AUGMENTED REALITY IN EDUCATION: CUSTOMIZATION, CONTROL, AND INNOVATION

REALTÀ AUMENTATA IN AMBITO EDUCATIVO: PERSONALIZZAZIONE, CONTROLLO E INNOVAZIONE

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ABSTRACT

This article delves into the ever-evolving concept of mixed reality, examining its varying definitions across academic and gaming landscapes. It sheds light on common characteristics within this technology ecosystem, which aims to enhance our world by infusing digital content into our physical surroundings through movement-driven interactions and human-computer interfaces. To accomplish this, several examples will be provided, focusing on museum education and its interaction with formal educational settings.

Questo articolo investiga il concetto in costante evoluzione della "mixed reality," esaminando le diverse definizioni associate nel contesto accademico e ludico. Si propone una sintesi delle caratteristiche comuni all'interno di quest'ecosistema tecnologico. La mixed reality si distingue per la sua capacità di arricchire l'ambiente fisico con contenuti digitali mediante interazioni basate sul movimento, facilitate da un'interfaccia uomo-macchina avanzata. Verranno esemplificati alcuni casi di studio relativi all'impiego della mixed reality nell'ambito della didattica museale e formale.

KEYWORDS
Mixed reality, museum education, human-computer interfaces.
Realtà mista, museum education, interfacce uomo-macchina.

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Introduction

This paper advocates for the seamless integration of virtual spaces, the invaluable preservation of our rich cultural heritage using QR codes and virtual reality technologies, and the cutting-edge practice of scanning real artworks, all of which serve as innovative and transformative tools for fostering inclusive education in a rapidly evolving digital age. Moreover, this work addresses the contemporary relevance of research themes within the field of Pedagogy and Special Education, focusing on those actively engaged in the development of educational pathways linked to individual growth and maturity, especially concerning issues related to disabilities, special educational needs, and inclusive education (D'Alonzo, 2015; Aiello, Di Tore, Pace, Sibilio, 2016; Mura, 2016). Inclusion, the ultimate goal of Special Pedagogy, transcends mere models or school simple integration but something more (EADSNE, 2012); it represents a fundamental theoretical standpoint aimed at eradicating all forms of marginalization and social, institutional, and educational exclusion. Inclusion encompasses the uniqueness and distinctiveness of each individual, their needs, and their resources, shifting the focus from deficiencies to functionality, abilities, and context (D'Alonzo, 2015; Aiello, Di Tore, Pace, Sibilio, 2016; Mura, 2016). Recognizing and catering to the needs and characteristics of each individual necessitates critical reflection and a conscious value-based choice, drawing from theoretical and operational contributions within the domain of Special Education. This leads to innovation on both organizational and educational fronts, contextualized within a social and cultural paradigm characterized by difference and diversity (Zúñiga, 2003; Subedi, 2008; Sibilio, 2020), a theme that is also valid in non-formal educational contexts (Shaindlin, 2020; Skubikowski, Wright, Graf, 2023). In accordance with these premises, this paper emphasizes the necessity for Special Pedagogy to embrace technological advancements such as the integration of virtual spaces, the utilization of QR codes and virtual/augmented reality. These innovative tools offer unique opportunities for inclusive education by addressing individual learning styles and needs. Individualization and personalization processes serve as the educational support for addressing each person's specific cognitive, motor, social, and relational potential. Every individual develops their own unique learning style, which must be considered to achieve personal, educational, and didactic success. Thus, those engaged in promoting and developing inclusive educational pathways are called upon to design educational interventions with pedagogical awareness, referencing models, strategies, and actions that can be deemed effective, while contextualizing interventions based on a profound understanding of the contexts and individuals involved. The development of effective educational strategies that aim to become exemplars of best practices is essential for creating valid teaching and learning paths. Educational and training interventions must be designed to enable individuals to gain self-awareness, developing their potential in socio-cognitive, emotional, and affective dimensions (Wolfe, 2006), linked to the different perspectives that virtual environments create (Aïte & Alii, 2016), especially when creating simulation environments and serious games (Volante & Alii, 2016). To accomplish what has been written so far, several examples will be provided, focusing on museum education and its interaction with formal educational settings as well as a constructivist vision of the educational use of these technologies used in the educational field. I t is worth remembering, however, that in addition to history, the same technologies can be used for mathematics, biology (think of a virtual and augmented reality system that lets you explore the human body), astronomy (think of systems that let you explore the cosmos), the fact that the subject of archaeology and art is presented is only due to the experience that the XXXXX laboratory of the Department of XXXX of the University of XXXX has developed over the years on this specific topic, which is remodelled in STEAM subjects and the humanities.

1. Interactive Learning and Technologies, various issues: bringing school workshops to the museum

In this section, we address the topic of museum education as a specific case of a workshop activity to be done by school students doing activities outside the classroom context. In order to contextualise the change that has taken the museum from a place of heritage conservation to a place where education is provided, it is worth remembering that, over the past decade, museology has seen significant momentum from a novel approach to museum communication based on the use of scientifically reliable metadata, which can now be readily activated through an operational chain of Data Acquisition-Data Restitution-Data Visualization that digital technology has strongly integrated and expedited (Puma, 2018) and that these data in digital format were used to create multimedia products for educational purposes. Resuming the discussion after this clarification, the ability to access high-definition 3D models of archaeological artifacts, for example, offers the undeniable added value of several advantages related to visual and perceptual engagement (and in more advanced cases, even interaction) with an object that is either inaccessible due to time or location constraints or not available for conservation reasons. This enables, for instance, a closer examination of details not visible to the naked eye, rather than merely reconstructing the original context, ultimately leading to virtual restoration. This methodological and instrumental sequence allows for the development of increasingly flexible “interactive heritage” systems, with data acquisition progressively shifting towards Structure-from-Motion (SFM) alongside traditional surveying. In particular, the availability of photomodeling has facilitated the necessary transition to the use of multidimensional data for innovative cultural communication strategies and advanced multidimensional outputs. Today, these outputs encompass a wide spectrum of devices and languages, ranging from 3D reconstructions and animations to Augmented Reality, Virtual Reality, immersive experiences, and virtual scenes (Ibidem). In recognizing that interpretation and presentation are integral components of the broader process of cultural heritage conservation and management, the Charter presented here aims to establish seven fundamental principles upon which Interpretation and Presentation, in various forms or mediums tailored to specific circumstances, should be grounded. These principles are as follows: Principle 1) Access and Understanding; Principle 2) Information Sources; Principle 3) Attention to Setting and Context; Principle 4) Preservation of Authenticity; Principle 5) Planning for Sustainability; Principle 6) Concern for Inclusiveness; and Principle 7) Importance of Research, Training, and Evaluation. This framework, inspired by The Icomos Charter for the interpretation and presentation of cultural heritage sites, as articulated during the ICOMOS 16th General Assembly in Québec in 2008, aligns with the Principles of Seville established in 2011, which define the international principles of Virtual Archaeology. Additionally, these principles are consistent with UNESCO’s classification of heritage into categories such as Built Heritage, Culture & Traditions, Museums & Collections, Libraries & Archives, and Art & Creativity, encompassing a wide range of tangible and intangible cultural assets (Ibidem). Incorporating an additional set of principles[1], it becomes imperative for museums, in the fulfillment of their societal service mission, to proactively engage with the issues of inequalities and exclusion. This imperative is further underscored within the contemporary context characterized by heightened migratory trends, escalating polarization, and the prevalence of divisive public narratives. Museums, in response to these challenges, are actively addressing a diverse array of thematic concerns. These concerns encompass facets such as participatory engagement, accessibility, the promotion of well-being, considerations of gender, the examination of marginalization, and the overarching dialectic of inclusion and exclusion through an array of multifaceted initiatives.

[1] https://icom.museum/en/research/cultural-democracy-and-inclusion/

In order to analyze the issues addressed in this study and develop some operational proposals, it is deemed appropriate to initiate a process based on fundamental but accessible concepts, focused mainly on the museum, considered both in its physical and virtual version. It is of substantial importance, first of all, to turn our attention to the very definition of a museum and the contingent historical vicissitudes that have determined its current concept, which, despite this, is to be considered in a continuous process of change, influenced by the constant renewal of exhibition practices, both in terms of physical (or virtual) spaces and in terms of the content of the objects to be preserved, which, in relation to changes in society's customs and habits, determine the artifacts that are destined to become "museum pieces" for future generations. The word museum commonly conjures up the image of a physical, circumscribed and protected place within which visitors can explore and admire rare and valuable objects. However, this concept presents some problems, since museums should not be conceived primarily as a bank *vault*, where access is limited and opening hours kept to a minimum. A proper balance must be struck between the safekeeping of assets and the promotion of them. The use of virtual technologies is an effective solution to overcome these limitations and allow interaction with objects in the form of digital replicas, which can be manipulated with "peace of mind". Indeed, it is well known that technologies have for years played the role of educational mediators and compensatory tools for people with specific learning disorders (Di Tore, 2016). In addition to the spatial dimension, the concept of a museum is also linked to the temporal dimension. It is in fact a place of study and research, similar to a library, which can be explored in depth and consulted in a timely manner. Unfortunately, situations frequently occur in which some visitors and tourists devote themselves exclusively to seeking out a main work of art, as is the case, it could be happened, just for better understand with an example, at the *Museo Nacional Centro De Arte Reina Sofia* in Madrid, where tourists flock to admire Pablo Picasso's famous painting, *Guernica*. However, such visitors often do not show an interest or understanding of the other works on display and, as a result, leave the museum quickly or disappointed. In order to prevent the museum visit from turning into a frantic rush to contemplate the main work, it is essential to devote considerable attention to the educational aspects, which must guide and engage the visitor, enabling him or her to assume the role of a curious and attentive student. Here again, technologies can give explanations, entertain the visitor for example through interfaces with artificial intelligence[2].

[2] https://www.youtube.com/watch?v=_lTkfL5EiTY&t=218s&ab_channel=micheletodino

In order to improve attention span, it should be considered that the individual perceives the environment through three-dimensional vision, which allows for the acquisition of information to be stored in "long-term memory" (Atkinson, Shiffrin, 1968; Di Tore, 2016) and in particular its function of then recalling it when needed (Marchetti, 2004). The positive experience, for example in the terms expressed by Dewey (Ed. 1993), associated with visiting a museum generates a sense of affinity between the visitor and the discipline on display, whether related to science and technology, archaeology, chemistry, astronomy, earth sciences, physics, biology, etc. In the past, the promotion of interaction between museum objects and visitors' memories was achieved through the use of dioramas or reconstructions that effectively conveyed information and knowledge. An example of such a practice can be found at the Smithsonian Museum District in Washington, D.C., or in some exhibition sections of the Art Institute of Chicago, where, given the scarcity of archaeological artifacts, extensive use is made of historical reconstructions and evocative settings. In the case of natural science and ethnography museums, virtual reconstructions are a real revolution, they are more sustainable and in line with modern sensibilities than ethnography museums that still have stuffed animals. The advent of technologies based on 3D graphics, augmented or immersive reality, and 3D printing has further facilitated such practices. However, this does not imply that installations prior to the spread of dioramas and thematic showcases are obsolete or to be abandoned; rather, they represent historical evidence of the display and educational techniques employed by museums of the past and can be made more usable through integration with new technologies. Overall, these technological innovations are designed to create an educational environment that is accessible to a wide audience, as well as to scholars, who can acquire the displayed content with greater immediacy even if they are already familiar with the subject matter. In the light of these preliminary considerations, the museum is revealed as a reflection of human activity, its nature and culture, in which the visitor, regardless of his or her level of education, is able to acquire knowledge through an accessible language that emphasizes the visual and spatial relationship between the work and the viewer.

2. The Constructivism: the importance of "imaginary worlds" in contemporary museum design

An approach that links well with immersive teaching through technologies is *constructivism* (Bruner, 1982; Bruner, Haste, 1987; Shanker, Stuart, Talbot, 2001) which derives from a conception of knowledge as the construction of personal experience rather than as a reflection or representation of a reality mediated by a black box vision of the brain, in brief with *behaviorism* (Galimberti, 2018, p.263), or from a deduction of the mechanisms of the brain, in this case we refer to *cognitivism* (Galimberti, 2018, p.238). Therefore, some considerations on this psycho-pedagogical approach will be made below. In order to introduce the topic discussed in this section, concerning constructivism, it is deemed appropriate to make use of the gnoseological framework outlined by Sibilio (2020, p.35) to introduce this philosophical and epistemological position. It is premised that gnoseology is a philosophical discipline concerned with the study of human knowledge and its modes of acquisition. However, the approach to gnoseology[3] varies widely within different philosophical systems. In particular, *realism* holds that reality exists independently of the knowing subject, and knowledge is relative to the properties ontologically attributable to the real itself (Ibidem). In contrast, *nominalism* denies ontological consistency to human cognitive properties (Ibidem). *Empiricism* holds that knowledge is derived from experience through the senses, while rationalism holds that reason is the source of "all" human knowledge. In *criticism*, reason plays an active role in knowledge, but it cannot disregard sense experience (Ivi, p.34). *Idealism* denies any ontological autonomy to phenomenal reality, regarding it as a phenomenon internal to the perceiving subject (Ariano, 2013b, p.47). In *skepticism*, the possibility of attaining any true knowledge is denied (Sibilio, 2020, p.34). Finally, in the *phenomenological* approach, knowledge is derived from the way a subject interacts with an object, while in constructivism, reality is regarded as the result of the constructive activity of human cognitive structures (Ariano, 2013b, p.40). Constructivism, therefore, can be seen as intertwined with the foundational phenomenological principles in a way that underscores its inherent connection to the broader philosophical framework. In other words, the constructivist perspective is inextricably linked with the fundamental concepts of phenomenology, and this interconnection plays a pivotal role in shaping the theoretical and practical implications of constructivist thought. This symbiotic relationship between constructivism and phenomenology highlights

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[3] In Anglo-Saxon countries the term used is epistemology (see gnosology entry in the Treccani online encyclopedia).

how constructivist ideas are deeply rooted in the phenomenological tradition, drawing upon its core principles to inform and enrich the understanding of how individuals construct knowledge and make sense of their experiences in the world (Ariano, 2019), bearing in mind that phenomenology constitutes the essence of human cognition and invariably possesses intentionality (Ariano, 2013a, p.92). Consequently, the acquisition of knowledge may appear arbitrary (occurring by chance), but at that juncture, with intention, an individual can engage in learning. Within the realm of educational constructivism, scaffolding may serve as a framework through which occurrences cease to be mere happenstance, instead leading to deliberate episodes that facilitate learning. Therefore, it can be seen that the concepts of ontology, gnoseology, epistemology and perception take on different connotations depending on how reality and human beings' interaction with it is considered. Linking what has been previously enunciated, repositioning on the constructivist approach and updating it, more in details with the research of Alain Berthoz Professor Emeritus at the *Collège de France*, it could be argued that the ability of human beings to create infinite worlds can be explained through the concept of *vicariance* (Berthoz, 2011, 2015), that is, the ability to simulate actions before performing them in order to make the most appropriate choices (Aiello, Di Tore, Di Tore, Sibilio, 2013) and there is consequently a relationship with the teaching-learning process (Di Tore, Aiello, Sibilio, Berthoz, 2020). Vicariance, moreover, represents the secret of the wonderful faculty of human beings to create imaginary worlds, which can be transposed into everyday reality, novels, fictional invention, worlds accessible through *imaging* techniques, and virtual worlds. These *worlds of utopia* (Berthoz, 2015) can also describe a community or society that is no longer imaginary and can be used in educational activities through play, simulation, and experience, putting learning by discovery at the center and fully engaging body, mind, and brain (Aiello, 2012; Sibilio, 2012; Di Tore, 2013; Rivoltella, 2015; Rivoltella, Rossi, 2019; Di Tore & Alii, 2022; Sibilio & Alii, 2023). Still on the notion of *possible worlds* (typical of the constructivist approach to knowledge and the learning process), it is also "ties" in with how we grow up and how we learn as children, in fact, Antonio Iannaccone, from the *Institut de psychologie et éducation* of the *Université de Neuchâtel* with Perret-Clermont and Convertini (2019) argue that playful narratives play a crucial function in sharing children's understanding of physical and social reality with other subjects such as adults and peers. This concept was developed based on Piaget's pioneering research on the symbolic capacity of thinking (Ibidem). Over the past decades, the notion of possible worlds has contributed to a new representation of children's thinking, in which imagination allows them to explore alternative and multiple versions of reality, using sophisticated forms of causal reasoning and understanding of the rules of social life. In accordance with what was expressed earlier, *in constructivism, these worlds are not discovered but emerge*; however, the virtual environment, equipped with a range of objects from museum collections, can produce multiple educational actions, in perfect analogy with a *sandbox*, a place where a child, playing with a few tools and sand, can create towers, castles, moats and other structures from his or her imagination. It is observed that the child does not create from nothing, but by using existing elements, manages to create formulas that allow infinite worlds to emerge from among the possible ones (Ariano, 2019, p.70). Taking a global view, in constructivism, humanity is faced with a world already given, but in the process of becoming (Ivi, p.71) and only some of these infinite worlds are destined to become reality. Two possible observations emerge from this reasoning. First, virtual reality becomes a simulator that allows worlds to be tested before they are called into "existence". This means that the use of virtual reality applications for experimental archaeology experiences, such as in a museum or in a classroom, becomes fascinating because the world called into existence may come from the past rather than the future. Second, humanity shapes reality according to the worlds it brings into existence and in which it chooses to live. An exemplification of this concept can be found in the extensive use of plastic in the 1950s, instead of trying to "conjure up" a less harmful material, as would have been feasible. This capacity of humanity represents a considerable power, but also a considerable burden. And a great responsibility (Ivi, p. 71). Among the most important emerging technologies are: virtual reality because it creates a virtual environment through the computer, simulating a real physical environment and allowing the user to interact with it through a headset or glasses; gesture and eye movement recognition because it is a technology that enables users to interact with objects on display in museums through their own body and eye movements, without the need for any kind of tool; tactile sensors and controls, which allow users to physically manipulate objects on display in museums through hand controls or sensors that detect hand movement; morover, augmented reality and digital twins that are technologies that integrate digital objects and information into a physical environment, creating a multi-channel experience for museum visitors. In the future, mind-controlled sensors will be a technology still under development that will allow users to interact with objects on display in museums through thought, detecting the user's brain waves and interpreting them as commands. In general, these technologies offer new possibilities for interaction with museum exhibits and enhance the learning experience of visitors, however, it is important to consider the possible risks associated with their use. At the same time, artificial intelligence and machine learning (technologies enable computers to learn and improve autonomously), offering new possibilities for automation and data analysis that underpin many information systems; *the Internet of Things*, or the connection of everyday devices and objects to the network, allowing them to collect and exchange data in real time (Rose, Eldridge, Chapin, 2015; Li, Xu, Zhao, 2015); *blockchain* technology that enables the creation of secure and immutable digital ledgers (used particularly for financial transactions and the creation of cryptocurrencies) and which can also be used in museum settings to ensure the authenticity of scanned pieces; furthermore, advanced robots that can mimic and replace human activity in a many areas; and finally, synthetic biology that is a technology that enables the creation of new forms of “artificial life”, offering new possibilities for scientific research and teaching applications. Considering the “division” of learning in a museum proposed by Hein (2001b), i.e. different ways of learning depending on the model of interaction with the museum visitor, into four categories (and taking into account the principle of constructivism) which envisions learning through the creation of worlds, it is possible to establish a relationship between these premises and the technologies illustrated above: virtual reality, gesture and eye movement recognition, haptic sensors and controls, augmented reality, and digital twins can be effectively integrated into a museum environment to facilitate cognitive, social, affective, and psychomotor learning. Virtual reality, for example, can create realistic virtual environments that allow visitors to interact with exhibits in an immersive manner. Gesture and eye movement recognition allows visitors to interact with museum exhibits through their own bodies and eyes (Sparacino, Davenport, Pentland, 2000). Tactile sensors and controls allow visitors to physically manipulate exhibits. Augmented reality and digital twins integrate information and digital objects into a physical environment, creating a multichannel experience for visitors. In the future, mentally managed sensors could make it possible to interact with exhibits in museums through thought. In this way, emerging technologies can offer museum visitors a unique and engaging experience that encourages learning and exploration of art and culture; as urged by the European Community for over a decade (EC, 2012).

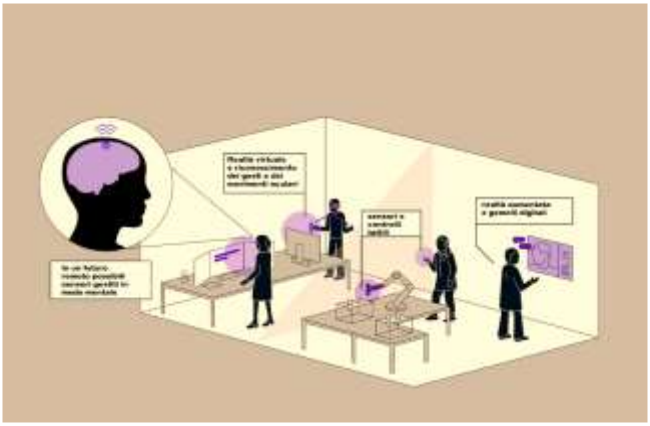

Figure 1. Some emerging digital technologies, in the figure from left to right: mentally managed sensors, virtual reality, tactile control sensors, augmented reality, and digital twin.

3. Augmented reality technology and creativity: bridging pedagogical perspectives and knowledge enhancement

Attempting to provide an initial framework for understanding his contribution, it could be asserted that his existential phenomenological perspective allows, within certain limits, the interpretation of other psychological currents (such as behaviorism and cognitivism) at a higher logical level (Ariano, 2010). The existential phenomenological view enables the utilization of behaviorism and cognitivism at a congruent logical level, respecting their peculiarities and efficacy, while at its own level (existential phenomenological), they become parts that acquire meaning in relation to a broader horizon of sense, which takes into account the individual and the directionality he consciously wants to give to his life(Ibidem). What has just been stated recalls the principle of sense in Alain Berthoz's notion of semplexity (2011), where a regulatory system establishes the connection and functioning that gives value to actions (effectively performed or inhibited) and the act itself, "redefining the relationship and reshaping its meaning". This can occur by generating new decision-making "norms" with which to confront one's own existence. At various logical levels and with equal dignity, but with different perspectives, behaviorism, cognitivism, and the existential phenomenological level collaborate to determine when to perform or inhibit certain actions (Todino, 2023). Within this integrative framework that combines different levels based on distinct anthropologies, Hein's constructivism seamlessly complements phenomenology.

Technology no longer serves as a means to achieve human ends; conversely, human purposes are molded by the availability of technical means. Technology is not merely a means, but a culmination, as it determines the possibilities at our disposal. Our freedom is constrained by the necessity to employ these technical means for common objectives, such as communication through mobile devices or access to online services. Technology operates as an absolute, liberating us from limitations and conditioning, while simultaneously compelling us to follow its rationale. The ethics of technology lie in doing everything possible without necessarily forecasting or taking responsibility for the consequences (Galimberti, 2023, pos. 184-249). The concept of "The end justifies the means" no longer holds significance; rather, the means themselves justify the ends. Technology has become ubiquitous, encompassing the entire planet, including the environment and humanity itself. This blurs the distinction between experimentation and reality, leading to irreversible effects. In this technological age, the pursuit of meaning is also subordinated to the logic of technology. Meaning becomes a means for survival, and if not found, it must be invented. In summary, according to Galimberti, technology dominates both humans and nature, imposing its efficiency- and speed-based rationality. Humanity is compelled to suppress its irrational dimensions, such as love, imagination, and dreams, in favor of a purely calculating thought. This radical transformation of the world is disquieting, as humans are inadequately prepared to manage it. Galimberti notes that with great foresight, Francis Bacon proclaimed *Scientia est potentia* recognizing the power of knowledge. In Bacon's time, technology was limited, and humans retained control over technical instruments. However, today, technology has evolved significantly, fundamentally altering the relationship between humans and tools. Technology has become a world unto itself, no longer merely a tool. With a thought that, in some respects, recalls the theme proposed by Galimberti, professors Illetterati, Masi and Mazzarella (2023, pp. 6-10), also inquire: How far have we come from 1954 when Heidegger published the pioneering work *Die Frage nach der Technik*[4,5], where do the issues concerning technology assert themselves, where technology is a world in which we are born and is no longer a mere tool in the hands of humanity? Morover, how can one attribute pedagogical value to augmented reality technology and the scans that can be conducted in places housing art pieces, based on what has been observed so far? Certainly, a practicable approach is to utilize these technologies, recognizing that they have become a world unto themselves rather than mere tools subjectively separable from one's life. This realization is

[4] https://www.bard.edu/library/arendt/pdfs/Heidegger-Frage.pdf
[5] Translated from German, "the question concerning technology"

increasingly evident; consider a driver navigating an elevated highway in a city: immersed in a world comprised of elements stemming from the fields of civil engineering and structural science, they see bridges, overpasses, buildings, skyscrapers, and railways all around them. To this tangible world, the “invisible” realm of the ether is added, where radio signals, GSM, and GPS create digital substrates. Indeed, the truth of this matter becomes evident when considering the difficulty of attempting to circumvent the modern world entirely by, for instance, opting for travel on foot. This was exemplified by Sergio Rumiz’s journey in retracing the ancient Appian Way from Rome to Brindisi (Rumiz, 2017), a similar experience to that of the author when charting the southern segment of the Via Francigena in the Benevento region[6]. How, then, can we address the question of “how can one attribute pedagogical value?” One possible approach is provided by the use of augmented reality to aid various knowledge processes, reflecting on the fact that human knowledge has specialized in at least four non-overlapping yet integrable ways (Ariano, 2013, a, p. 93). Through this technology, it is possible to promote “objective knowledge”, understood as the consensus of a group of people who perceive things in the same way (Ibidem). In this context, one might draw a parallel with the allocentric vision typical of humans (Berthoz, 2011). There is also “subjective knowledge”, which places importance on an individual’s unique perspective (Ariano, 2013a, p. 93), and by analogy, it resembles the egocentric way of perceiving things (Berthoz, 2011). Furthermore, there is “empathetic knowledge”, which involves understanding another’s conscious point of reference (Ariano, 2013a, p. 93), akin to Berthoz’s (2011) proposition of a shift from egocentric to heterocentric perspectives as a prerequisite for empathy. Lastly, there is “intersubjective knowledge”, which establishes the rules of communication among individuals’ subjective knowledge (Ariano, 2013a, p. 93), and this intersubjectivity forms the basis for educational interaction (Sibilio, 2020). Starting with the concept of social justice in museums as a foundational point, the discussions and critiques surrounding empathy in the provided sources have a direct relationship with the broader goal of promoting social justice within cultural institutions. The idea of empathy as a tool in museums, aligns with the aspiration

[6] The assignment, based on the proven capacity in computer design, involved "the identification and digital mapping of the cultural route within the framework of the Cooperation Project - European Paths Via Francigena del Sud (Measure 421 – PSL: Paths of Samnite Excellence)" and the development of the web portal galtaburno.it/camminideuropa (last access on October 3, 2023) on behalf of Gal Taburno (from December 29, 2014, to July 11, 2015).

of museums to promote social justice7. By encouraging visitors to step into the shoes of marginalized individuals or groups, museums can foster a deeper understanding of the challenges and injustices these communities face. This, in turn, can lead to increased awareness and support for social justice causes. On the other hand, the critiques of empathy as a political strategy, including the notion of selective empathy, are essential considerations within the context of social justice in museums. These critiques underscore the importance of critically examining the effectiveness and potential biases of empathy. Museums, as institutions aiming to advance social justice, must be aware of the limitations of empathy and actively work to address these shortcomings. For instance, they should strive to ensure that empathy is not limited to select groups or issues but is extended to all individuals and situations where social justice is at stake. The relationship between empathy and social justice in museums is complex and multifaceted. While empathy can be a powerful tool for raising awareness and promoting understanding, it also requires critical examination to ensure it aligns with the broader goals of social justice within cultural institutions. Museums play a pivotal role in facilitating these discussions and guiding visitors toward a more empathetic and socially just society. In future work, this issue, which is only hinted at here, can be explored[8.] As evident in human knowledge, the awareness of "being aware of" something is fundamental. Therefore, augmented reality and digital assets used for educational purposes can aim to enhance such awareness. For instance, they can enable more people to be conscious of a particular "object of knowledge", whether it be a tangible object or an abstract concept (Ariano, 2013a, p. 94). Digital Assets used through virtual reality can enhance the four types of knowledge mentioned earlier through various activities that engage the creativity of those who "manipulate" them in the digital world. It is noteworthy to delineate a minimum of three approaches through which the subject matter of creativity can be expounded upon, even though it is a vast topic that goes beyond the scope of this work. Creativity can be of a "quantitative" nature when two or more structures are added, divided, subtracted, or multiplied, resulting in only a quantitative change (Ariano, 2013a, p. 100). This concept is readily applicable with Digital Assets. Then there is a form of creativity that can be

[7] http://empatheticmuseum.weebly.com/maturity-model.html (last access on October 3, 2023)

[8] In this regard, it is advisable to refer to the list of sources provided by the *Social justice & museums resource list*, which was initiated and curated by Tanya S. Autry. The list can be accessed at https://www.aam-us.org/wp-content/uploads/2018/02/Social-Justice-Resources-for-Musuems.pdf

termed “qualitative or structural”, which requires a structure to transform into a different one (Ibidem). In this case, consider Digital Assets representing molecules; they can form new structures (elements) conducive to the study of chemistry. Additionally, one can think of “transcendental” creativity, which involves the transition of one or more structures into another that is qualitatively different and previously nonexistent, such as the transition from the mineral to the plant kingdom, or from the animal to the human kingdom in evolutionary theory (Ivi, p. 101). In this scenario, Digital Assets can facilitate real-time processes that promote structural changes because being immaterial, they do not face the limitations of material objects, which are bound to spatial and temporal structures.

4. Building empathic connections to the past: empathetic and intersubjective knowledge and the role of physical and virtual experimental archaeology

In this brief paragraph, the focus is on a specific case, that of archaeological and historical museums. The integration of experimental archaeology, both physical and virtual, offers unique opportunities to create intersubjective and empathic connections between the audience and the past. In the physical form, through traditional experimental archaeology, people can actively engage in practical experiences, involving themselves in the creation and replication of ancient objects or historical processes. This physical involvement allows for a deeper understanding of the challenges and skills involved in the production of artifacts or the execution of ancient techniques, promoting empathy through direct experience (Ceppatelli, Godino, Montelatici, 2013). On the other hand, the use of Digital Assets in Augmented Reality within the context of experimental archaeology offers an equally engaging virtual experience. Augmented Reality allows users to interact with virtual reconstructions of ancient objects, archaeological sites, and behaviors in an immersive and detailed manner. This virtual experience can evoke a sense of empathy through immersion in the ancient world (Bertelli & Alii, 2013), enabling people to see, hear, and interact with the past in ways that would be otherwise impossible. Through Augmented Reality, users can explore ancient civilizations, understand their daily challenges, and appreciate their art and culture in ways that stimulate empathy and emotional engagement (Ibidem). In both cases, whether in physical or virtual experimental archaeology, direct and participatory experiences foster a deeper and more personal connection with the past. These experiences not only educate the public about history and archaeology but also promote a sense of affinity and understanding for the lives and challenges of people in the past. In this way, experimental archaeology, both physical and virtual, can be a powerful tool for cultivating empathy and promoting intercultural understanding (Ibidem), helping people establish meaningful connections with societies and cultures from the past (Morton Coles, 1979; Mathieu, 2002; Paardekoper, Reeves, 2014; Hermann, 2022). We shall now contextualize this specific case within the realm of the educational sphere, a visit of students to archaeological and historical museums offers a unique opportunity to foster their connection with the past. The integration of experimental archaeology, both in physical and virtual forms, provides engaging ways to create intersubjective and empathic connections between the audience and historical eras. In the physical domain, traditional experimental archaeology allows individuals to actively participate in practical experiences, such as replicating ancient objects and historical processes. This hands-on engagement deepens their understanding of the challenges and skills involved in ancient craftsmanship, promoting empathy through direct experience. On the other hand, the use of Digital Assets in Augmented Reality within the context of experimental archaeology offers an equally immersive virtual experience. Augmented Reality enables users to interact with detailed virtual reconstructions of ancient objects, archaeological sites, and behaviors. This virtual engagement can evoke a sense of empathy through immersion in the ancient world, enabling people to see, hear, and interact with the past in ways that would otherwise be impossible.

5. Empowering Education through Tailored Augmented Reality Solutions, a first case study: *Marge Cube*

The definition of mixed reality varies depending on the perspective; this assertion arises from an investigation conducted by Speicher, Hall, and Nebeling (2019), which takes into account the viewpoints of the academic, gaming, and industrial worlds. Nonetheless, it is possible to establish a context, some borders, that allows for the delineation of a set of characteristics of this ecosystem of technologies that aim to enrich the world we explore through movement and in which we operate. Here, this context is defined in terms of educational interface of a technology, and the objective is to enhance, through human-machine interfaces and their implications on the teaching-learning process (Todino,2018; Rivoltella, Rossi, 2019), a visual content that serves as a bridge to other senses by adding sensory elements related to audio, movement, haptics, and, maybe in the future, taste and smell. What currently varies significantly is the number of users who can share an environment, the level of immersion and virtuality, and the degree of interaction fidelity.

Notwithstanding what has been stated so far, in computer science, mixed reality is a particular style of developing graphic applications that realize a process of combining ("mix") augmented views of photographs, QR codes, or objects created for this purpose in the style of *Marge Cube* (mergeedu.com/cube), overlaying images, videos, or real-time generated 3D digital assets (Hosch, 2022). However, it is important to note that *Marge Cube* is a digital learning platform focused on scientific and STEAM subjects. While it offers many pre-prepared lessons, developing on this platform involves very high costs, diverging from the philosophy of Open Education, promoted by the Teaching Learning Centre for Education and Inclusive Technologies - Elisa Frauenfelder" laboratory, and presents a limitation for institutions with limited budgets, as is often the case with schools.

Figure 2. *Marge Cube*, an example of augmented reality for educational purposes. Through a dashboard, it is possible to upload .fbx, .obj, .stl, .gltf files for manipulation using the cube.

It is important to clarify, even if it is now well known, the difference between virtual and augmented reality. It is important to specify that, if the user's eyes are covered by a headset (think of *Oculus Rift*), we are dealing with a Virtual Reality system; if this does not occur, we are within the context of Augmented Reality (this is the case of *Marge Cube*). However, all these clarifications are continually evolving. Indeed, the aforementioned *Oculus Rift* has been replaced by a new model known as *Meta*

Quest 2, which, thanks to cameras, no longer isolates the user from the surrounding world (problem slightly solved by *Meta Quest Pro* which allows the user to look down at the surrounding reality). Nevertheless, to make things easier, we are concerned with a specific application: an augmented reality application that, when given a QR code, projects a 3D Digital Asset onto a mobile device (tablet or smartphone with Android operating system). In this particular case, the 3D assets are scans from cultural heritage. A system designed according to this framework allows for reasonably rapid configuration of various forms of interaction (Di Tore, Todino, Sibilio, 2020) and the creation of educational settings. These QR codes can also be applied to 3D prints of the 3D Digital Assets, enriching the experience with the accessibility potential of this additional technology (Neumüller, Reichinger, Rist, Kern, 2014). Actually, one of the most fascinating aspects of this technology is the possibility of using it with one's own device in a BYOD (Bring Your Own Device) perspective, also known as Action #6 of the National Digital School Plan (PNSD), an integral part of Italian law 107 of 2015[9]. This policy encourages the use of personal electronic devices during educational activities, efficiently integrated with the school system, including *Digital Facilitators*, and all teachers are encouraged to identify and promote possible mixed uses of private devices in various school activities, ranging from electronic record keeping to participation in project-based activities among students and teachers (Kokotsaki, Menzies, Wiggins, 2016). There are all the prerequisites for BYOD and Augmented Reality to become learning environments. Another element to add to the described scenario is the concept of a virtual museum, a collection of images, audio, text documents, and, more generally, Digital Assets with historical, scientific, or cultural value that can be accessed through digital media. Such a museum does not house real objects but virtual replicas that, nonetheless, document real collections to create new meanings that facilitate teaching and learning processes (Panciroli, 2019). By their very nature, virtual museums can be set up anywhere. Hence, the idea proposed here is to promote cultural heritage by setting up an educational path directly in schools through an application that, when reading QR codes, projects 3D scans via augmented reality directly onto the mobile devices of students and teachers, potentially enhancing the installation with 3D printing of the objects in question. In this way, the museum is transported to the school, and students, guided by their teachers and researchers, become curators of a temporary exhibition. The Digital Assets become an application of the concept of "vicariance of use", as indicated by Jakob von Uexküll and taken up by Berthoz (2011, 2015), who have attributed a

[9] https://www.istruzione.it/scuola_digitale/allegati/2016/pnsd_en.pdf (last access on October 3, 2023)

new meaning to vicariance, such as the stem of a flower, which is simultaneously food for the cow, a stem for the lover to present the flower to their beloved, and a ladder for the ant (Berthoz, Tramus, 2015). In this new century dominated by technology, recognizing in a device we always have in our pocket, the mobile phone, which often distracts us, an opportunity for promoting cultural heritage through educational paths is certainly one of the noblest forms of vicariance of use for this device. There are several advantages to having an internally developed augmented reality system compared to using a pre-packaged system like *Marge Cube* in an educational context: customization, an internally developed system can be specifically designed to meet the educational needs and learning objectives of the school or institution. This means that the augmented reality experience can be tailored to fit the curriculum content and the students' needs; flexibility[10], with a customized system, it is possible to make changes and improvements quickly and flexibly to keep up with changes in the educational program or new discoveries in the field of education and technology, beside, a "tailored" system can be seamlessly integrated into the existing school curriculum, made of a core/general core, subjects, methodologies to bring it out, etc. (Richmond, 2018), creating a direct link between augmented reality activities and learning objectives. Another aspect to take into consideration is the following: it is possible to have full control over the privacy and security of student data, minimizing concerns related to sharing sensitive information with third parties; adaptation to *Special Educational Needs*, an approach to inclusion based on valuing the multiplicity of ways of being, beyond all forms of "labelling" and "stigmatisation" (Aiello, 2018), a customized system can be designed with the specific needs and resources of the educational institution in mind, allowing for greater adaptability to local realities, student engagement, involving students in the development of the system can provide a unique learning opportunity that makes them active participants in the educational process and the creation of innovative teaching tools; and also skill development, continuous updates (Di Tore, Todino, Sibilio, 2020). Thus, developing an internally designed augmented reality system for educational purposes offers a higher degree of

[10] Flexibility, vicariance, and the capacity for adaptive, on the terms proposed by Berthoz (2011, 2015) responses to dynamic environmental alterations are pivotal attributes enabling an entity to effectively discern and employ the optimal strategy from a repertoire of potential choices for addressing a given problem. Furthermore, these qualities facilitate the entity's ability to discern, apprehend, make determinations, and take actions in consonance with the contextual circumstances within which the system operates. Consequently, these attributes assume a paramount role in the realm of decision-making, problem resolution, creative ideation, the management of stress and emotions, the initiation of novel endeavors, and the cultivation of an entrepreneurial disposition.

flexibility, customization, and control, allowing for the creation of learning experiences that are better suited to the specific needs of the institution and students. However, it is important to consider the resources, time, and skills required for the development and management of a customized system (Ibidem).

6. Exploring 3D Scanning and Education: Bridging Digital and Physical Spaces

Certainly, a pre-packaged system (for example *Marge Cube*) can certainly facilitate the work of the educator; however, it would be akin to a “big-box store” package, rather than a bespoke one. Instead, envision a school that equips itself with its own scanner and the competencies to independently work on what truly matters in lessons and school projects, significantly enhancing the quality of activities. In this regard, consider that everything seems difficult at the beginning, now it seems difficult to use a 3D scanner, at the time it seemed difficult for teachers to use the slides and the multimedia board but through appropriate ICT training these digital skills will be possible learn. Just to give a few examples, consider the various possibilities based on the teachers’ fields of expertise secondary schools[11] (just to briefly focus on this type of Italian classification of teachers defined by italian law *Decreto Ministeriale 93 del 23 febbraio 2016 - Ambiti disciplinari nuove classi di concorso*): geometric disciplines, architecture, interior design, scenography; painting, sculpture, plastic arts, dental modeling; aeronautical sciences and technologies; one could continue for over hundred different teaching disciplines. What is becoming disruptive is 3D scanning, which, along with 3D printing, is becoming an integral part of how we use technological devices at a pace where it is only possible to interpret the changes rather than pause for deep reflection, which must take into account a market that has now “exploded”. It has become an integral part of documenting cultural heritage and its long-term preservation. Depending on the tools used, one can perform amateur scans (think of smartphone applications like *Scann3D*) and progress to very sophisticated hardware and software devices such as the handheld 3D scanner, *EinScan-Pro+.*

[11] However, applications can be thought of for primary and lower secondary schools.

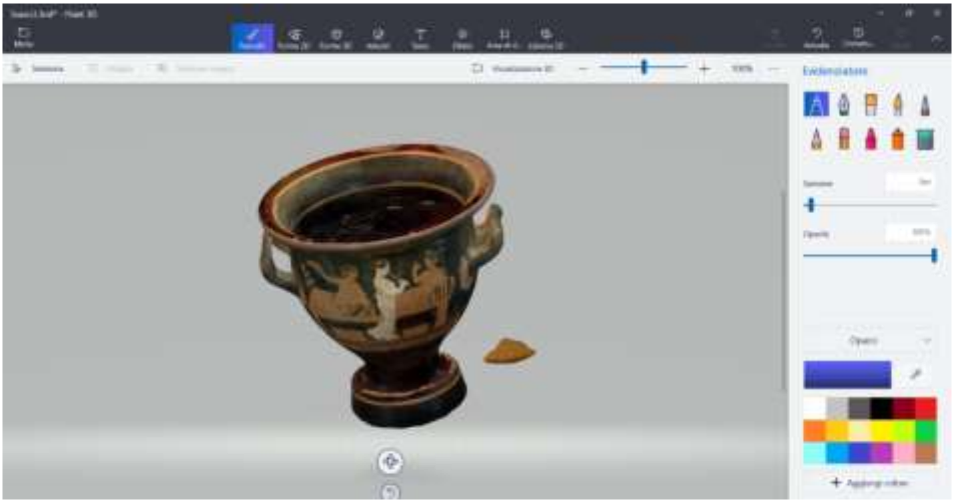

Figure 3: 3D scan carried out with an EinScan-Pro+ handheld scanner, of a red-figure crater, carried out at the National Archaeological Museum of Sannio Caudino in Montesarchio (BN, Italy), note a small “typo” on the right of the vase which can be deleted using a digital sculpting process.

Halfway between these two possibilities is the EinScan SE desktop 3D scanner which however poses limits in terms of the size of the object to be scanned compared to handheld scanners. The first scanning phase concerns the registration of the surfaces and shapes of the object; this activity is usually carried out at the highest possible graphic resolutions. Once the object has been memorized in raw form, we move on to a second phase, the so-called digital sculpting, or a reworking of the acquired object to make it usable for 3D graphics engines and 3D printing. For example, digital sculpting is necessary to remove “3D-typos” present in the scan, recreate cavities, improve details starting from the photographic material which is usually created together with the actual scan. 3D scans offer some benefits compared to other methods of archiving museum collections because they allow collections to be monitored, studied, disseminated and understood and shared.

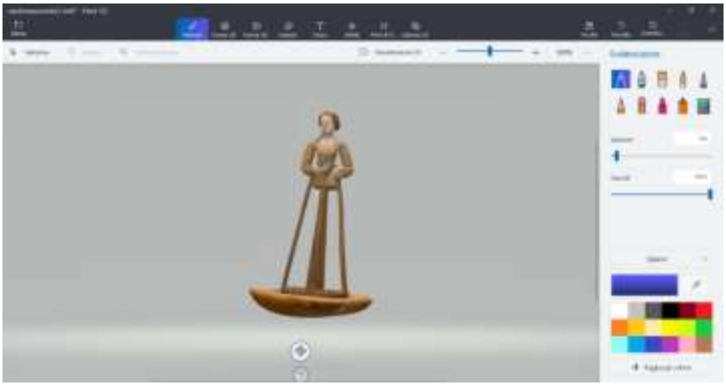

Figure 4: 3D scan carried out with an EinScan-Pro+ handheld scanner, of an “undressed” Madonna, carried out at the De Chiara De Maio Foundation in Solofra (De Maio, Russo, 2023), note a wooden base under the object which can be eliminated with a digital sculpting process.

Figure 5: 3D scan carried out with an EinScan-Pro+ handheld scanner, of a work by Andy Warhol carried out at the De Chiara De Maio Foundation in Solofra (AV, Italy).

In the context of a three-dimensional scanning process, it is imperative to make a rigorous distinction between the concepts of “resolution” and “accuracy”. Resolution, firstly, is a parameter of a purely technical nature that pertains to the degree of detail in the content stored in the three-dimensional file. This aspect is primarily influenced by the physical specifications of the sensor used, the optical characteristics of the lenses, the precision of the sensors employed, and the software algorithms used for data processing. However, the critical point lies in ensuring a proper correspondence between the data acquired during scanning and the actual surface of the object under examination. Such correspondence is often conditioned by variables such as the settings used during scanning, the lighting of the environment, and, in some cases, the application of spray substances to prevent unwanted reflections. To verify that the scan has reached an adequate degree of fidelity to the original object, it is common practice to subject it to a mimicry test, which involves a direct comparison between the obtained data and an original reference (such as a photograph). Only if the result of this test successfully surpasses the comparison can one assert that the scan can be considered accurate and reliable. The installation of an exhibition or the delivery of lessons based on 3D scans within an educational environment demands meticulous planning and the execution of several crucial phases. Primarily, it is imperative to establish specific educational objectives for the 3D scan-based exhibition or lessons. What is it that we aim for students to learn or comprehend from this experience? Then, 3D scans of objects or artworks need to be generated employing appropriate equipment and software. Ensuring high-quality scans with good resolution and accuracy, as previously described, is essential. More in detail, 3D scans might necessitate post-processing to eliminate imperfections or optimize 3D models. This step should be undertaken by personnel with the requisite technical skills. In the case of an exhibition, it is vital to arrange an exhibition space to effectively display the scanned objects. This could involve the creation of platforms, the installation of suitable lighting, and the design of informative captions. It is necessary to carefully choose objects or content for display based on educational objectives. Ensure they are representative and relevant to the curriculum. Besides these activities need Integration into the students’ Curriculum: lessons based on 3D scans should be meaningfully integrated into the school curriculum. Identify how these lessons align with learning objectives and when they will be taught. Ultimately, for the sake of conciseness, it is imperative to maintain awareness of all the subsequent themes (which, regrettably, cannot be exhaustively elaborated upon within the confines of this study): 1) student engagement, actively involve students in the exhibition or lessons, allow them to explore 3D scans, ask questions, and participate in discussions; 2) mimesis testing and accuracy verification: if possible, conduct a mimesis test, as described in the initial statement, to verify the accuracy of the scans compared to the original objects; 3) assessment of learning: evaluate the level of learning achieved by students through the exhibition or lessons based on 3D scans. Utilize appropriate assessment methods to measure the attainment of educational objectives; 4) feedback and improvement: gather feedback from students, educators, and exhibition participants. Employ these insights to further enhance the process and future exhibitions or lessons based on 3D scans. Kirsten Gibbs, Margherita Sani, and Jane Thompson (2006) posit a contemplation regarding exhibition spaces that consciously or unconsciously reflect the curator's perspective; if this apex figure possesses a sensitivity toward educational themes and implements strategies conducive to the teaching-learning process, the space can become conducive to pedagogy. To achieve this, the space must be transformed by the designer into a bona fide educational setting that, no less importantly, should be an arrangement aimed at promoting accessibility for one and all. Gibbs and her colleagues, therefore, underscore the necessity of input from educational experts (consider the roles of the media educator and digital animator) for a continuous enhancement of cultural heritage promotion and to ensure that an exhibition or display speaks to all students from an inclusive perspective that also takes into account the principles of Universal Design for Learning[12]. Simultaneously, this approach is grounded in an analysis of the connections with topics covered in the school curriculum (Hermann, 2022).

Figure 6: augmented reality relating to a 3D scan, carried out with the EinScan SE desktop 3D scanner, of a perfumer from a Samnite tomb preserved in the Civic Museum of Carife (AV, Italy).

In a certain sense, the establishment of a museum takes on the role of a tangible task, with students and their instructor assuming the roles of art curators,

[12] https://udlguidelines.cast.org/

responsible for the selection of artworks (among those virtually available through augmented reality), determining the sequence of these artworks, and making organizational and presentational choices. This approach heightens the level of responsibility for the students, as they engage in co-designing the environment in collaboration with the educator, including defining points of interest within the school building and potentially in external spaces, facilitated by additional technologies (consider virtual reality installations, video mapping, or video projectors). As it becomes apparent, students are encouraged to undertake the creation of a comprehensive exhibition project. Such an educational experience can be configured, for example, as a Pathways for Transversal Competencies and Orientation (PCTO, school-work interaction systems in high school[13]) in an Artistic High School (In this context, we address the issue of competitive categorization among secondary school educators), a Media Education experience in other high school settings, or, with adjustments for complexity, an initiative led by a Digital Animator in primary (fifth grade) or lower secondary education.

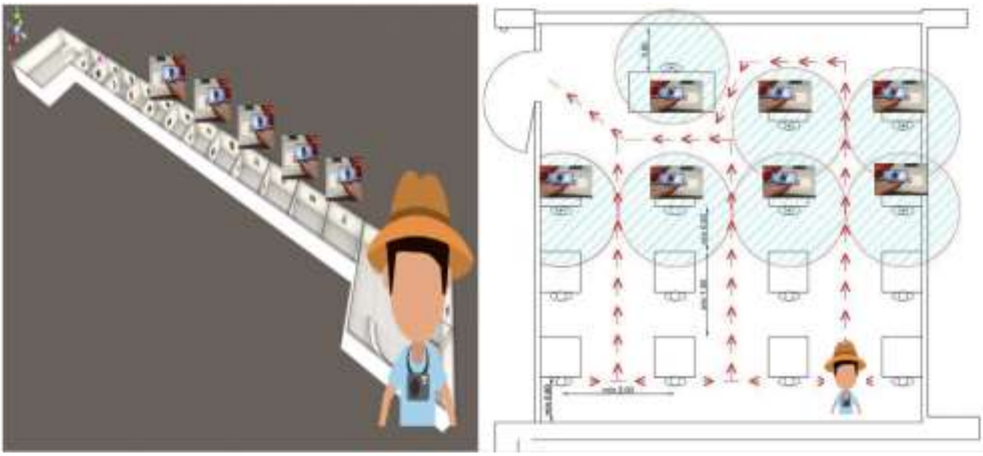

Figure 7: hypothesis of the museum plan to be created at school with the students; to the left, adapted from Garnier, Vuarnesson and Alain Berthoz (2017), to the right, adapted from Piatti (2020).

In a 2017 study, Garnier, Vuarnesson, and Alain Berthoz introduced the concept of a virtual museum, envisioning a visitor navigating through it in a manner akin to the progression through interconnected rooms. While educational institutions are often scrutinized for their architectural layouts, in this specific case, the main

[13] alternanza.miur.gov.it

corridor, sequentially leading to various classrooms, can be harnessed as an advantageous feature. Similarly, the physical distancing of desks in compliance with anti-COVID-19 regulations can be leveraged as an opportunity to arrange the desks in a suitable manner for an exhibition. The virtual exhibition proposed by Garnier, Vuarnesson, and Alain Berthoz (2017) comprised a training zone and the exhibition area itself, which consisted of twelve consecutive virtual rooms designed in a similar fashion; this is different from the case of a pure performance in augmented reality with QR code, but it is very useful as a starting case study to have a possible "touchstone". In each of these rooms, four pieces of art, including paintings and photographs, were exhibited, with each artwork displayed on one of the room's four walls. The placement of the artworks on the virtual walls was randomized, and a doorway allowed visitors to transition from one room to the next. The decision to utilize game based approach with virtual replicas of real objects to implement this exhibition offered several significant advantages. Firstly, it led to a reduced cost of implementation. Additionally, this approach leveraged a production environment that was already well-known and mastered by student-researchers in environments with limited or pre-established spaces. Furthermore, it provided a high degree of flexibility in terms of use and an open programming environment; the comprehensive management of interactions, interfaces, and databases was conducted within the Unity (Ivi, p.50) the same one also used at the XXXXXX laboratory of the University XXXXXX.

7. Discussion

This paper delves into the convergence of educational and museum spaces, accentuating the pivotal role of the curator's perspective in molding the pedagogical potential within exhibition spaces. Kirsten Gibbs, Margherita Sani, and Jane Thompson (2006) underscore the imperative for educational expertise to enhance the promotion of cultural heritage and ensure inclusivity by adhering to Universal Design for Learning principles. This work posits that educational experiences can be restructured to stimulate active student involvement in crafting and curating their exhibitions, thereby nurturing a sense of responsibility and collaboration. This approach exhibits adaptability across a spectrum of educational levels, extending from higher education to primary schools and post-primary education/junior secondary education. Furthermore, the conceptualization of a virtual museum, as introduced by Garnier, Vuarnesson, and Alain Berthoz, offers a promising framework for navigating educational institutions and harnessing physical spaces for exhibition purposes. Their design of a virtual exhibition, fusing augmented reality with virtual replications of tangible objects, conveys distinct advantages in terms of cost-efficiency, flexibility, and adaptability. The integration of game-based technology, coupled with the utilization of platforms like Unity, streamlines the administration of interactions, interfaces, and databases, thereby enhancing the educational encounter (Kim & Alii, 2014). This pioneering approach underscores the potential for fabricating immersive, educational, and all-encompassing museum-like environments within the educational domain. In tandem, the overarching themes of research in the realm of Pedagogy and Special Education revolve around the establishment of educational pathways tailored to address a range of challenges linked to disability, special educational requirements, and, more broadly, inclusivity. The primary aim of Special Pedagogy transcends mere adherence to a singular model or the principle of school integration; instead, it aspires to combat marginalization and social, institutional, and educational exclusion. It prioritizes the recognition of each individual's originality and distinctiveness, embracing their unique and irreplaceable characteristics. This approach not only attends to an individual's limitations but also focuses on their functional capacities. Recognizing the diverse needs and characteristics of each individual is particularly relevant in the context of augmented reality (AR) applications in education. This acknowledgment necessitates a dedicated commitment to values deeply rooted in educational theory and practice, stimulating innovation not only in how educational organizations are structured but also in how instruction is delivered. In the realm of AR, this commitment is paramount, especially within a social and cultural landscape that embraces diversity as a core paradigm. Here, the capacity to develop and implement individualized, personalized, and tailored AR solutions to cater to the unique learning requirements of all individuals becomes essential. AR technologies offer a dynamic platform for delivering customized educational content that can adapt to the specific needs and preferences of each learner, thus aligning with the overarching goal of inclusive and personalized education. It can be useful to consider Digital Assets as those elements indicated in Bruner's (1992, p.27) text, where he, with deliberate cognitive and a clearly pedagogical perspective, emphasizes the fact that humans modify the environment in which they live, within certain limits, by constructing amplifiers that facilitate memory and adaptation to change. This concept is also echoed by Berthoz (2011), highlighting a specific aspect of the human species that occurs among various possibilities through "the use of culture". Many things need to be "drawn" from culture, not just relying on a generic knowledge base or common cultural heritage accumulated over several generations, which includes historical values and various practical skills. This makes the human species distinct as it is built upon a socio-technical way of life. In this context, Bruner refers to earlier studies by Howell (Ivi, p.28), and the psychologist also reminds us that "civilization" is not just a façade or a mere veneer, but a deeply ingrained trait of adaptation to change that unites groups of individuals. To summarize, Digital Assets can serve as vehicles for learning, integrated into a constructivist and socio-cultural mode of learning that drives change (Ibidem).

Conclusion

The principles outlined here align seamlessly with the capabilities of augmented reality (AR) in education. AR technology, by its very nature, allows for the tailoring of instruction to meet the distinct needs and learning pathways of each individual. It provides a dynamic platform through which education can be personalized, permitting every learner to tap into their intellectual, motor, social, and emotional potentials using a variety of interactive and adaptable methods; this is a topic that has been discussed for over twenty years (Johnson, Rickel, Lester, 2000) and which is now at the heart of the debate thanks to technological evolution. This recognition of individual uniqueness, facilitated by AR, holds the key to personal, educational, and pedagogical success. It places a challenge before all stakeholders in the educational process, urging them to craft educational interventions and implement strategies that genuinely resonate with learners. AR's adaptability and contextual capabilities make it a powerful tool in this endeavor, enabling educators to provide effective, personalized instruction that considers the varying contexts and the diverse needs of their students. The development of such effective AR-based educational practices serves as exemplars of best practice, ultimately playing a pivotal role in achieving successful learning outcomes. By harnessing AR's potential, educational interventions can be designed to enable individuals to reach their full potential across socio-cognitive, emotional, and affective dimensions, thus enhancing the overall quality of education. In this context, the theme of Inclusive Education serves as a cornerstone, supporting innovative educational strategies that aim to promote diversity and inclusivity, particularly through playful game-based learning. The use of augmented reality (AR) in schools, museums, and homes for educational purposes becomes instrumental in this regard, as it can accommodate various learning styles and abilities. This very journal issue endeavors to gather a diverse array of contributions that encompass epistemological, methodological, and didactic perspectives related to education. It seeks to integrate these viewpoints with specific regulations and cultural and scientific references to offer a comprehensive understanding of how AR and game-based learning can foster truly inclusive educational experiences. Through the utilization of AR and playful learning approaches, this initiative aims to provide semantic clarity on pedagogical and didactic strategies that enhance the educational process. It encourages comparative analyses and the development of innovative solutions tailored to the goal of achieving a genuinely inclusive educational perspective. The convergence of technology, pedagogy, and inclusivity creates an educational landscape that caters to the individual needs and learning pathways of all students, fostering a more inclusive and engaging learning environment at school, in museums, and domestic settings alike.

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