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Educational Perspective Of The Application Of Extended Reality In Cultural Heritage Sphere

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Abstract: In recent years, with the advance of technology and the progressive popularity of the application of new technology empowered by Artificial Intelligence among the public, museums and cultural organizations are moving more and more towards applying digital technologies, specifically Extended Realities, in their exhibitions, preservatives, and educational programs.Extended reality (XR) refers to augmented reality (AR), virtual reality (VR), and mixed reality (MR), and this article argues the application of Extended Reality in museums and cultural heritage organizations' educational programs, contributes to the enhancement of the learning process and consequently to the improvement of the learning outcomes. To achieve this objective major learning theories, including Constructivism, Social Constructivism, Experimental Learning, Learning by Doing, Flow Theory of Learning, Generic Learning Outcome, Free Choice Learning, and Gamification of Learning, will be referred to, demonstrating their accordance with the characteristics of the Extended reality learning environment.The findings of the present study demonstrate the accordance of the referred learning concepts and theories with characteristics of the learning environment created by XR technology which leads to the enrichment of the learning experience and amelioration of the learning outcomes.

Keywords: Educational programs; Cultural Heritage; Extended Reality

1. Introduction

While living in the digital era, in recent years, museums and cultural organizations have realized the beneficial potentials of digitalizing their materials, therefor they show more and more tendencies to update their approaches in terms of educational and preservative practices. The Digital Era is characterized by the use of technology which enhances the speed of process and the spread of advanced knowledge in societies. Over the past few decades with the development of digital communication and computational infrastructure, and the high rate of knowledge turnover, creating a sustainable society has been assisted.

The digital age has revolutionized the methods of conservation, promotion, and education, in all cultural sectors including museums and cultural organizations, and the pandemic years specifically had a key role in pushing cultural and educational sectors toward speeding up their practices in terms of adaptation to the digital era and

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digitalization of their materials. In museums, likewise, the pandemic and the restrictions it imposed respecting physical communication, intensified the necessity of alternative approaches to increase the accessibility of the museums' materials. Cultural organizations and museums, as sectors meant to serve all society members, in search of developing new democratized and decentralized narratives, and new ways of interacting with the public, sharing knowledge, and engaging the audience, embraced the tools and means offered by digital technology.

Another key factor in this regard is the intention of museums and cultural organizations to comply with the guidelines and recommendations of major organizations, *The United Nations Educational, Scientific and Cultural Organization (*UNESCO), European Union (EU), United Nations (UN), and The International Council of Museums (ICOM), that define the actions and policies of cultural sectors.

The 2017 EU Declaration of Cooperation on advancing the digitization of cultural heritage, (European Commission [EU], 2018)[2], the EU work plan for Culture 2023-2026 (EU, 2018)[3], the 1948 United Nations Universal Declaration of Human Rights (United Nations [UN], 1949), the 2001 UNESCO Universal Declaration on Cultural Diversity (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2001), the 2003 UNESCO Convention for the Safeguarding of the Intangible Cultural (UNESCO, 2003)**,** the 2015 UNESCO Recommendation on Museums and Collections (UNESCO, 2015)[4], the 2004 ICOM resolution on the importance of intangible heritage and its role in the preservation of cultural diversity (International Council of Museums [ICOM], 2004), the 2010 ICOM resolution on Cultural Diversity Charter adopted during the 25th General Assembly of ICOM (ICOM, 2010), Resolutions adopted by ICOM's 28th General Assembly of 2013 (ICOM, 2013), the 31st General Assembly of ICOM recommendation in 2016 following up on Resolutions from ICOM 2010 (ICOM,2016), and the ICOM strategic work plan for 2022-2028 (ICOM, 2022), encourage development of inclusive practices to assist the social inclusion and respect for cultural diversity, as well as technological enhancement to increase accessibility and ensure proficiency.

Apart from the institutional policies, promising competencies of the new technology in terms of effective pedagogical and conservational means it offers, have encouraged museums and cultural organizations to apply digital technology in their preservative, educational, and promotional policies to a greater degree. Such application extends from collecting and archiving areas to exhibiting and knowledge-sharing practices and involves a variety of mechanisms. However, this paper will stay focused on the employment of Extended Reality as a digital technology empowered by Artificial intelligence in educational programs of museums, and the scope of application will stay bound to the case study of the tangible and intangible cultural heritage.

2 See European Commission, *Decision (EU) 2017/864 of the European Parliament and of the Council of 17 May 2017 on a European Year of Cultural Heritage* (2018). Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017D0864&qid=1706513363073

3 See European Commission, *Council Resolution on the EU Work Plan for Culture* 2023–2026 (2022). Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022G1207%2801%29&qid=1671635488811

4 See UNESCO, *Recommendation concerning the Protection and Promotion of Museums and Collections, their Diversity and their Role in Society adopted by the General Conference at its 38th Session, Paris, 17 November 2015* (2015). Available at https://unesdoc.unesco.org/ark:/48223/pf0000246331?posInSet=1&queryId=0d9dec3e-872d-4cbd-8678-dfa7d02dba5b

2. Materials and Methods

This study takes an interdisciplinary approach and the document analysis and qualitative research methods of this research are the combination of descriptive and case study methods with an interactive nature. The data collected from library resources, both primary and secondary resources, reviews available literature and /or data and materials in the form of academic research papers gathered using the Google Scholar web search engine and Scopus database, journal articles, books, E-books, and reliable websites, using the Internet. Visual data in the form of photographs are similarly collected from the mentioned resources.

Regarding the theoretical framework, a cluster of learning concepts and theories including Constructivism, Social Constructivism, Experimental Learning, Learning by Doing, Flow Theory of Learning, Generic Learning Outcome, Free Choice Learning, and Gamification of Learning are used to draw an in-depth understanding of how the application of Extended Realities contribute to the improvement of educational programs in museums and cultural organizations regarding the tangible and intangible cultural heritage.

As Extended Reality is an umbrella term referring to all Virtual Reality, Augmented Reality, and Mixed Reality which are not synonyms concerning the applicational and technological aspects, therefore the learning theories and concepts referred to in this study are carefully chosen to be effective respecting the mutual characteristics of all three VR, AR, and XR digital technologies.

3. Results

3.1 Artificial Intelligence

Digital technology has revolutionized the means of communication as well as the methods of production, distribution, and conservation of artworks and cultural heritage. The role and function of museums in parallel, have witnessed major changes which have challenged their traditional theoretical and practical framework. The new definition of "Museum" set by the ICOM Extraordinary General Assembly on August 24th, 2022, defines the museums as follows:

> "A museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage. Open to the public, accessible and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection and knowledge sharing." (ICOM, 2022, p. 3).

Therefore, the main role of the museums by its most recent definition could be understood as relating to conservation, entertainment, and education, and the main task would be to increase accessibility to, and inclusivity of the public. The notable change in defining the museums' role in society, lies in the recognition of the significance of inclusivity, community participation, and sustainability. By this definition, museums are no longer understood as places for storing physical objects, rather they are defined as spaces of nonhierarchic communication. Respecting the new landscape and perspectives, museums accordingly, need to recognize the demand for changing their policies. In the Digital era, museums need to adapt their communicational strategies in compliance with the needs and desires of their visitors who increasingly employ new technologies in their mundane doings (Bryant-Greenwell, 2014). They need to develop new communicational channels that could accommodate cultural access for all society members, referencing UNESCO's 2015 Recommendation concerning the Protection and Promotion of Museums and Collections, their Diversity, and their Role in Society, stating "…museums should be encouraged to use all means of communication to play an active part in society by, for example, organizing public events, taking part in relevant cultural activities and other interactions with the public in both physical and digital forms." (UNESCO, 2015, p. 8).

Museums, seeking to engage their audience and expand the number of their visitors, need to become more versatile. They need to understand the importance of social media, their website, and other network-based communication channels, to retain close contact with their visitors, and to reach out to online users as potential audiences. and consider the direct impact of their online presence on their reputation, and consequently, on the number of their physical visitors (Dodge, 2014). Nowadays museums and cultural organizations, despite their initial hesitant approach, evidently are recognizing the beneficial potentials of digital technologies as strong tools for developing decentralized and democratized narratives, and new ways of interaction and information sharing, therefore they seem to be increasingly interested in exercising artificial intelligence and extended realities. Museums, despite the challenges the digital environment may impose on the traditional models they had set, have become aware of the urgency for modification of their strategies to stay sustainable, relevant, and inclusive. For museums, the dramatic transformation from analog to digital implies a revolution in every aspect of their function, linked to new ways of thinking, planning, and working (Levä, 2013, p. 27). This transformation, on one hand, calls for new investments, and on the other hand, promises a lucrative return by attracting a greater number of visitors, thereupon museums need to set the balance between their public mission and commercial exploitation policies to not undermine their nature as a not-for-profit institution (Hamma, 2005).

The status of museums in the Digital Transformation era is firmly linked to the characteristics of the environment of their operation. An environment in which technologies develop constantly, and therefore museums need to stay up-to-date and in line with these developments, to grow their interaction with their visitors and involve the public in museum life as a cultural institution (Grigore et al., 2019, p. 559).

3.2 The Extended Reality for Constitution of Inclusive Museums

The swift advance of technology drastically impacts how people understand the world and modifies their interactions with their environment. Living in the period known as the Digital Transformation era implies the increasing use of network-linked intelligent devices and consequently extending interaction between humans and machines (De Giorgis, 2021). In recent years, with the development of Extended Reality and the popularity of Artificial Intelligence among the public, the main objective in this regard has been the reconstruction of a kind of relationship that resembles the real world. In the cultural heritage sphere, digital technology and its application, act as a means to identify pathways that could facilitate the accessibility of cultural heritage and ensure sustainability. In this regard, digital technology is applied as a tool for producing information based on the needs of diverse groups and communities and keeping museums and cultural heritage organizations inclusive. To demonstrate how museums and cultural heritage organizations use AI and digital technologies, primarily, we need to indicate the definition of Digitalization, Artificial intelligence, and Extended Reality.

While the analog or physical process of documentation of materials in museums has a long history, the development of the digitalization of the materials is rather a recent trend. However, we need to consider Digitizing and Digitalization, sometimes referred to as similar processes, are not the same. Digitizing refers to the conversion of analog data into digital form, meaning by encoding information into zeros and ones, therefore computers could process the information (Picard, 2011, p. 6). The conversion of typed or handwritten texts into digital form is an example of such a process (Bloomberg, 2018, p. 2). Therefore, the history of digitization is linked to the advent of computers in the 1950s. In museums, the post-war realization of the collections' movements, highlighted the importance of digitization in terms of the registration of the information related to the collections including state, date, and place of origin. Without a proper record, museums could lose their objects and collections, therefore the first digitizing projects were initiated in the 1960s. however, due to the high cost, only large institutions had the necessary funds to conduct such projects (Navarrete, 2014, p. 13). As one of the recent examples of the digitization of museum collections accessible to the public, we could refer to the fully digitized Medieval collection of The J. Paul Getty Museum.

Digitization, as a means of information conversion and storage, is the first step of Digitalization, which refers to the combination of procedures related to digitization, and the application of digital innovative technologies to improve the existing assets of an organization and its procedural models (Yoo et al., 2012). Therefore, while in digitization data is converted to computer-friendly language and codes, in digitalization the data is processed through advanced digital technologies. One of the most controversial examples of these advanced digital technologies is Artificial Intelligence which has been the subject of many debates recently. To define the term Artificial Intelligence, we could refer to several pieces of expertise starting from Turing, the father of computer science, and his paper "Computing Machinery and Intelligence" and his "Turing Test" designed to determine whether or not computers could think like humans. He suggests computers could possess artificial intelligence if they could mimic human responses (Turing, 1980). In the definition offered by McCarthy, AI is the science of creating intelligent machines in general and intelligent computer programs in specific. He relates artificial intelligence to the tasks performed by the computer to understand human intelligence (McCarthy, 2004). Russel and Norvig in their leading book, Artificial Intelligence: A Modern Approach, bound the definition of AI to its four potential objectives of two different approaches: the Human approach, including Systems that think like humans and Systems that act like humans, and the Ideal approach, including Systems that think rationally and Systems that act rationally (Russell, & Norvig, 2021), and lastly, Dobrev simply defines Artificial Intelligence as a program that can function equal to or better than humans (Dobrev, 2012, p.2). Therefore, we understand that AI is a digital technology related to the capability of a computer or computer-controlled machine, to carry out the tasks associated with human intelligence.

Artificial intelligence has two types. Type-1 AI which is ability-based includes Narrow AI (able to perform specific tasks), General AI (resembling human capabilities), and Artificial Super AI (beyond human capability). Type-2 AI which is function-based includes Reactive Machines that have no memory and only respond to different stimuli, Limited Memory which uses memory to learn and improve its responses, Theory of Mind which understands the needs of other intelligent entities, and Self Awareness which has human-like intelligence and self-awareness. From the technical point of view, Artificial intelligence has several subfields including Robotics, Natural Language Processing (NLP), and Machine Learning (ML), and the latest refers to the computer systems that use the sample data to train computer programs to recognize patterns based on algorithms. Machine Learning itself, has a subset known as Deep Learning, in which Neural Networks act as the backbone. Neural Network refers to the computer systems designed to imitate the neurons in a brain. The networks are designed to learn via processing examples, using a well-understood input and a predicted result. Accordingly, the term Generative Artificial Intelligence is used to describe sophisticated Deep-Learning models that are capable of analyzing raw data and generating likely outputs upon being prompted. Broadly speaking, generative models encode a simplified version of their training data and use it to generate new data that bears resemblance to the original but it is not a replica (McCorduck & Cfe, 2004; Russell & Norvig, 2021, Murphy,2012).

Therefore, Artificial Intelligence is an advanced digital technology that could be used to process and analyze large amounts of data automatedly without human involvement. AI is used to enhance efficiency and to increase productivity. In terms of Extended Realities, AI generates the content for these realities. But what does Extended Reality mean?

Extended Reality (XR) represents the 3D digital content of integrated technological platforms that users could experience through interaction with digital or physical materials in a virtual or real environment. It includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), from which, the lattest generalizes the VR and AR (Gaugne et al, 2022, p. 1406).

The history of VR can be traced back to the 1950s and the futuristic ideas of Hugo Gernsback, American publisher and editor of “Amazing Stories” pulp magazine who coined the term “Science-fiction”. He was also an inventor and from his many ideas, specifically his “Teleyeglasses” as we could see in figure 1, with separate screens for the users’ eyes and the possibility of displaying stereoscopic images, were very near VR goggles or 3D virtual reality glasses of today (Ackerman, 2016).

Figure 1. Hugo Gernsback, Ph: Alfred Eisenstaedt for Life Magazine Collection/Getty Images (Ibid.)

However, to identify the term Virtual Reality in terms of the new digital technology that is the subject of this study, we could refer to the definition provided by Jaron Lanier, the father of virtual reality, in an interview with Adam Heilbrun which was first published in 1988 in the "Whole Earth Review". Lanier describes the term as:

> "a technology that uses computerized clothing to synthesize shared reality. It recreates our relationship with the physical world in a new plane, no more, no less. It doesn't affect the subjective world; it doesn't have anything to do directly with what's going on inside your brain. It only has to do with what your sense organs perceive. The physical world, the thing on the other side of your sense organs, is received through these five holes, the eyes, and the ears, and the nose, and the mouth, and the skin." (Heilbrun, 1988, p. 110).

Figure 2. The first VR system which was presented at a trade market show in the late 1980s. (Lanier, 2017, p. 3)

Therefore, Virtual Reality corresponds to a type of human-machine interaction and could be referred to as a digital simulation of a real or unreal world perceived through human senses with the aid of a computerized gadget. AI empowers this digitalized environment in the sense of its reality, interactivity, and personalization. Jaron Lanier and his friend, Thomas Zimmerman were the VR pioneers who founded the very first VR startup, VLP Research as early as 1984, which was the first company trading Head-Mounted Displays (HMD) and gloves as presented in figure 2. Lanier describes VR as an elixir of a boundless experience, a high-tech dream that situates the user in a fantasy world in which they could experience their body as avatars, and could share this arbitrary experience with others as an alternative to the persistent physical world (Ibid., pp. 1-3).

Virtual Reality fully immerses users in a synthetic world and completely separates them from the real world. In such a virtual environment, users could only see the world through computer-generated representations. (Carmigniani et al., 2011) Hence, the main objective of VR is to provide the possibility of operation of cognitive activities and sensorimotor in a digitally created virtual environment which could be understood as a simulation of certain aspects of the physical world, or a purely fictional one. Therefore, the user of this technology, through their body, mind, and senses would become immersed in such a virtual world perceptually, emotionally, and mentally (Zhao, 2009).

Virtual Reality, based on the immersion degree it offers could be divided into three sub-categories: *immersive virtual reality* in which the user is fully immersed in the digital environment through the use of devices, *semi-immersive virtual reality* in which projections on walls stimulate immersion and allows a group of users a kind of shared experience, and *non-immersive virtual reality* in which 3D-designed environments are displayed on 2D screens (Ware et al., 1993).

Augmented Reality, on the other hand, combines digital and real content, and as Azuma states, provides a real-time interactive environment, and registers in 3D. (Azuma et al., 2001) AR does not replace the real world but rather completes it. (Milgram, & Kishino, 1994) AR could be defined as a system that enhances the users' understanding of the real world by adding virtual elements through digital computer-generated information and provides them with the possibility of interacting with those virtual objects. (Casella, & Coelho, 2013; Liarokapis, 2007) Azuma et al, define Augmented Reality as a system that "[…] combines real and virtual objects in a real environment; runs interactively, and in real-time; and registers (aligns) real and virtual objects with each other". (Azuma et al., 2011, p. 34) The application of AR dates back to the '90s, (Rauschnabel et al., 2022) but it gained public attention later in the 2010s. (Harborth, & Pape, 2021, p.1) It could be considered a newer technological system compared with VR, however, the quality of the users' experience in terms of the feeling of presence and the level of reality presented, could be considered the same (Botella et al., 2005).

And lastly, Mixed Reality, refers to an environment in which real-world and virtual items are presented within a single display. Therefore, as demonstrated in figure 3, in a Mixed Reality environment, virtual and real worlds are merged, and the notion of immersion falls anywhere between two extremes of the "Virtual Continuum". The concept of "Virtual Continuum" refers to the amalgamation of various categories of objects presented in a specific display context. As illustrated below in Figure 7, it has two opposite extremes, the left one describes the environments that are entirely composed of real, physical, tangible objects, while the opposite extreme on the right defines the environments composed exclusively of virtual items. (Milgram, & Kishino, 1994, pp. 2-5) Milgram and Kishino, define six classes of existing hybrid environments of Mixed Reality concerning the technologies they are equipped with and the degree of immersion they impose (Ibid., pp. 3-4).

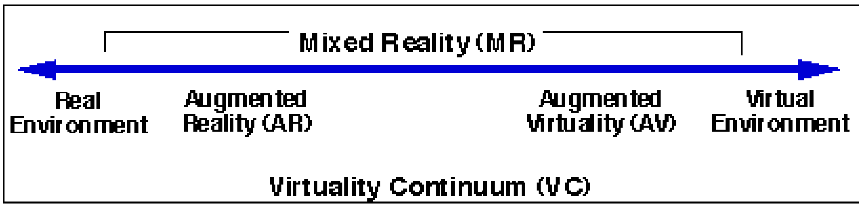

Figure 3. The Milgram Continuum. Simplified representation of a "virtuality continuum" (Ibid., p.3).

The MR environment offers an immersive and interactive experience and while users are exploring the real world immerses them in the virtual environment by employing gadgets including Head Mounted Displays (HMD) and smartphones, to improve their experience. Microsoft HoloLens for instance is an optical device that employs HMDs to see through, responding to sensual gaze, voice, and gesture commands. Cheaper alternatives that work through smartphones for data processing and visual display, include Mira and Holoboard.

The application of Extended Reality in the cultural heritage domain has been significantly increasing in recent years. In Archeology, for recording the excavation and virtual excavation, Reily introduced Virtual Archeology in 1990 (Reilly, 1999), Krasniewics suggested a 360-degree visualization system in 2000 to facilitate archeological research (Krasniewicz, 2000). For pedagogical purposes, Christou et al. proposed a CAVE-like display that reconstructed and visualized the Messene, an ancient Greek temple, in a museum exhibition (Christou et al., 2006).

Extended Reality projects launched worldwide, effectively contribute to the improvement of both functional and operational processes in the cultural heritage domain. To name a few numbers of the projects related to the tangible Cultural Heritage domain, we could refer to Papagiannakis et al., 's impressive work in which the Asinou church (Papagiannakis et al., 2018), a UNESCO cultural heritage monument located in Cyprus has been virtually demonstrated using Augmented Reality (AR) and Holographic Mixed Reality (HMR) technologies (Geronikolakis, & Papagiannakis, n.d.). The main purposes of this project were first to assist the conservators and architects in safeguarding the monument, and to engage the visitors with the rich history and significance of both tangible and intangible assets of the site.

In another interesting project led by Nevola and Cooper in 2019, the lost church of San Pier Maggiore was restored as an Augmented Reality (Nevola et al., 2022). The San Pier church was demolished in the 18th century and the artworks were scattered in collections around the world. The project, Immersive Renaissance, funded by the Getty Foundation, aimed to provide the tourists and locals in Florance, and the visitors of the National Gallery of Londen which hosts the altarpiece of San Pier church, painted by Jacopo di Cione in 1371, with access to the original context of the church.

In Switzerland, an AR project devised by Jon Torpus in 2004, LifeClipper, with its second and third research-based versions conducted by the University of Applied Science Northwestern Switzerland, reconstructed the Medieval landmarks and streets of Basal in the St. Alban Quarter allowing the users to explore the medieval life of the city. LifeClipper users wear a Head-mounted display (HMD) and a portable computer unit to enjoy the audio-visual walking experience in a 3D reconstructed context among the virtual people wearing medieval garments (Reid, 2005)[5].

In South Korea, the Donuimun Gate of the Joseon Dynasty era which was one of the four great gates in the city wall of Seoul, originally built in 1396 and demolished in 1915 during the Japanese colonial period, was restored using Augmented and Virtual Realties (Youn, & Ryoo, 2023, p. 33). The Seul Metropolitan Government (SMG) in partnership with the Cultural Heritage Administration of Korea, the Design Cheil, and Woomi Construction, digitally restored the Gate using cutting-edge technologies including AR and VR, aiming to foster tourism in Seoul, to preserve lost national cultural heritage, and to raise awareness and interest of the visitors, including the young generation, towards cultural heritage[6].

While the aforementioned projects mainly use XR to reconstruct the tangible and monumental cultural heritage, we need to consider the significance of the intangible value integrated into them.

Respecting the intangible cultural heritage to name some of the conducted XR projects we could mention The Tales of the Tokoloshe (Skovfoged et al., 2018), a game based on the stories of the mythical African character Tokoloshe, with an interactive nature designed to create awareness in the younger generation and to safeguard the related oral intangible cultural heritage.

I-Treasure (Dimitropoulos et al., 2018), in which through a process of collective recreation, I-Treasure was designed as a gateway through which access to intangible

[5]See Reid, (2005, 04, 22). *Beyond virtual reality*. Retrieved on 22 February 2024 from http://news.bbc.co.uk/1/hi/programmes/click_online/4472491.stm.

[6]See the Reference Letter for the IT-based Restoration of Donuimun Gate for UN Public Service Awards of 2019 by Jung Byung-Guk, accessible at https://publicadministration.un.org/unpsa/Portals/0/UNPSA_Submitted_Docs/2019/02379e7c-ebc3-48c5-b442-815eaf66cc3d/2020%20UNPSA_The%20utilization%20of%20specialized%20tourism%20resources%20unique%20to%20the%20city_Ref.%20Letter%201_26112019_092733_95dbffd9-c833-48ed-bb4d-da8779429567.doc?ver=2019-11-26-212733-080.

treasures is provided. I-Treasures focuses on the capture and analysis of intangible cultural heritage performances with the use of multi-sensing technologies.

Mostar Bridge Diving App (Selmanović et al., 2020), in which users select stories from the 3D menu after an intro story. They perform a quiz after watching all the stories to assess how much they have learned. If the questions from the stories are answered correctly, they can proceed to the simulation of the virtual bridge dive.

Hua'er and the Youth (Liu, Yan, Lu, & Zhao, 2022). Hua'er is a type of traditional oral performance listed as an ICH of China. The mentioned project proposes an interactive VR system engaging audiences to experience and understand the connotation of Hua'er's performance.

3.3 The Extended Reality and Educational Perspectives in Museum

Museums have been considered centers of education for a long time, the tradition could be traced back to the museums with unintentional educational functions including the Museum of Alexandria 4th BC and Medieval European museums with their "Cabinets of Curiosity", and the ones intended to contribute to learning including Palazzo Medici 15th which laid the foundation of the modern museum and 17th century with the donation of John Tradescents' collection to Oxford University (Günay, 2012). Even so, the placement of the educational role of the museums as their principal priority is a more recent trend.

The American Association of Museums in 1984 (American Association of Museums, 1984), and The United Kingdom's Museums Association in 1993, defined Education as the core function of museums (Museums Association, 1993). However, we should notice that the educational role of museums has gone through a dramatic change in museums in recent years. Formerly, the educational role of the museums was limited to providing specific materials for limited groups such as students or guided tours for visitors. Museums had a building and a collection to conserve and their responsibility was primarily linked to their collection rather than their visitors (Hudson, 1998). By contrast, now, the complexity of the task is understood more widely and includes a variety of activities including participatory projects, co-curated exhibitions, workshops, events, and so on (Museums Association, 2013; Watson, 2007, pp. 28-31; Hooper-Greenhill, 2007). This new approach highlights the necessity of reconsideration of educational tools and methods. In new interactive museums or as Hopper describes, *post-museum*, museum education in terms of its content and style needs to be considered in relation to the context of museums, and or cultural organizations within the heterogeneous social framework to facilitate accessibility and enhance the quality of the learning process and outcome, in both face-to-face and distant methods and strategies applied. Accordingly, we need to consider the different needs and requirements of specific museums as well as the audience, and instead of a single unified response to museums' pedagogy, move forward replacing the concept of the general public with the differentiated audience (Hooper-Greenhill, 2020, p. 7).

Respecting the museums' education, understanding of the learning process and the way people learn in general is a necessity to demonstrate how the application of Extended Realities corresponds to facilitating the learning process and maximizing its outcome. In this article two of the major learning concepts and theories related to the application of Extended Reality in pedagogy will be proposed to shed light on the subject under this study and demonstrate the accordance of these theories with the characteristics of Extended Realities in educational settings.

3.3.1. Constructivism

Constructivism is one of the most frequent theories referred to regarding the application of Extended Realities in educational programs. Regarding the paradigm of Constructivism, Knowledge is produced through construction and interpretation based on personal experience, mental structures, and perpetual mechanisms rooted in the interaction between individuals and simulated contexts, and does not reflect an objective ontological reality, but exclusively how individuals construct meaning and organize the world based on their experience (Hein, 1991). Learning in this sense is an active and constructive process through which learners construct their knowledge starting from their prior knowledge and experience through interactions with the environment and construct the meaning through exploration, instead of receiving information passively (Piaget, 1976).

Thereupon, learning in its constructivist definition is an active process of construction rather than representation (Aiello, D'Elia, Di Tore, & Sibilio, 2012; Dochy, & Moerkerke, 1997), and as Jonassen states, in the Constructivism viewpoint cognition is focused on the individuals' experience and interactions with the world determined by individuals' capacity in terms of action and perception (Jonassen, 1991, p. 6). Therefore, educational programs with a constructivist approach that use technology as a means of improving the context, action, and interaction, could contribute to the facilitation of the learning process. The characteristics of constructivist learning environments proposed by Jonassen, support the application of XR in pedagogy as the Extended Realities represent the complexity of reality, provide tasks to be completed, are interactive, and allow learners to construct new knowledge in the context. Accordingly, as Huang and Liaw state, Virtual Reality could be considered an effective means that promotes the outcomes of the learning process in a variety of educational contexts with a constructivist approach (Huang, & Liaw, 2018, p. 106).

3.3.2. Social Constructivism

While Piaget's Cognitive Constructivism is focused on personal experience, Social Constructivism, developed by Vygotsky, highlights the importance of social interactions in the learning process. According to this theory, learners construct knowledge through active collaboration with others along a personal critical thinking process (Vygotsky, & Cole, 1978). In this view, interaction is the prominent element in knowledge acquisition, and creating an interactive learning environment would help most in facilitating the learning process for learners. The interactive environment of the XR in this regard, aids the learning process by promoting peer learning and offering the opportunity of communicating and collaborating with other learners.

3.3.3. Experimental Learning (ExL)

One of the most compelling theories of learning regarding the appropriation of Extended Reality in pedagogy is the Experimental Learning (ExL) theory proposed by Kolab. Based on the Experimental Learning Theory model, concrete experience, and reflective observation, in terms of grasping experience; and abstract conceptualization, and active experimentation, in terms of transforming experience, through a cycle of four stages, Diverging, Assimilating, Converging, and Accommodation lead to the effective learning. The cornerstone of the Experimental Learning Theory is the prioritization of active experience in the learning process. This learning theory encourages the learners to construct knowledge through their own interactions and experiences (Kolb,2014).

The key point here is the sensorimotor interaction of the learners with their environment that structures the body as a mediator between mental perception and the surrounding context. In this sense immersion in the virtual world promotes the optimization of the learning process and the simulated environment provides learners with the possibility of body involvement and interaction in favor of cognition, and consequently knowledge acquisition (Morganti, & Riva, 2006). Therefore, the application of technology to create a virtual environment for educational programs with an experimental approach facilitates the learning process (Sibilio, & D'Elia, 2007), which occurs mainly through contextualization and immersion, two elements that characterize Extended Reality environments.

Contextualization in educational programs refers to the placement of learners in everyday life situations (Barron, Schwartz, 2014) to increase their sensitivity toward the situation they have been situated in (Darling-Hammond, & Snyder, 2000). Thus, it could be defined as being in the context and exploring it through having an interactive engagement and inclusive experience instead of receiving information through traditional passive modes. Immersion as another impactful element in the experimental learning process, that also characterizes the Extended Realities, contributes to the state of being surrounded by the context and gathering information through the senses in an interaction with the virtual environment (Aiello, D'Elia, Di Tore, & Sibilio, 2012; Dochy, & Moerkerke, 1997). Some scholars have defined Immersion as the objective measurement of the sensory fidelity of technology, and the level of immersion as the mode of interaction with virtual reality depending on the capacity of the virtual environments to be inclusive, extensive, surrounding, vivid, and matching (Slater, & Wilbur, 1997).

Extended Realities provide learners with immersive environments that are flexible and controllable and therefore, allow learners to complete tasks with progressive complexity. They also provide learners with personalized feedback during the learning process which responds to the reflection as another important element in the experimental learning process (Marougkas, Troussas, Krouska & Sgouropoulou, 2023). Hence, the principles of Experimental Learning theory, reveal the benefits of implementation of XR digital technology in educational programs as a means of enhancing the learning outcome by creating a virtual world with a realistic simulation of the real one granting a safe, controlled, and interactive learning context (Valdez, Ferreira, Martins, & Barbosa, 2015; Riva et al., 2019, pp. 3-7).

3.3.4. Learning by Doing

While Kolab's theory is centered around the individual's experience, by contrast, John Dewey's Experimental Learning theory, Learning by Doing, places the stress on the learners' active engagement and interaction with the surroundings in the learning process. Learning in this sense is conceived as a continuous process of construction and reconstruction of experience supported by received feedback (Dewey, 1929/2011). According to this theory, knowledge construction is reinforced in task-oriented and hands-on learning processes, and the learners most effectively learn through active participation and involvement rather than passive ways of information acquisition (Dewey, 1938/1986, p. 69). The virtual learning environment provided by XR, as a realistic simulation of the real world, suggests the possibility of active interaction with other learners while solving problems. The learner using XR can also reflect on the feedback during the learning process which accelerates the assimilation of the new knowledge.

3.3.5. Flow Theory of Learning

In his Flow Theory of Learning, Csikszentmihalyi describes the Flow as a mental state in which people are so deeply and joyfully immersed and engaged in an activity that nothing else can hold their attention and everything else appears to lose importance (Nakamura, & Csikszentmihalyi, 2002). Flow Theory in education, suggests that learners are most likely to achieve optimal learning results and reach their peak learning potential when they are presented with tasks that offer a blend of challenge and skill, as well as enjoyment and personal interest, a sense of control, and a high level of focus (Csikszentmihalyi, 1990).

Respecting the Flow Theory of learning, the interactive and immersive nature of the environment provided by Extended Realities facilitates the occurrence of the flow state resulting in the improvement of learning outcome (Akman & Çakır, 2019).

3.3.6. Generic Learning Outcome (GLO)

As Hooper-Greenhill argues, learning is not always purposeful, but it could happen unintentionally, and it involves emotion and body as well as intellect. It could be experimental or performative, and the level of learning could range from shallow to deep. She discusses the Generic Learning Outcome (GLO) model of learning in museums to demonstrate the impact of the users' experience on their learning outcomes and argues the most valued perspectives of museum learning are pleasure and enjoyment which contribute to inspiration and new ideas and remove the psychological barriers for those who find learning difficult, and consequentially to the development of knowledge and skills (Hooper-Greenhill, 2007). Regarding the museums' educational policies, she suggests the personalization of learning and enjoyment, could meaningfully improve the learning outcomes of museum visitors.

Personalization responses to the modification of the mode of gathering information based on specific individuals' needs, competence, and preferences. Personalization in the learning context is an effective result-oriented strategy that contributes to the improvement of the learning outcomes and the development of the learners' thinking skills by removing the frustration caused by traditional non-personalized learning environments (Troussas, Krouskan & Sgouropoulou, 2020, 2022).

Implementation of the XR personalized environments that use personalization techniques such as Real-time object manipulation, Intuitive navigation, Personalized feedback system, and Guidance assistance in educational programs, can positively influence the learning results (Marougkas et al., 2023), and together with the fun and engaging experience it provides for the learners, can response to the GLO learning theory.

3.3.7. Free Choice Learning

Falk, and Dierking in their inspirational work "Learning from The Museums", argue that people construct much of their knowledge through "Free-Choice Learning" experience, and learning happens in overlapping contexts of Personal context, Sociocultural context, Physical context, based on "Contextual Model of Learning". They discuss that learning is facilitated through personalization and the free-choice learning process, meaning when, where, with whom, and what, visitors choose to learn. As demonstrated in this study, learning in museums is influenced by the visitors' prior knowledge and experience, their experience in the museum, and the subsequent experience they have after their visit (Falk, & Dierking, 2018).

Extended Realities in relation to this theory, improve the learning outcome through personalization and contextualization of the learning environment. Users of the XR technology are provided with a range of options that could be modified based on their needs and preferences. Moreover, they have the possibility of interacting with other users based on their free personal choice which directly contributes to the characteristics of this learning model.

3.3.8. Gamification of Learning

Karl Kapp defines gamification as "using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems." (Kapp, 2012, p. 10). Gamification or as Deterding et al. define, "the use of game design elements in non-game context" (Deterding et al., 2011, p. 9) in the educational context, refers to the modification of the learning process by incorporating game elements into the educational procedures (Landers et al. 2018). The theory of gamified learning developed by Landers (Landers, 2014) offers the theoretical framework for understanding the positive impact of gamification on the learning outcome. As Sailer & Homner claim, the Self-determination theory (Ryan & Deci, 2002) which focuses attention on the significance of the environment in satisfying the three psychological needs of the individuals, competence, relatedness, and autonomy, together with Landers' theory of gamified learning, demonstrate that the use of game design elements for modification and enrichment of the learning environment results in the improvement of the learning outcomes through effecting the learning behaviors (Sailer & Homner, 2020, p. 79).

XR technology with gamification features provides learners with an engaging and immersive virtual environment in which they can safely experience and interact with virtual elements (Yang, Asaad & Dwivedi, 2017). Gamification in the simulated environment of extended realities offers a memorable and effective learning experience (Akman & Cakir, 2019) which enables the users to enjoy their experience and learn in a fun way (Lazzaro, 2004). Therefore, the major benefits of XR-based gamification include creating a safe and low-risk learning environment (Marougkas et al., 2023), enhancement of the learners' motivation through providing a dynamic and fun learning experience (Haowen, Vimalesvaran, Kyaw & Car, 2021), increasing the learners' motivation through personalization of the learning process based on their preferences and needs (Zhang, Suo, Chen, Liu & Gao, 2017; Chen, Lee & Chen, 2005).

4. Discussion

Educational programs of Cultural Heritage Organizations and Museums are considered a part of their social function, and therefore of increasing importance in recent years. The digitization of historical artifacts and their virtualized or physical reproducibility through 3D printing will also allow for an in-depth study of the most effective forms of inclusive interaction that can be used in teaching.

Leading studies in the field have shown that Extended Realities could be used as a powerful tool to create the possibility of interactive participation in an immersive environment whose characteristics are aligned with the major learning concepts and theories including Constructivism, Social Constructivism, Experimental Learning, Learning by Doing, Flow Theory of Learning, Generic Learning Outcome, Free Choice Learning, Gamification of Learning, which accordingly could facilitate the visitors' learning process through their multisensory involvement in an engaging experience.

The constructivist theory of learning emphasizes the importance of the active participation of learners in the learning process and knowledge construction based on their previous knowledge and experience through interaction with the learning environment. The virtual environment created by XR technologies in this regard facilitates the learning process by providing the learners with the possibility of interaction and exploration. Extended realities also offer a learning experience in which learners can collaborate, interact, and communicate with other learners and instructors which is in line with the principles of the social constructivist learning theory.

Experimental learning theory highlights the role of active experience and reflection. The immersive virtual environment of extended realities offers the opportunity to learn through hands-on experience and engagement with the learning contexts and receiving personalized feedback which facilitates the learning process. Moreover, the interactive nature of XR corresponds to Dewey's learning by doing theory through engaging learners in problem-solving tasks and sharing experiences with other learners.

While the constructivist and experimental theories as frequently referenced theories concerning the extended realities efficiently demonstrate the effectiveness of the XR in the learning process, other learning theories and concepts including the flow theory, generic learning outcome, free choice learning, and gamification of learning, similarly, support the implementation of the extended realities in educational programs.

Furthermore, such an approach would signal accordance with the guidelines and recommendations of major organizations related to cultural heritage including *the United Nations, the Educational, Scientific and Cultural Organization*, the European Union, and The International Council of Museums, which means enhancing the public experience and encouraging their interaction and participation, and consequently improving the museums' function in society

4. Conclusions

The application of extended Realities in the educational context has received increasing interest and attention in recent years. Cultural organizations and museums worldwide, intending to follow the guidelines of the respected organizations in the field, and also to improve their educational approaches utilizing benefits provided by digital technologies, are more and more motivated to employ XR in their educational programs.

Respecting the educational programs in terms of tangible and intangible cultural heritage, some of the main concerns of cultural organizations include accessibility, flexibility, sustainability, and inclusivity of such programs. Extended realities provide virtual learning environments that are accessible to all, including individuals with specific needs such as visitors with handicaps or disabilities, flexible as the learner can choose their learning timetable and set accordance with their schedules, durable as it provides the possibility of repeating and recurrence of the experience or going back to the process unlike periodic events, collaborative as learners can communicate with other learners, controllable as learners can determine the degree of the amount and complexity of information imposed, and interactive as learners have the opportunity of active participation in the learning process and having a joyful and engaging learning experience.

Furthermore, as demonstrated formerly, learning theories and concepts mentioned, value contextualization, personalization, immersion, participation, motivation, and interaction as impactful factors in the learning process that could optimize the learning outcomes, all of which are considered effective characteristics of the virtual environment created by employing digital technology of Extended Reality. These concepts provide the theoretical framework for understanding how the XR technology allows the optimization of learning by providing learners with a safe, immersive, interactive, and inclusive environment in which all learners would have an equal chance to maximize their information acquisition and develop their particular skills.

It is also worth mentioning, that despite the majority of studies supporting the application are XR in educational programs, few studies claim otherwise. Some of the negative aspects of XR discussed in these studies include the possibility of a high cognitive load created by immersive VR which causes difficulties in data analysis and processing information (Frederiksen et al., 2020), and the hardship of applying XR technology in everyday educational settings (Cho & Chun, 2019).

The present study claims implementation of Extended Realities including Virtual Reality, Augmented Reality, and Mixed Reality, contributes to the improvement of educational programs in the cultural sphere and enhancement of the learning outcomes. However, the hypothesized negative aspects and disadvantages of XR-based educational programs could be subject to further studies.

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