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AUGMENTED REALITY TO PROMOTE CULTURAL ACCESSIBILITY

LA REALTÀ AUMENTATA PER PROMUOVERE L'ACCESSIBILITÀ CULTURALE

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Abstract

In recent years, the rapid progress and consumerization of Extended Reality (XR) technologies has led to a growing development and use also in the educational field. This technological revolution has forced a rethinking of teaching and educational practices regarding how students access immersive environments. Such technologies offer a new paradigm for learning, enabling students to explore and learn in innovative and engaging ways in a constructivist framework. Therefore, the following project aims to promote cultural accessibility in museum education by analysing the potential of Extended Reality (XR) systems for the design of inclusive digital environments. Specifically, the project is divided into two main processes: 1) 3D scanning of archaeological finds from museums in Campania; 2) creation of 3D models that can be reproduced found or placed in digital environments. Specifically, an AR app was created to allow students to view the 3D models of archaeological finds scanned in museums in Campania to promote cultural heritage through dynamic and accessible communication.

Negli ultimi anni, il rapido progresso e la consumerizzazione delle tecnologie di Extended Reality (XR) ha portato a un crescente sviluppo e impiego anche in ambito educativo. Questa rivoluzione tecnologica ha imposto un ripensamento sulle pratiche didattiche ed educative in merito alle modalità di accesso per gli studenti negli ambienti immersivi. Tali tecnologie offrono un nuovo paradigma per l'apprendimento, consentendo agli studenti di esplorare e imparare in modi innovativi e coinvolgenti secondo un impianto costruttivistico. Pertanto, il seguente progetto ha lo scopo di promuovere l'accessibilità culturale nella didattica museale analizzando le potenzialità dei sistemi di Extended Reality (XR) per la progettazione di ambienti digitali inclusivi. Nello specifico, il progetto si suddivide in due principali processi: 1)

scansione 3D dei reperti archeologici dei musei campani; 2) creazione di modelli 3D che possono essere riprodotti fisicamente o inseriti in ambienti digitali. Nello specifico, è stata realizzata una app AR per consentire agli studenti di visualizzare i modelli 3D dei reperti archeologici scansionati nei musei campani al fine di promuovere il patrimonio culturale attraverso una comunicazione dinamica e accessibile.

Keywords

Accessibility; Augmented Reality; Educational Museum; 3D Printer.
Accessibilità; Realtà Aumentata; Didattica Museale; Stampa 3D.

1. Introduction

In the international scientific literature there are numerous studies on the use of simulation practices in virtual environments to promote the learning process in students (Cromby et al., 1996; Di Tore & Axelsson, 2023; Ria, 2022; Roussou, 2004). These virtual environments are characterized by flexibility and can be considered a resource for teaching practices in which interaction plays a fundamental role. In virtual environments, every action that a user performs can have repercussions in real life but, at the same time, it is possible to experiment in a protected space without running any real risks. In the school environment, this technology overturns the so-called "traditional scheme", knowledge becomes interaction with objects in the virtual environment and experience becomes a source of learning. In particular, some researches (Standen, 2005; Wilson et al., 1997) have shown how virtual reality and augmented reality can foster the development of specific skills in students with Special Educational Needs (SEN) through a constructionist model aimed at supporting knowledge based on environmental exploration digital. Furthermore, these immersive environments are characterized by controllability, teachers and educators can progressively increase the degree of complexity of the task to control the learning process. These technologies that extend the real world and combine it with computer-generated digital objects are called Extended Reality (XR) and offer students the opportunity to enhance their creativity and think outside the box. Extended Reality (XR) includes virtual reality (VR), augmented reality (AR) and mixed reality (MX) and refers to real and virtual environments generated by computers to create interactive environments. The terms augmented reality (AR), virtual reality (VR) and mixed reality (MR), are often considered as interchangeable but even if they are part of the same macro-category of extensive reality, they have the following application and technological differences:

- *Virtual Reality* (VR) offers the opportunity to enter an immersive environment simulated by the computer, using the head-mounted display, and live a multi-sensory experience in which it is possible to interact and manipulate the objects in the space.
- *Augmented Reality* (AR), unlike virtual reality systems, consists of a "digital superposition" of virtual objects (non-manipulable) on physical objects in real space to provide more information about a place or a product.
- *Mixed Reality* (MR) is a hybrid technology that derives from the fusion of the digital world with the physical one represented within the same screen. Virtual elements do not "overlap" but blend with the real environment so that they can be manipulated by the user (Pallavicini, 2020).

2. Application of Augmented Reality (AR)

In the literature there are different definitions of augmented reality, for example, it is understood as "the increase of natural feedback to the operator with simulated signals" or "a form of VR in which the display mounted on the head is transparent, allowing the vision of reality " (Milgram et al., 1995).

These definitions highlight the relationship between virtual reality and augmented reality even if they are considered two different concepts, since in virtual reality the user is completely immersed in this synthetic world where the laws of physics that regulate time, gravity, and material properties, while in augmented reality it is related to the real environment which is bound by physical laws. For this reason, instead of considering them as antitheses, they must be understood as the opposite extremes of a continuum that takes the name of *Reality-Virtuality continuum* (Ibidem).

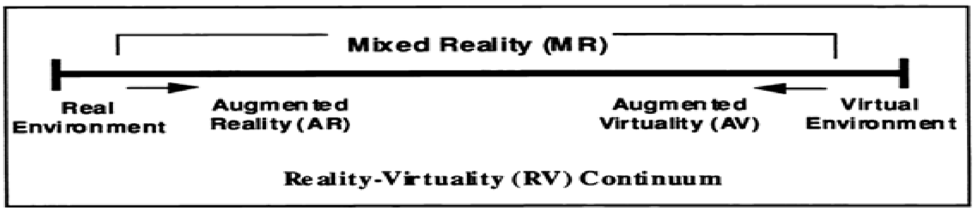

Figure 1: Reality-Virtuality Continuum (Milgram et al., 1995, p. 283)

Figure 1 on the left shows everything that a person can observe in a real environment through a sort of display, while on the right the virtual environment simulated through computer graphics is shown. The generic environment that is inside the painting is defined as Mixed Reality (MR), in which the real and virtual world mix in a single display, between “exirema of the RY continuuim2” (Ibidem). Therefore, in the

Milgram diagram between "reality" and "virtual reality" there is augmented reality, in which reality, even if integrated with the virtual, assumes a preponderant role. With reference to the broad definition of augmented reality as "the increase of natural feedback to the operator with simulated signals" it becomes understandable in figure 1 where we also note the link with Augmented Virtuality (AV), in which real data co-exist with those virtual but the latter assume a prevailing role. Finally, with virtual reality we arrive at the complete replacement of real data with virtual ones.

From these comparisons it emerges how augmented reality, unlike virtual reality and augmented virtuality, does not aim to replace reality in part or entirely but tends to increase human perception while usually maintaining the link with the real world. Azuma (1997) defines augmented reality as a system that combines real and virtual worlds, in which it is possible to interact in real time with virtual and real objects. In other words, Augmented Reality means the expansion of human sensory perception through the addition of information (text, 3D models, audio, etc.) conveyed electronically using smartphones or other devices, such as smart glasses or hi-tech bracelets.

In essence, we can speak of an "enhancement" of the sensory perception of individuals through this technology, as it provides additional information to the real world, increasing students' experience of reality (Squire & Klopfer, 2007). Augmented reality offers new opportunities for teaching and learning, as the fusion between the real environment and digital elements allows students to experience phenomena impossible in reality (Klopfer & Squire, 2008), to envision spatial relationships (Arvanitis et al., 2007) and interacting with synthetic objects in mixed reality (Kerawalla et al., 2006).

In particular, virtual reality (VR) and augmented reality (AR) are innovative technologies that can be used to "break down" barriers in communication and design personalized user experiences (UX) to find solutions to problems in daily life. These technologies can allow people to visit places that are not accessible to everyone, think of people with physical disabilities who are unable to reach distant places, offering the opportunity to manipulate archaeological finds displayed in museums or view them via smartphone. Furthermore, these technologies can be used in conjunction with the 3D printer to allow visually impaired users to manipulate an object, which can also be digitally viewed through AR, to learn its details. Therefore, the following project focuses on cultural accessibility through the development of a georeferenced AR app capable of displaying the 3D models of archaeological finds scanned in Campania museums via QR Code framed with smartphone cameras.

3. Augmented reality to promote cultural accessibility

As anticipated in the previous paragraph, the following project focuses on cultural accessibility in museum education, analyzing the potential of extended reality systems, in particular augmented reality, to promote an inclusive environment in which to make communication dynamic and understandable to heterogeneous users. Specifically, the project has the following objectives:

• Promote knowledge of cultural heritage through the creation of an AR app;

• Scan the archaeological finds of Campania museums to create *digital assets* of the works and the subsequent physical realization through the 3D printer.

At first, 3D scans of the archaeological finds at the Campania museums were carried out using the *Shining 3D Einscan Pro 3D scanner* to create the 3D models to be "cleaned" with the 3D graphics software *ZBrush* (Figure 2). The 3D models of the archaeological finds were subsequently inserted into the AR app (Figure 3) created with the Unity3D graphic and created an engine available through the *Formlabs SLA 3D printer*.

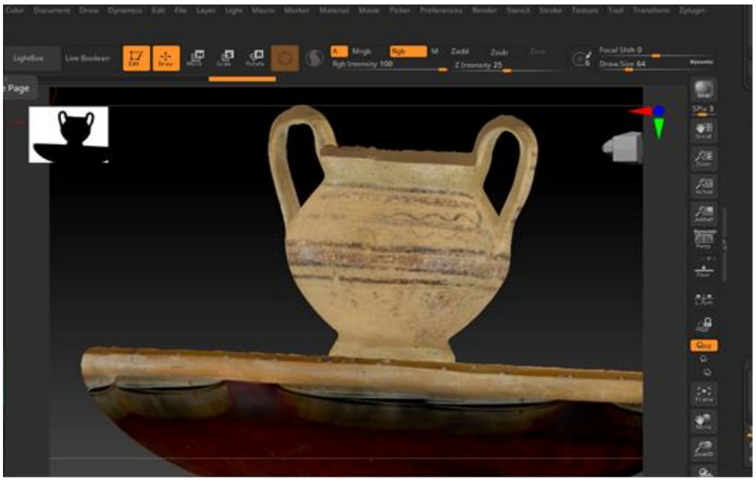

Figure 2: cleaning the 3D model with Zbrush

Figure 3: visualization of the 3D model of the vase through QR Code

In order to maximize accessibility in museum teaching, different technologies have been used to meet the different learning styles of students. For this reason, the 3D printer was used (Figure 4), which has a medium technological impact, so it is possible to 3D print the scanned works and create educational paths to maximize accessibility even for students with sensory disabilities. Another technology, as already described above, is augmented reality, which has a low technological impact, as you only need a smartphone to scan the QR code and view the 3D object.

The first museum where the first scans of the works were made is the National Archaeological Museum of Sannio Caudino in Benevento, where the "Red Figure Crater" was scanned which in Greek culture was used to mix wine with water and it was served at banquets, especially at the symposium. Another scanned archaeological find is the so-called "Bell Tower Crater" considered a necessary tool until Roman times (4th century BC). Another museum where scans were made is the Archaeological Museum of Carife, in particular a "Guttus" and a "perfume" in terracotta from the Samnite era were scanned, as in the past they were considered expensive goods. The digital assets of these exhibits were used within the virtual reality app to allow students to view these works and read their history through a mobile device, which frames the surrounding environment in real time. In other words, through the use of markers (stylized drawings in black and white that are shown to the webcam) the multimedia contents are superimposed in real time, such as video, audio, 3D objects, etc. In the specific case, through a QRcode it is possible to view the vase scanned in Carife (Figure 3). Another vase scanned at the Carife museum was subsequently

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printed in 3D (Figure 4) with the SLA printer, to try to preserve the details of the vase and allow people with visual impairments to directly touch and manipulate the work to get to know the details and receives more sensory information.

Figure 4: vase made with SLA 3D printer.

Therefore, the joint use of augmented reality and the 3D printer can allow people with disabilities to access interactive experiences, improving their quality of life. Some of the potential of these technologies may concern: 1) *accessibility*, as AR can provide information to people with disabilities in different ways, for example through smartphones or AR viewers, in which it is possible to give vocal indications to people with visual impairments and receive information relating to the environment that surrounds them; 2) *learning*, as an AR app can be used to guide a person with a disability in the process of learning a specific skill; 3) *communication*, i.e. AR can facilitate communication for people with disabilities, for example by translating a text or offering visual support to people with autism; 4*) social experiences*, since through an AR app it is possible to create a game that involves both the real and virtual world, in which one can interact with others; 5) *orientation*, AR can help people with disabilities to orient themselves in the surrounding environment through signals that are visible through AR devices; 6) *creation of educational models*, with 3D printing it is possible to create tactile and visual models useful for learning complex concepts. For example, tactile maps or archaeological finds for blind people can be printed; 7*) customization*, as 3D printing offers the possibility to customize objects quickly and cheaply according to individual needs. These examples only partially report the potential of these technologies, which are constantly evolving, but new applications could emerge in the future that improve the accessibility and autonomy of people with special educational needs.

4. Conclusion

In education and teaching, the application of Extended Reality (XR) can transform the teaching-learning process, offering students immersive and engaging experiences. XR, which include virtual reality (VR), augmented reality (AR), and mixed reality (MR), can improve student engagement, and enable deep understanding of even complex concepts, surpassing traditional learning methods. XR can promote experiential learning by allowing students to explore virtual environments and manipulate 3D objects, acquiring knowledge in real context. In fact, some studies have focused on the use of immersive technologies in museums to create an effective learning environment for people with SEN and promote the active participation of all, rethinking communication in the museum and designing interventions based on the needs of the visitors. Thus, augmented reality and virtual reality can be understood as forms of human-machine interaction as they have new ways of communicating and gaining experience. Augmented reality can promote the learning process through realistic simulations of real objects, which allow the user to manipulate the object and observe its characteristics in detail. Furthermore, augmented reality can be used to break down cultural barriers, offering a new way of enjoying culture that allows people to be at the center of their learning process, favoring the teaching-learning process of cultural heritage.

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