with the artefacts deeply in seeking information. Accordingly, thematic analysis helps to understand how the museums use these technologies and devices to promote sustainability in its spread of educational information equally to all visitors so that nobody is discriminated such as those with disabilities or remote locations. This prompts the application of the philosophy of interpretivism in this research to identify the intertwined meanings pertaining to sustainability and social inclusivity through analysis of the message generated by the use of these technologies by the museums. This helps to ensure the understanding of various sociocultural, political, economic, and other implications that museums have on the historical and cultural values and social position of the visitors.

2.4 Theoretical framework: technological determinism

Keeping the above ideas in check, the current research applies the theoretical framework of technological determinism that studies the implications of the use of technologies such as AR, VR, and AI on the educational attainment and social sustainability of the viewers. Some critiques of technological determinism note that technology defines the social condition of the lives of the users that revolutionises the economic, political, and social aspects (Adler, 2006). However, it is also evident that the use of technology in the everyday lives is itself socially constructed and it co-evolves together with the social structures where the effects of technology depends on its implementation, which is again socially determined. The term is often used to understand and analyse the autonomous and social-constructivist trait of technology that may often by guided by the social, political, and militaristic tendencies of using technology that determines the implications of the it and determines its social cosntructivity (Dafoe, 2015). In the context of the use of mixed reality technologies by museums to promote social inclusivity and promote educational sustainability of cultural and historical knowledge on visitors, the framework of technological determinism can be applied to perform an interpretive analysis of the use of the technology in this domain in guided by the social understanding of the use of these technologies. It can also be used to further identify whether these technologies determine the way people from all social backgrounds view museums and these technologies, or is it the way these technologies are viewed socially by common people that determines the degree of its implementation and use within museums for educational purposes. Accordingly, applying the interpretivist approach in this context, the paper attempts to identify the feasibility of these technologies in museum industry to promote sustainability and inclusivity among the visitors.

3.0 FINDINGS

Themes	National Museum of China (n.d.a)	Palace Museum (Forbidden City) (n.d.a)
Simulated reality for immersive reality	While the museum does not specifically present simulated reality to the visitors, it allows the use of digital technologies for an interactive learning guided by the museum's smart guide platform. This allows the visitors to install the software on their mobile devices and access information on the historical and cultural artefacts in an interactive and inclusive way. The software allows the users to listen to the guide and gain information on the cultrual relics which suggests that it is beneficial for the visitors who may face certain kinds of disabilities. This creates an interactive learning session and this can also help those visitors who are remotely located and lack the physical access to the museum and its artefacts. This can also aide visitors having difficulties in walking and having a tour of the museum that allows them to scan the QR code to access the software which present them all the information in audio format.	The Palace Museum is housed in the Forbidden City in core Beijing which is the remodelled presentation of the imperial palace to the public showcasing the governance and family life of the imperial family in China during the Ming and the Qing dynasties. The official website of the Museum is vibrantly presented giving the sense of witnessing a simulated environment of the Imperial palace through the screen reflecting the various collections and their cultural significance through its online tour. The virtual display of the objects allows people from the remote locations to access the information on various cultural artefacts such as the painted terracotta figurines of the twelve birth signs and represents their significance in cultural settings such as the celebration of the dragon new year. The online catalogue presents detailed information on the artefacts and the cultural and historical event to the readers which helps the museum to break any spatiotemporal barriers and create a simulated interactive experience.
Breaking spatiotemporal barriers to increase virtual storage	The presentation of the historical and cultural information about the artefacts such as various jade, pottery, bronze, and ironware collections, as well as information on the ancient Chinese food culture such as the tea drinking culture and the information on the use of chopsticks and spoons in ancient China. Most importantly, the website presents information in both English and Mandarin languages which suggests that the Museum caters to visitors not only from native China but also from the global world. This is an evidence of how the museum breaks the spatiotemporal limitations and allows the visitors from any part of the world to gain information on the artefacts as well as ancient Chinese cultural traditions and practices. This indicates an inclusive outlook by the musuem to make an open an sustainable learning environment with no physical and social	In the Palace Musuem, the information about various artefacts are presented in their online catalogue that not only stroes tectual data but also presents high definition images that can be zoomed in by the viewers to visually explore the intricacies of the carvings such as the 'Openwork Ivory Dragon Boat with Gathered Immortals Celebrating Longevity' from the Qing dynasty. The presentation of the high quality images and detailed textual information through the virtual medium of their online official website along with the graphic visualisation of the museum environment that simulated the physical environment of the Forbidden city palace from the Ming and Qing dynasty in their official page indicates that the museum breaks the spatiotemporal barriers. This allows remote visitors to experience the immersive environment of the Palace Museum which helps them to experience the simulated environment of the

	boundaries. This can be attributed to the virtual storage and display of information by the museum for its remote visitors using digital technologies.	historical palace and its relics through virtual immersive and interactive experience. This suggests that the Palace Museum used the digital technology and its virtual space to create an inclusive learning environment for the visitors from all domains and spaces to create an inclusive and sustainable public education.
Promoting inclusivity through interactive AI	The National Musuem does not directly use the interactive AI for the visitors with any kind of disability or remote visitors. However, the official website of the museum is simulated virtually to present interactive engagement and informative learning by the viewers which is guided by digital technology making it easier for the viewers to study the information from the virtual storage on the museum. The use of digital archives and virtual storage processes by the musuem can help to avoid the problems of storing limited data and limited information for the visitors. This allows the museums to use their virtual storage space and avoid the pshysical barriers of storing data. This helps the museums to store detailed information on the historical artefacts and the cultural events and allows the viewers to gather information in the public education sector in much more details that the availability of phsycial information. To that end, use of virtual interaction can also be guided through AI in the museum's interaction with the visitors.	The virtually simulated environment of the Palace Museum creates an augmented and virtual reality-based experience for the viewers where the visuals of the home page of the official website of the museum displays the artefacts from the perspective of the viewer creating a simulated viewing. However, the museum significantly uses the interactive virtual landscape for the viewers that allows them an immersive virtual experience such as the panoramic veiw of the Palace Museum. This allows the viewers to engage deeply with the simujlated environment and interact with the artefacts and the museum environment where the caption on the page says 'Explore the World of Dragons: Begin Your Journey here' suggesting an interactive AI based simulated learning of the historical and cultural events for the visitors. This caption on the page prompts the viewer to click on the link and thus enter a different page that presents the details of the festival. The page gradually zooms in making it an immersive and simulated reality-like experience so that the viewers experience a life-sized experience amplified by the use of VR devices.
Remote access through simulated AR and VR viewing	The various technological implementations by the museum and its official online website indicates the significant use of digitial media technologies as well as is suggestive of the mixed reality technologies as well as intercative AI use for the viewers. The use of these digital technologies for the spreading of more information in the virtual space of the museum suggests that the visitors from remote locales can easily access thre information related to the cultrual and historical events and artefacts. This suggests an inclusive and sustainable communication of of information in the domain of public education.	The simulated environment of the museum and its inclusion of information about the palace as well as the cultural artefacts from the Ming and Qing dynasties indicates and the virtual simulation and mixed reality environment. However, these technological assistances by the museum to the viewers is based on the accessibility of the information and its simulated experience without the indulgence in any heavy AR and VR devices that makes it affoirdable and accessible by viewers from all walks of society. These aspects indicate that the use of these technological facilities are meant to even reach out to those visitors and viewers who ae remotely situated and still present complete access to information.
Technological affordability and scoial sustainability	The museum uses basic level of technological aspects in its virtual storage and display through their image based guided smart views. This ensures that the viewers can access the information easily through their regular-use technological devices such as mobile and laptop, making it more affordable for all viewers from all social class.	The palace museum uses basic level of technological integration through its simulated reality environments and virtual storage of the information related to the various cultural and historical artefacts within the simulated environment of the imperial palace from the Ming and Qing dynasty. This requires minimal engagement with high performing technological gears by the viewers and they can access ths information as well as the simulated environment of the palace with only their mobile phones and laptops. This indicates and economic and social inclusivity and sustainability among the viewers of the museum.

4.0 DISCUSSION

Objective 1: To study the increase of storage and accessibility of cultural information through digital archives.

The findings above indicate that the National Museum of China uses its official website extensively as a virtual space for storing the information and data about the artefacts. This indicates that the museum is essentially engaging in increasing its virtual storage space which presents thre groundwork for promoting higher and easy accessibility of the cultural and historical data from the museum (Fig. 1). As noted by Hawkins (2022), it is important to make the information of the objects and data as well as their metadata available in their digitised and machine-readable formats making the datafication process quantifiable for the sake of easy access and analysis. Hedegaard (2008), on

that note, records that it is important to implement digital archives and machinised information accessibility so that interested learners from remote locations could easily access institutionalised information without the spatial barriers of geography. This indicates that the implementation of digital archives can help to increase the virtual storage space of the museums allowing a higher rate of recording information online. These information can be eqasily accessed by viewers from amy location and it also allows the museums to store higher range of information. The National Museum of China is exemplary of this aspect as it uses its virtual storage space which allows it to prevent the spatiotemporal barriers of not being able to include information because there is limitation of physical storage space or their inability to reach out and cater to visitors and interested people from remote locales because of geographical barriers. The inclusion of the digital archive and virtual information space by the museum, therefore, proved beneficial in this case as it can not only provide information about artefacts and objects but also about cultrual and traditional practices such as the food and tea culture of ancient China. These information communication strategies by the National Musuem of China indicates that the inclusion of digital archives essentially increases the scope of presenting information to the viewers through online access.

Figure 1: The virtual exhibition space of the National Museum of China with user navigation interface that is accessible through mobile and computer devices (National Museum of China, n.d.)

The use of digital archive by the Palace Museum essentially in the form of simulated environment and interactive learning space indicates that the museum engages in digital archiving of information to enhance the scope of storage and communication of the information to the viewers. The virtually simulated vieweing of the musuem which indicates to the viewers that they are 'walking in' to the museum even from the physical distance of their remote location only using their laptop of mobile device creates a simulated reality experience (Palace Museum, n.d.). This creates a visual experience for the viewers where various intricacies about the information of the museum can be viewed by the viewers. This viewing indicates the expansion of virtual storage space by the museum which not only includes textual information but also graphic and image-based information that allows an expansive information exchange through visual modes. The use of multimodal environment simulation to create multisensory information communication through the simulation of the indoor environments for the viewers that can provide guidance to the viewers to function even within cluttered indoor environments (Savva et al., 2017). This informs that the virtually simulated environments of the museum spaces guide the viewers to navigate through the simulated environment and seek the information they require from the comfort and distance of their home from the actual physically cluttered environment of the museum. This helps the museums to increase their storage space as they can communicate information the the viewers not only by looking at them but also by interacting with the artefacts and the visually simulated environments. Paired with these aspects of the museum environment simulation, is the use of high definition images that allows the viewers to zoom in extensively in the image to view the intricate details such as the minute design patterns on objects such as the ancient imperial carpets with dragon motifs and the intricate bronze details on the decorative elements of the traditional objects like the throne from the Ming and Qing dynasties. These factors enhance the storage and information communication scope for the musuem through such digital archive and virtual space.

Objective 2: To study the importance of AR, VR, and AI in promoting democratisation of educational and cultural information.

The use of mixed reality technologies such as AR and VR by the museums leads to the democratisation of information and maintains an inclusive and sustainable accessibility of information by the National Museum of China. The museum uses the simulation and online information strategies to communicate with the viewers that allows the democratisation of the educational information as it allows people from all parts of the world to have equal access to information and opportunity to engage in public education (Fig 2). Scientifically, the term democratisation acts as a social notion of opposition to the act of privilege in the twenty-first century where in this democratisation indicates an act of making open access for anyone (Gauld, 2017). "AR, VR, and immersive technologies improve accessibility for diverse user groups, including people with disabilities and distance learners. Virtual interfaces cater to specific needs, and VR enabled virtual libraries and exhibitions enable remote access, democratizing knowledge and education" (Isa, 2023, p.2). In the context of the National Musuem of China, this democratisation of information is performed through their use of their online space to store information about the physical objects and artefacts as well as the cultural traditions of ancient China. To that end, these mixed reality technologies help to gain diverse information by the diverse group of people and also allows people with disabilities and remotely located learners to access knowledge in the public education sector. The use of these mixed reality technologies such as VR and AR then can allow the museums to create collaborative projects through online platforms that are meant to promote the educational access and growth for the visitors from all sections of society. While this can help remote visitors who are unable to physically visit the museum, it can also help the children and adults alike, as well as also those visitors who might be physically disabled in some way. This leads to the democratisation of information that is driven by the initiatives and prerogatives of the museum industry. This produces a wider knowledge base for the users with varying demands and needs and allows the museum officials to cater to a broader domain of visitors, creating a sustainable and inclusive knowledge-gaining site through these projects . Such approaches mitigate any form of geographical, physical, social, or economic divide among the viewers in their approach to knowledge acquisition through public museum education.

Figure 2: Virtually simulated museum display (National Museum of China, n.d.)

The idea of democratisation of information through the use of mixed reality technologies such as AR and VR is further enhanced by the implementation process of the Place Museum. The Palace museum makes an extensive use of the simulated reality technology to communicate not only the factual and textual information to the viewers but also the visual display of the simulated imperial palace of the Ming and the Qing that allows the viewers to experience the simulated reality of imperial China. These technological implementation in the academia in the public education sector that aim to promote democratisation of educational information and maintain the governance of sustainable access to information prove to be a promising measure for the academic future (Costa et al., 2022). Accordingly, the effectiveness of the virtual reality technologies in the interactive educational domain is guided by the e-participation of the community users that follows the community guidelines of dialogue exchanges and overcome the challenges that hinder such participation by addressing the affordances of immersive VR technology (Porwol & Ojo, 2021). The application of these notions about the VR technology along with the other mixed reality concepts such as the augmentation of the simulated environment in the context of the Palace Museum denotes that significant implementation

of these approaches that aim to democratise the information base and user experience by the viewers. The interaction of the viewers with the simulated environment of the imperial palace through the simulated environment that the viewers can visually access through their devices such as mobile phones and laptops without the use of separate VR gadgets indicates the approach towards inclusivity, sustainability, and democratisation by the museum which presents equal scope for all the viewers to equally access all information without the emergence of any economic binary. These ideas and attributes of the museum, when paired with the textual information present on the official page of the museum in both Mandarin and English language suggests how the museum promotes equality among its viewers through the democratisation of information.

Objective 3: To study how AI can improve interactive engagement with VR museum artefacts for users.

The user interface of the official website of the Ntional Musuem in China indicates the presence of AI in the context of images and art in the public education domain. Pisoni et al. (2021) identify the applications of AI in these domains as the digital and automatic presentation of information pertaining to the cultural relics, when clicked on certain images in the simulated relaities of exhibits, increase the cultural accessibility by those viewers who may have disabilities such as visual impairement through audio feedbacks that guide the viewing and recording process. This leads to the conservation and valoraisation of the cultural heritage objects and sites that allows closer interaction of the viewers with the knowledge and information through the simulated environments and virtual technologies. The use of AI guided technologies such as the Smart Guide platform of the National Museum creates an inclusive learning environment through its concise presentation of the information by the musuem. This creates a guided tour of the museum for the viewers where the information is presented based on the serial number of the relics portrayed in the museum, making it easy for the readers to access. Further, it is also noted that these virtual touring and information platforms, when paired with the wearable gadgets, can create a participatory and involving environment for the viewers (Zhao et al., 2022). This suggests that upon accessing the softare, the visitors therefore gain the privilege of accesing information on a deeper level which is not otherwise available, and also enhance the interactive experience of the viewers without presenting the challenge of physical spatiality. This can allow the all viewers to access the information of the museum through the virtual platforms using only their mobile devices from any part of the world. This allows them the flixibility of accessing information at their convenience without abiding to certain standard required in physical museums that may lead to discrimination among the visitors based on their economy, geographic position, or even their education and language barriers. The visitors of the museum can then access the information through the software which can create an inclusive and sustainable learning environment in the museum industry. Therefore, the application ofAI guided tools in the information echange process of the National Musuem of China present s significant scope for the inclusion of the visitors from all social background and create a sustainable furture for the information industry.

Figure 3: The augmented virtual entrance to the musuem with panoramic view accessible through computer and mobile devices (Palace Museum, n.d.b)

The use of AI is also significantly evident in the Palace Museum where the simulated visuals of the museum presented in the official online website indicates the technological inclusivity of visitors in a sustainable information environment through AI guided tours. The virtual simulation of the imperial palace environment for the viewers with each click that takes the viewer visually to the deeper spaces of the palace which, in turn, leads the viewers to various pages for the respective cultural objects present in the simulated environment (Fig. 3). This creates a sense of almost physically visiting the musuem or the imperial palace during the Ming and Qing dynasty rule which could potentially allow the viewers to physically experience, interact, and witness the objects and artefacts. On that note, Majd and Safabakhsh (2017) impinge on the need to expand the machine-learning industry by engaging more people in various types of AI-based machine-learning process which can allow the industry to go beyond the art simulated approach and include a wider range of information exchange factors. This AI technology of the mixed reality technologies therefore extended exponentially in the cultural heritage industry due to its extended applicability and disruption potential that allows its stakeholders such as companies and public instituions to use these AI driven factors to solve a wide range of problems (Duguleana et al., 2020). The Palace Museum implements AI and simulated reality for not only identifying the design patterns of the cultural objectives, but also presents cultural sites such as the Nine-dragon screen (Jiulong bi) which changes colour on each click on the screen to access visual knowledge of the screen through visual access. These approaches by the museum in its incorporation of the mixed reality and AI technologies, therefore, improve the quality of information access, knowledge gain, and interaction with the objects that create an inclusive and sustainable cultural learning.

Objective 4: To study how AR, VR, and AI can promote educational outreach and community engagement with diverse communities through educational programmes and collaborative projects.

Considering the application of AR, VR and the AI technologies by the National Museum of China as well as the Palance Museum (Forbidden City), the use of digital archive, interactive virtual learning, and AI guided tours to mitigate non-inclusivity among the learners suggests a significant shift towards the cultural sustainability of historical knowledge as well as an inclusive learning space for for the visitors of the museums. The implementations of these digital technologies cited in the open access platform of museums and public education promotes the scope of community engagement where the people from various locations as well as of various needs interact with these technologies within the scope of the museums. They use these technologies to access information related to their interest areas through these technologies that heightens community engagement with the museum artefacts and enhances the public outreach of the cultural and historical artefacts and the information about the same. The visitors from various sociocultural backgrounds and geographical locales may also be able to participate in collaborative projects through the online and virtual spaces that breaks any spatiotemporal barriers. Alongside, this also presents a sustainable and inclusive educational outreach for all users irrespective of their individual needs which is including but not limited to the users with physical disabilities, remote locales, and other differing needs. Such increased community engagement and social expansion of information then allows the museums to function by proliferating in the public education sector by providing equal access to information to any viewer irrespective of their social, geographical, physical, economic, and cultural conditions. Therefore, the use of these mixed reality technologies in the academia is guided by the cultural perception of the efficiency of these technologies in communicating knowledge as well as promoting cultural and social sustainability of the users.

To that end, both the National Museum of China and the Palace Museum (Forbidden City) makes effective use of these technologies to engage viewers from wide demography and communicate the cultural values through an inclusive community outreach. This means, visitors from any part of the world can visit the site and use their mobile devices to take a virtual tour of the museum in China even when they are physically not present in China. Other than that, the AI app of the museums can also help users speaking different languages as well as children who require information on certain historical concepts in accessing information through textual and visual modes that allow the viewers to infer the meanings they seek. On that note, the theoretical framework of technological determinism and the interpretivist philosophy of the study holds effective in understanding how the

digital technology of AR, VR, and AI determine the social participation and community engagement of the viewers within the knowledge exchange paradigm of the museum while the use of these technologies by the users are also determined by the social conceptions and understanding by the users about these measures based on the various social factors that determine their user experience. The interpretivist approach of the paper therefore helps to interpret that the use of these technological measures in the education domain of the museum industry is guided by the individual and community experience of the users that determines the social implications of sustainability and inclusivity of the users in the cultural and historical information context.

5.0 CONCLUSION

The current paper aimed to study the importance and benefits of digital archives paired with the mixed reality technologies of augmented reality and virtual reality in museums to enhance inclusivity, accessibility, and cultural sustainability of the visitors and the museum knowledge communication process. Accordingly, the paper found that museums such as the National Museum of China and the Palace Museum (Forbidden City) promote the educational outreach and community engagement by through their virtual learning space that help to engage with diverse communities through their educational programmes and collaborative projects. The paper noted the importance of such approaches in catering to all visitors despite their varying needs which includes people from various sociocultural. Economic, and educational backgrounds, remote geographical locales or other needs such as any form of disability. This promoted inclusivity among all visitors and promotes the cultural sustainability for both, the viewers as well and the various cultural artefacts and the museum heritage.

5.1 Limitations of the study

The current study lacks in its scope as it performs a qualitative case study on only two museums from China amidst a multitude of museums, galleries, and librearies that function in the public education sector and attempt to use various digital technologies. The limited scope of the paper presents a qualitative analysis of the National Museum of China and the Palace Museum (Forbidden City) guided by the technological deterministic factors of the mixed reality technologies that studies how these technologies are interpreted and used by the users in their everyday experience of cultural knowledge from the digital database of the museums. However, what remains lacking is that the paper cannot draw a significant conclusion on the efficiency of these technologies in the context of inclusivity and sustainability based on the performance of only these two museums.

5.2 Future directions

Future research in the similar domain demands the collection of a broader range of data from multiple museums across the globe which are not only located in one country to note the outreach of these mixed reality and AI technologies in public education. It needs to perform and empirical form of study to present statistical data on the user attributes of these technological implementations in the education and information sector. The future studies can also perform interviews with the museum officials from various museums across the globe to gather inputs on the responses these museums have received from the various users. These approaches can help to mitigate the concern of limited scope and data in such researches and present a larger data for effective generalisation of the results.

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