BYOD MUSEUM: ENHANCING CULTURAL HERITAGE WITH AUGMENTED REALITY

BYOD MUSEUM: VALORIZZARE IL PATRIMONIO CULTURALE CON LA REALTÀ AUMENTATA

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Double Blind Peer Review

Citazione

Schiavo F., Chiusaroli D., Di domenico M., Ianniello A., Caldarelli A., Di Tore P.A., (2023) Byod Museum: enchaning cultural heritage with augmented reality, Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva - Italian Journal of Health Education, Sports and Inclusive Didactics. Anno 7, V 2. Edizioni Universitarie Romane

Doi: **https://doi.org/10.32043/gsd.v7i2.888**

gsdjournal.it
ISSN: 2532-3296
ISBN: 978-88-6022-470-5

ABSTRACT
In recent years, an increasingly significant role in education has been attributed to cultural heritage, which can become a means of interweaving knowledge and fostering a sense of belonging to that "community of heritage" present in the contexts in which Italian schools are located, and it finds a new impetus in the Educational Community Pacts that become the tool through which schools rethink themselves as an integrated educational system capable of connecting formal, non-formal and informal within a vision of a school of proximity.

Negli ultimi anni, un ruolo sempre più significativo in ambito educativo è stato attribuito al patrimonio culturale, che può diventare un mezzo per intrecciare i saperi e favorire il senso di appartenenza a quella "comunità di patrimoni" presente nei contesti in cui si trovano le scuole italiane, e trova un nuovo impulso nei Patti di Comunità Educativa che diventano lo strumento attraverso il quale la scuola si ripensa come sistema educativo integrato capace di connettere formale, non formale e informale all'interno di una visione di scuola di prossimità.

KEYWORDS
Byod Museum, educational environments, Augmented Reality.
Byod Museum, ambienti educativi, Realtà Aumentata.
Received 11/05/2023
Accepted 18/05/2023
Published 20/05/2023

Introduction[1]

Through progress made in technology, our lives are changing, allowing us to live in a digital world that exponentially facilitates the way we communicate, collaborate, share and learn. In particular, increasingly high-performance mobile devices have become extensions of our bodies, changed our lifestyles, and redefined the concepts of space and time. In the light of a digitization process that, especially in recent years, has also involved schools, it has become evident that it is no longer possible to re-propose traditional school practices, which are characterized by indirect knowledge and an excessive amount of abstract and decontextualized information, but it has become necessary to rethink the educational system in order to create new pedagogical models capable of capitalizing on the potential related to the use of technology and foster "experiential learning" (Kolb, 1984; Dewey, 1986) that enhances the active participation of each student.

The complexity of classrooms, characterized by cultural and social differences, the presence of different educational needs, different skills and abilities, calling for a rethink on the annual, weekly and daily forms of school planning, which allows not only to find new formats to enumerate skills, objectives, content, methodologies and assessment methods, but also to think about a "common path" that allows the "branching" of different personalized paths, in accordance with the inherent heterogeneity of the group class and different ways of working (Rossi & Giaconi, 2016). In this way, the experience that develops during the learning process fosters the acquisition of new knowledge, new skills and abilities that enable all students to build and strengthen their identity, learn to relate to people, things and, more generally, to the environment in which they grow up.

In recent years, an increasingly significant role in education has been attributed to cultural heritage, which can become a means of interweaving knowledge and fostering a sense of belonging to that "community of heritage" present in the con-

[1] The entire contribution is the result of the shared reflection and joint work of the authors. However, regarding the writing of the text, Fabrizio Schiavo and Pio Alfredo Di Tore contributed equally to the writing introduction and conclusions; Diletta Chiusaroli and Annalisa Ianniello contributed equally to the writing “The BYOD Approach”; Monica Di Domenico and Aldo Caldarelli contributed equally to the writing “Project evolution”. Pio Alfredo Di Tore is Scientific Coordinator of the Project BYOD Museum.

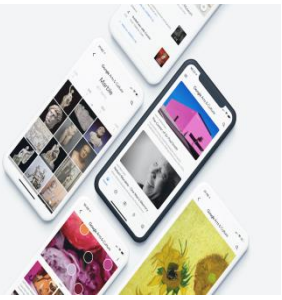
texts in which Italian schools are located, and it finds a new impetus in the Educational Community Pacts that become the tool through which schools rethink themselves as an integrated educational system capable of connecting formal, nonformal and informal within a vision of a school of proximity that involves the entire community in co-design to expand the places and times of learning with a view to Lifelong Learning that is not only about the lifelong learner, but also about knowledge that evolves and transforms in continuous relationship with subjects and contexts. The museum, in this perspective, has the function of cultivating personal and community identity, presenting itself as the place where the memory and past of a territory, a nation or the entire mankind are preserved and communicated. It also performs a social action, allowing the development of a sense of membership and socialization, offering opportunities to share experience with other people (Tomassoni & Santangelo, 2021).

Creating a synergic relationship between culture and technology, putting multimedia tools side by side with educational pathways, can enable school and museum institutions to step outside their own walls and create a network that engages the entire community toward new experiences in the enjoyment and enhancement of cultural heritage. In this sense, as Russoli already argued in 1971, "A museum is not only a sacred place, a safe or an archive for insiders, but it must be above all a school and a laboratory" (Bruno, 2019), within which it can develop effective solutions and, thanks to digitalization, become a fun, interactive and educational place.

In the White Paper on Artificial Intelligence at the Service of the Citizen, the importance of fostering digital transformation to improve the services offered by the public administration is reiterated: Italy must excel in the search for innovative strategies, perhaps capable of feeding on the historical, cultural and social heritage of the Country and the Mediterranean, and at the same time be able to take advantage of the best that has emerged from the strategies of those States that were the first to make the evolution of public information technology the lever for the transition to a new global structure of economy and society (Digital Italy Agency, 2018).

Museums have been experimenting with Augmented Reality (AR) since the early 2000s. Most commonly paired with mobile devices, the technology overlays virtual content on top of its physical surroundings, displaying the two as a single image on a screen, to enhance interaction between visitors, collection objects, and their contextualized information (Marques & Costello, 2018).

Numerous apps have been developed over the years. Perhaps the most famous is the Google Arts & Culture project, which, since its creation in 2011 until now, has collected more than 6 million digitalized artworks and ten thousand places of historical and artistic interest, such as theaters and historic buildings. Fifteen thousand museums around the world have joined the project in collaboration with the Google Cultural Institute, a nonprofit association established for the express aim of preserving and making art and culture accessible to anyone and anywhere in the world. The platform allows people to virtually explore galleries and art collections through virtual tours with 360° panoramic images. In fact, the proposed tours use the same technology as Google Street View (already used by Google Maps to map and shoot every street on earth). Many images are also supported by augmented reality, and for some particularly valuable works, images with very high resolution (ranging from 6 to 10 billion pixels) are available. The pictures represent an inestimable asset, not only because they allow us to observe details of a painting that are invisible to the human eye, but also because, in several years' time, they will become a reference for the works' restauration, or may prove useful in case they need to be reconstructed. On the platform, there are also 360° interactive videos that can be enjoyed in 2D and 3D, as well as detailed and insightful captions that complement the photographic material and allow the viewer to discover unexpected details and textures related to the artwork.



Figs. 1 Pictures taken from the Google Arts & Culture site

The potential related to this type of technology, both in museum and school settings, is unimaginable.

1. **The BYOD Approach**

Before addressing the issue of BYOD, "Bring your own technology/device (BYOT or BYOD), some preliminary information is needed.

Since 1946, with the announcement of the Electronic Numerical Integrator and Computer (ENIAC), the first general-purpose electronic computer, it has taken more than thirty years to develop sufficiently small and low-cost computers and more than fifty to have a mobile device (smartphone) capable of combining mobile phone capabilities with those of a Personal Digital Assistant (PDA) with the possibility of browsing Internet and downloading software. Since then more and more technology companies have dedicated time and resources to the development of Virtual Reality (VR) and Augmented Reality (AR).

To fully understand the concepts of virtual environment (VE) and augmented reality, it is necessary to start with the concept of mixed reality (MR) and the relationship between reality and virtuality. With the seminal work of Milgram and Kishino (1994) today a more nuanced definition of virtual reality is commonly accepted, where mixed reality, described as a continuum between real and virtual environment, represents the set of technologies that involve the fusion of what is completely real (reality) and what is completely virtual (virtuality). Within these two extremes we find a spectrum of combinations that, depending on the proportions used of real and virtual content, leads to the definition of two distinct subcategories of MR: Augmented Virtuality (AV) and Augmented Reality (AR).

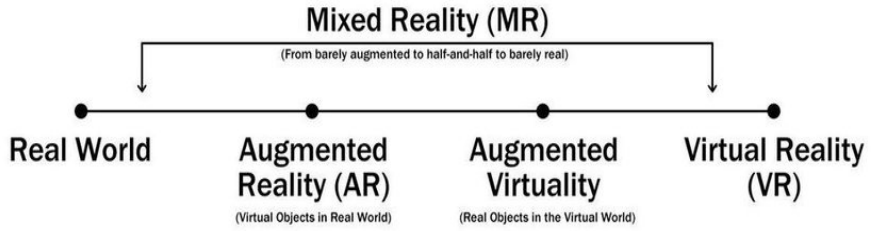


Fig. 2. Mixed reality scheme (Milgram & Kishino, 1994)

If in Virtual Reality, the user is totally immersed in virtual reality (in a completely artificial world), virtuality/augmented reality environments essentially offer a different experience because they allow simultaneous access to both real and virtual environments and require attention to be paid to both the virtual and real worlds

due to the overlay of information (Azuma, 1997). Augmented reality (AR) is, therefore, a real-world environment that is "augmented" with virtual objects or information. This is made possible by tracking and registering (aligning) virtual objects with real objects or geographic spaces and visualization technologies that allow the user to see virtual objects in geographic space.

These concepts are fundamental to understanding the Byod initiative as one's mobile device allows each student to become an active participant in learning both inside and outside the classroom.

We took our cue from the study conducted by Ackerman & Krupp (2012) on the five components that must be considered for a successful BYOT/BYOD implementation. According to the research these five components are security, stakeholders, policies, professional development, and financial planning, which are critical to ensure the safety of students and their data, involve all stakeholders in the implementation process, create effective policies and procedures, provide necessary professional development for teachers and staff, and allocate sufficient funds for technological sustainability. Effective integration of these components can provide a contemporary, rigorous, and relevant learning experience for students beyond the confines of traditional classroom settings. In detail:

1- *security*: security is critical when introducing new technology into the school. Successful examples cited in the paper include the MAC address register at New Canaan High School in Connecticut and the user verification screen at Alvarado Independent School in Texas. Proposed recommendations for improving security include using security codes for e-mail and choosing secure alternatives for storing content, such as iCloud or web-based programs like Dropbox and Evernote;

2- *stakeholders*: it is important to involve all stakeholders in the choice and implementation of BYOT/BYOD, including parents, administrators, and community members. Their feedback and collaboration can be critical to the success of the project;

3- *policies*: the creation of appropriate policies and regulations is critical to the success of a BYOT/BYOD program. Examples cited are Fayette County Schools' Protocol for the Use of Personal Technology and the same school's BYOT pilot user agreement. It is important to strike a balance between protecting students and schools and promoting their digital literacy.

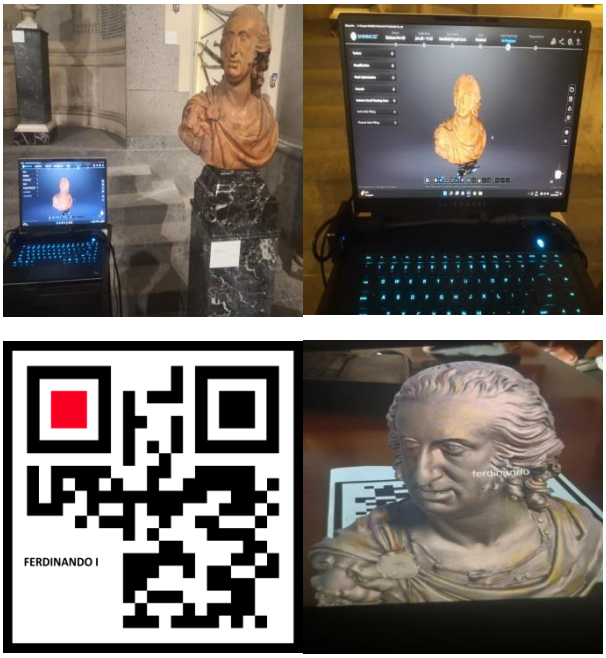
4- *Professional development*: teachers need training to effectively integrate technology into their teaching practice. The focus is shifting from teacher-centered to student-centered teaching, which requires a new range of teaching skills and methodologies. Appropriate teacher training is therefore critical to the successful implementation of BYOT/BYOD;

5- *Financial planning*: the introduction of new technologies can incur costs, however, choosing BYOT/BYOD can result in short- and long-term savings. It is important to create financial planning to ensure program sustainability and equitable and balanced instruction for all students.

In summary, we can consider the Bring Your Own Device (BYOD) Museum approach a first step in the creation of a solid school-museum partnership that can promote and enhance the cultural heritage of the area and connect formal, non-formal, and informal learning within a vision of a neighborhood school. Adoption of this technology can address monetary constraints while infusing 21st century learning. Teachers and students can change the orientation of the classroom and make it more student-centered.

2. Project evolution

The project has the dual purpose of digitizing, through 3D scanning, works of art and historical museum artifacts from the Italian territory to develop prototypes of inclusive open-source educational Digital Assets enjoyable in augmented reality. It is currently under development and consists of three phases. During the first phase, in accord with the museum directors involved, a selection of the objects to be digitized was made through a 360° scan of the artifacts with Shining 3D EinScan-SP. Next, the scanned raw object was "cleaned" using ZBrush software, which allows in the post-processing phase to obtain a perfect digital replica of the real object, and finally, the QR code was generated.



Figs. 3. Workflow example

In the second phase, an open source mobile application was developed with Augmented Reality (AR) technology that enables visualization of the digital resource. It was decided to use this technology for two main reasons: in most cases, the devices that can be used (tablets, smartphones) are already in the availability of the students, greatly reducing the costs that the school has to pay; it can also be used in the absence of specific devices (VR headset, glasses or 3D visors), allowing the subject to live an immersive experience, as in virtual reality, while maintaining contact with the real world.

Figs.4 Augmented Reality app

The choice of open source software was motivated by the intention to create an open and implementable product through replicable methods and accessible technologies for use in education. The AR application was created for iOS and Android mobile platforms and is designed to work seamlessly with game engines such as Unity3D. Before submission, however, the demo version undergoes a user test to evaluate its usability and identify critical interface issues. Accurate, low-latency tracking is critical to delivering high-performance virtual environment experiences, where the position, geometry, and actions of users and objects in the real world have one-to-one correspondences with their equivalents in 3D virtual spaces.

When the unique model of a marker is recognized, its orientation and position relative to the user's point of view (camera) is calculated. This information allows the AR software to position and render virtual digital objects corresponding to the position and alignment of the marker (QR code). The activation process of the content is clear and self-explanatory: after starting the app, the mobile device must be pointed in the direction of the QR code generated for the specific object, and the camera returns the digital resource to the display; 3D tracking continually and very naturally and smoothly adjusts the orientation and size of the augmented content based on any device repositioning so that the calibration is instantly corrected and the 3D model can be viewed in its totality.

Implementation of the offered content with contextually relevant information and resources to enhance interaction and experience in augmented reality is currently underway. The portability and versatility of mobile devices have significant potential in promoting a pedagogical shift from teacher-centered instructional learning to student-centered participatory learning. There will be times when students are engaged in self-learning or discovery, while at other times they interact with others, such as their peers, teachers, or experts. Teachers have a role to play in designing the learning activity and integrating it into their classroom program. In the third phase, in fact, it is planned to be tested at school, giving teachers the opportunity to design and integrate the lesson by exploiting the potential related to the use of this technology, and students the opportunity to be active protagonists of the learning activity. It is planned to divide one or more classrooms into a control group and an experimental group. The control group will be in charge of planning and setting up a digital exhibition, observing and assisting the experimental group

during the visit. After the experience is completed, it is expected that an online questionnaire will be given to data collection. In this type of "learning culture", teachers act as facilitators and partners in learning rather than as the only knowledge experts. Mobile devices can be used to help students explore digitally augmented physical environments where information and resources are provided for proactive understanding. To test the research hypotheses, it will be necessary to organize one or more meetings to analyze the data, draw conclusions and reflect on the experience gained and the goals achieved.

Conclusions

The aim of this work is to create a stable and durable connection between school and museum through the promotion and enhancement of cultural heritage, which can become a means of interweaving knowledge and fostering a sense of belonging to the "heritage community" present in the contexts in which Italian schools are located. In this sense, the portability and versatility of mobile devices have significant potential, and augmented reality experimentation in both school and museum contexts can offer new insights to direct research. It is believed that this type of situated experiential learning offers the possibility of creating "active" study paths with a high level of interaction and personalization and can increase students' motivation and cooperation, making them acquire more skills in the perspective of lifelong learning.

The digitization of cultural heritage, in this perspective, represents a valuable opportunity for the entire community, being able to innovate both the modes of communication and enjoyment of cultural heritage and the educational offer.

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