



**UNIVERSITY OF PIRAEUS
DEPARTMENT OF INFORMATICS**

MSc «Digital Culture, Smart Cities, IoT and Advanced Digital Technologies»

MSc Thesis

Thesis Title:	Digital Tools in Service of the Museum: The Virtual Museum in Educational Practice. Τα ψηφιακά εργαλεία στα Μουσεία: Το ψηφιακό Μουσείο και η εκπαιδευτική διαδικασία.
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July 2023

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Prologue

This master thesis with title “Digital Tools in Service of the Museum: The Virtual Museum in Educational Practice” took place in the context of the curriculum of Informatics department of Piraeus University. This thesis aims to study if and how modern new technologies and digital tools affect Museums and their exhibitions. Moreover is being discussed if and how these digital tools affect the way museums can transmit and share information and knowledge and how, as a result, a virtual museum plays a main role in educational practice.

I hope that this thesis can make all the readers think and inspire, but also be a tool that will contribute to the modernization of all museums, by proving the advantages of the use of digital tools in museum environments. For this purpose this thesis poses research questions such as:

- What kind of role digital tools and technology play in museum environments?
- Can digital tools and technology help people get closer to museums?
- What are the advantages and disadvantages of digital tools in museums?
- What is virtual and augmented reality and their similarities / differences?
- How digital tools and technology can be used in a pedagogical and educational way for the museum visitors?
- Which is the impact of technology in general in museums ?

In order the questions above to be answered the subject was approached in a theoretical framework based on the collection and processing of secondary data, which is based on the review of informational material from literary and online sources.

More specifically, thesis is structured in five capitals. The first chapter refers to the museum. The concept of the Museum and its evolution over time is been studied. Learning theories and museum-educational programs are discussed, which have shaped the contemporary museum, as well as a developing type of museum: the digital one. Then, the second chapter focuses on digital and augmented reality. A review of these new technologies over time is made and their definition and use in various fields of human activity is studied. In the third chapter, a compilation of digital tools is made and their role in education and museums is investigated. The fourth chapter lists the advantages and disadvantages of virtual and augmented reality. Afterward this paper examines the wider use of technology for the benefit of museums and cultural organizations through the use of social media. The final chapter presents step by step the process of organizing and operating a museum. A case study is also presented in which a digital tool has been used for the benefit of the Museum. In the end follow the conclusions and the present study concludes with the citation of the bibliographic sources.

Keywords:

Museum, technology, virtual museum, digital means, education, museum education, interactive experience,

Introduction

The historical path of a human society in a specific place consists of cultural elements which testify its historical memory and its path through time. These elements are the amount of cultural goods which are recorded in this place and constitute its cultural heritage¹. According with article one (1) of the Unesco² World Heritage Convention: *«the cultural heritage is the heritage of material and non material objects and characteristics of a group of people or a society which inherited from previous generations and remain preserved in the present, secured for the benefit of future generations»*³. The material inheritance is distinguished into mobile (material cultural products for which is possible to be moved as for example are paintings, furniture, coins, machinery, ceramic objects, ecclesiastical utensils etc) and immobile material cultural products for which there is no possibility of movement such as buildings, cities, ecosystems, monuments, excavations, mosaics, temples, etc).⁴ These material inherited products can also be tangible as for example useful or decorative objects such as tools, types of ceramics, wood carvings, various utensils, pictures, archives etc or they can be non-tangible as for example traditions, customs, music, songs, sounds, myths etc.

As the years passed these objects began, only in the recent past unfortunately, to be appreciated by humans and the need for their maintenance and preservation was created. Laws were established for the protection of tangible and non – tangible inherited products. MGO and other organizations were also created in order to support this purpose and ensure that the laws were followed. Already many years ago, special “places” were made to serve the need of maintenance, preservation and later exhibition of material inherited products. In these places, the precious, according to the perceptions of the time, tangible inherited products were kept and sometimes exposed, only to a small group of privileged people. These places were the ancestors of museums but they were completely different compared to museums in the present.

1 Pavlogeorgatos G. (2003). Preservation of material cultural heritage. Athens: Observer, page 27.

2 UNESCO: The Educational Scientific and Cultural Organization of the United Nations whose initials in English form its name.

3 UNESCO (1972). World Heritage Convention Article 1 page 2. Retrieved from the site

<https://whc.unesco.org/archive/convention-en.pdf>

4 Pavlogeorgatos G (2003) page 27-28

During the last two centuries museums had been rapidly developed and improved. Not only did they expand their size but also their collections and, as a result, objects that were previously considered of little importance are now saved and preserved. Therefore many, different kind of museums were created such as archaeological, children's museums, industrial, folklore, natural history museum, art museum, military naval museums etc. Moreover, their collections are now available to each person regardless of his origin, educational, economic, social background or any other characteristics. In fact museum show the desire and make an effort to attract more visitors, especially the youngest– children and teenagers. The pedagogical role of museums is nowadays proven and museums are included in the informal learning process, with many museum-pedagogic programs which take place in their space. In recent years the advancement of technology has also affected the museum environment which uses new technological means and digital tools to make the visit to its exhibits faster, easier, more interesting, interactive, accessible and enjoyable for the visitors, especially for the younger. These tools can be digital content in general such as screens, videos, portals to collections of exhibits, audio / sounds, different kind of VR simulation environment provided by 3D digital technologies such as 3D polarizing stereoscopic glasses, virtual or augmented reality, head-mounted displays, gesture-control interfaces, 3D printing or the internet in general through online activities such as games, escape rooms, downloaded games. Social media platforms, a nowadays innovation, such as Instagram, Facebook, Twitter etc help as well the purposes of museums by sharing content or activities.

1. Museum

1.1 The evolutionary path of Museum

According to the International Council Of Museums (ICOM)⁵ museum nowadays is considered to be “*a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment.*“

The concept of the museum, from antiquity to the present day, presents variations according to the political, cultural, scientific, technological, economic and social factors that were in force at any given time. Although for some time it was intertwined with the collection and preservation of objects of the past and / or the present, it soon became associated with research and the transmission of knowledge, necessitating the formulation of an educational policy.

Etymologically, the word “museum” refers to the Muses, ancient Greek deities, daughters of Zeus and Memory and patrons of Arts and Letters⁶. The institution of the museum has its origins in the efforts of people to collect and preserve objects. Collecting activity appears since ancient times in various regions of the world.

The first evidence of a museum can be found in Mesopotamia with the establishment of a library and archive of valuable objects by Hammurabi in the 17th-18th centuries BC. The term “museum”, however, was established in the pre-Hellenic period to designate mosques dedicated mainly to the worship of the Muses but also to important poets such as Homer’s in Smyrna in the 8th BC Century⁷. During the Hellenistic period, sanctuaries and centers of spiritual events acquired a scientific and didactic character. It was then that the museum was associated with the founding of the Lyceum of Aristotle in Athens (4th century BC). This was followed by the founding of the famous Museum-Library in Alexandria by Ptolemy I, Sotira (290 BC), which was a model research center for centuries.

⁵ ICOM: International Council of Museums

⁶ Dalacoura, 2008

⁷ Kakourou-Chroni, 2010:17-18, Glytsi, 2002:246-247

A characteristic of the time was collection and storage. This is how the Art Gallery was created in the Acropolis of Athens and in Heraion of Samos, as well as numerous public and private collections. Until the 4th century AD the collection of treasures from conquered countries is very popular. The spoils are exhibited like works of art of a vast outdoor museum and their cultural value is realized for the first time.⁸

The collection of objects continued in the Byzantine period exclusively by secular and ecclesiastical rulers. Particularly well known are the public art collections in the Hippodrome and the Gymnasium of Zeuxippus in Constantinople and the private collections of Marina and Lavsos (5th century AD). The Middle Ages followed the same path, with religious treasures being accumulated by the Church and feudal lords, allowing access to the people only on religious or royal holidays. The collections that stand out for their rarity and richness are those of Suger, in the royal abbey of Saint Denys near Paris and of Saint Mark in Venice.⁹

During the Renaissance period, the turn to the ancient Greek spirit and humanism and the worship of the face and nature, played a decisive role in the continuous and methodical collection of objects by the humanists. Thus, at this time, the “museum” perception of art is marked. Museum objects are housed in small, blind, privately owned spaces (studio, studiolo, guardaroba) and are treated as objects of aesthetic enjoyment and education for a few selective, interested admirers. In the following years, the collections of the Medici with the establishment of the Palazzo Medici-Ricardi, which would later become the first private museum in Europe, and the collections of the popes and European rulers, projected wealth and imposition, while also laying the foundations for the creation of many well-known, today, museums. Through similar collections, the first university museums were founded in the 17th century, such as the Cambridge museum with the Fitzwilliam collection (1616), the Ashmolean museum in Oxford (1683), Basel in Switzerland (1671), but also some of the largest museums of the world, such as the Vatican museum (1750), the Louvre museum (1793), the British museum (1753) etc.¹⁰

The Enlightenment movement that followed also played its role in the evolution of museums. Advocating rationality and a belief in progress through research and experience, it spoke of new,

⁸ Kakourou-Chroni, 2010:17-18, Glytsi, 2002:249-251

⁹ Hortarea, 2002:180

¹⁰ Kakourou-Chroni, 2010:18-20, Hortarea, 2002:182, Glytsis, 2002: 256-260

modern concepts such as freedom, justice and equality. The industrial revolution and the rise of the bourgeoisie also brought changes in, among other things, the economy, education and religion. Social progress through education and the right to knowledge and education created academies, which contributed to the transformation of museums into public spaces open to the people with the aim of cultivating the human being. The concept of the museum expanded to include new exhibits. Their educational work, however, remained poor until the French Revolution, when their collections were placed in the services of education and science.

After the French Revolution and the creation of nation states in the 19th century, ideas of national identity and pride developed. This created the need to connect the citizen with the national historical past and the need to preserve the cultural heritage of each state. For this purpose, the construction of many national museums in Europe, America, China, India, South Africa and Japan began. The same thing happened in Greece with the National Archaeological Museum of Athens. Museums undertake to cultivate the spirit and national consciousness of the newly founded states and often to manipulate, depending on the wishes of each government.

1.2 Modern Museum

The museum as we know today began to be created after the Second World War, when the departure from the traditional way of life and the rapid technological and scientific developments led to the need to preserve the cultural heritage, which tended to disappear. For this purpose, new categories of museums were created: folklore, ethnography and local history (Nordisk Museet, Stockholm, 1873), eco-museums (Museum of Man and Industry, France, 1971), open-air museums (Skansen, Stockholm, 1891, Colonial Williamsburg, Virginia, USA, 1926, Ironbridge Gorge, England, 1971) technology and science museums (Science Museum, London, 1857, Deutsches Museum, Munich, 1903, Palais de la Decouverte, Paris, 1937), city museums, children's museums, modern art museums, etc.¹¹

With the classification of museums and the emergence of new sciences such as sociology, history, linguistics, chemistry, archaeology, the history of art, etc., a new type of museology was born in the 20th century with the main concern being the protection and interpretation of the cultural heritage and also the targeting and organization of museums. Primarily, however, it focuses on the museum visitors and the ways in which each individual person can express themselves and develop through the museum.

The mission and philosophy of the museum as it was now formed took official form with the establishment of the International Council Of Museums (ICOM) first in 1946 and with the circulation of scientific journals in the field (The Museums Journal, Britain, 1902, Museumskunde, Germany, 1905) until the content and meaning of the modern museum were most aptly captured by the International Council of Museums in 1987. This definition talks about the museum collections that form the core of the museum, but also about the necessity of housing them in permanent spaces, with a long-term and stable character and a system of regulations, while it is expanded to include any monumental space, institution, organization or cultural center with a natural, archaeological, ethnographic, historical, industrial, scientific or environmental character.

¹¹ Glytsis, 2002:268-271, Economou, 2003:46-47

The priority of the modern museum is to promote its public character and place the human – visitor at the center of its attention. The multicultural reality that has taken shape in Greece as well brings to the fore once again issues of identity and memory management. Every multicultural society faces the difficult task of smoothly integrating, accepting and respecting cultural otherness. The right of equal access to knowledge and cultural life regardless of origin or religion, leads the educational sector to cross-cultural adaptation and calls on museums to change the way they approach memory and the historical past.

The modern museum studies the past and turns to the future, seeking to become more open, democratic and extroverted. It is revising its policy and practices in order to reach out to more categories of visitors, from different cultural backgrounds and to promote intercultural understanding and respect for human diversity.

Realizing the heterogeneity of audiences and the way in which objects and collections are perceived, museums are redefining their presentation and interpretation and developing activities and interpretive tools for approaching exhibits that cover all interests and cognitive backgrounds and cultivate critical thinking. This possibility of multiple readings of material culture combined with the use of communication, various media and new technologies in the dissemination of information, familiarizes the public with culture and art by promoting entertainment and consolidating their educational role.¹²

¹² Oikonomou, 2003 :49-52, Glytsi, 2002:271-274, Tsitouri, 2002:22

1.3 The influences of learning theories on museum education

The different performances, perceptions, knowledge and values of each era and society are projected, cultivated and expressed in the cultural environment of museums in all areas, from the thematic content to the exhibition logic and the educational and communication policy they apply.¹³

The promotion of progressive education by socio-political movements and pedagogical research conducted by the social sciences in the late 19th century contributed to the development of theories of learning and knowledge. Depending on the approach to learning (passive or active) and knowledge (gathering or constructing information) these theories are classified into traditional, modern and post-modern and their influences are evident in the reading of history, in the formation of the methods of their transmission in education and as natural consequence, in the way history is communicated in the museum space.¹⁴

Thus reality was given as something one – dimensional and simple and knowledge was inevitably distinguished into objectively right or wrong (positivist theory) and the historical past was identified with the real absolutely and objectively, without room for thoughts and suggestions.¹⁵ The only and correct historical knowledge was reproduced based on the learning theories of didacticism and behaviorism, which were based on the passive mind of the learner, the didactic monologue of the instructor who possessed the knowledge, and its accumulation as a result of linear gradual progress.¹⁶

Accordingly, in the field of museology learning more closely resembled a formal transmission of knowledge within the exhibition space, focusing mainly on the exhibits. It addressed a limited and specially trained audience and was indifferent to their particular individual and social needs, often creating discouraging feelings.

Fortunately, the modern epistemological views were developed on the pedagogical theories of the beginning of the 20th century, regarding the development of the child, the active construction

¹³ Nakou, 2002:117

¹⁴ Hein, 2011:31-37, Nakou, 2002:117-124, Hooper-Greenhill, 1999:47

¹⁵ Nakou, 2002:117-124

¹⁶ Hooper-Greenhill, 1999:48, Hein, 2011:31-37, Nakou, 2001:189-190, Oikonomou, 2003:86, Kougioumtzis, 2014:240

of knowledge and the educational value of experience in the learning process, by Montessori, Dewey, Piaget and Dilthey¹⁷ and in Cognitive Psychology¹⁸, which studied the cognitive functions (perception, memory, language, thinking, ability, problem solving) as responsible for the transformation and storage of information into knowledge.

In 1983, Howard Gardner developed with a democratic approach the theory of constructivism by distinguishing intelligence into five types: linguistic, logico-mathematical, spatial, somato-kinetic, musical, interpersonal and intrapersonal, while later he added the naturalistic or physiognostic and the existential¹⁹. The theory of multiple intelligences emphasized the diversity of individual intelligence and highlighted the need to recognize the importance of diversity in the learning process.

For the movements of Critical Thinking and Constructivism/Constructivism²⁰ reality is multidimensional and knowledge is shaped by all the points of view that arise from the thought process of each individual, as it uniquely emerges based on previous knowledge, values and beliefs. With these new data, the historical past is treated as uncertain and complex, while the theories of discovery and structuralism-constructivism are applied to its discovery. Its character becomes student-centered with the teacher assuming the role of mediator in the process of acquiring skills and producing knowledge

The postmodern educational dimension gives museums a human-centered character and promotes constructive dialogue with their public. Museums nowadays take into account the special characteristics, needs and interests of their visitors and thus give every population group the possibility of access. Their environments and objects foster active-experiential learning that results from sensory engagement, personal creative expression and interpretation, emotional engagement, critical awareness, skill development and entertainment.

In the modern era, museums, utilizing the pedagogical theories of the previous century, invite the visitor to be actively involved in lifelong learning with the rationale that the enjoyment of

¹⁷ Dirogiannis, 2011: 76

¹⁸ Dalkos, 2002:167

¹⁹ Kouyoumtzis, 2014:243

²⁰ Dalkos, 2002:167

cultural goods, intellectual life and cultivation are the right of all, regardless of educational, social or cultural background.

The museum, in an effort to bring all people into contact with culture, connects education with the concept of active-experiential learning. Museum pedagogy is an alternative form of approach to knowledge that is oriented towards the development of a learning that is not identified with examination, performance or success, nor follows specific learning standards.

Learning in museum spaces exists in informal forms of learning.²¹ This means that it does not follow the classic curriculum, the established educational model, where the learner is in a room, usually sitting, passively watching a lecture and then studying. Informal learning usually involves observation and self-activity, like a museum visitor looking at exhibits, and active participation in the learning process. Moreover it focuses on the self-determination of visitors. In other words, it must take into account the possibility of individuals in the formation of the social process and the experience of their individual abilities without the prerequisite of special knowledge.²²

In other words, the methods used in museum education practice focus on learning, entertainment, participation, experience, personal expression and creation. Modern theoretical approaches emphasize the individual particularities of the visitor regarding the ways of perceiving reality and the meanings that he forms (like constructivism, multiple intelligences) but also regarding the concept of experience and active participation to a continued enrichment of the methods applied in museum-pedagogical act.

For this purpose, museums shape educational actions characterized by temporal discontinuity, voluntary nature, freedom to choose content and time of engagement and interactive experiences with a modern character. Interactive experiences, such as museum-pedagogical methods are applied to educational processes that often take place with the support of the animators or other specialized staff of the museums, in active direct communication activities, known as educational programs. The educational potential of museum objects is enhanced when they are supported by new technologies with understandable and easy-to-use patterns, but also original and creative

²¹ Dewey, 1966

²² Lewalter 2009: 50

ones that will give rise to reflection and dialogue. Researches indicated that constructivism as a theory of learning has a greater identification and application with modern technologies in education, which utilize the use of learning in space, learning based on games and simulations, and experiential learning.

1.4 Museum education programs

The first connection of museums with education begins in the 19th century when the interest turns to the Natural Sciences. Initially in the United States of America and then in Europe, the first large educational museums were founded, such as the Natural History Museum in New York (1869) and London (1873), the Children's Museum in Brooklyn (1899), the Museum of Man in Paris (1937). In 1872, the first educational departments begin at the Metropolitan Museum of New York and the Museum of Fine Arts in Boston, while the first educational programs operate at the Victoria and Albert Museum in London²³.

With the transition to the 20th century, education takes on child-centered characteristics. When the international, professional, non-governmental organization ICOM was founded in 1946 as a representative of museums and their workers and a principal adviser to Unesco, the relationship between museums and education was cemented. Although the educational activities of the museums after the end of the Second World War were limited, there is a revolution that begins under the auspices of the director of the Boston Children's Museum, Michael Spock, and from there it is transmitted to the other children's museums of America, Europe and Asia. The idea that learning emerges from exhibits that promote discovery and active participation has found fertile ground in science centers that have contributed to the creation of discovery spaces and educational centers for children.

In Greece, the connection of museums with education was delayed, even though the first faint indications can be traced already from the foundation of the new Greek state. With the end of World War II, a preliminary period begins, in which museums experiment and improvise in the absence of a central coordinating body.

In institutionalizing educational activities, ICOM, UNESCO and the Byzantine Museum took the lead with the organization of the monthly seminar “*The Role of Museums in Education*” (1954). The first initiatives for the educational use of museums in Greece appear in the late 70s and early 80s. In the mid-1990s, the educational activities of museums have expanded rapidly. The educational use of Greek museums begins in 1978-1979 with the organization of the first

²³ Hortarea, 2002:182, Hein, 2011:27

educational programs for school units by the Benaki Museum in Athens.²⁴ The declaration of Athens as the European Capital of Culture in 1985, had given the opportunity for the Ministry of Culture, the National Gallery and the French Cultural Activities Service to work together to organize the first educational traveling exhibition for children “*The Birth of Scripture*”. Since then many other actions followed, however the educational activities of public and private museums as well as various state cultural bodies received a significant boost from the systematic action of the Greek section of ICOM, under whose auspices a working group was set up in 1986 for the exchange of opinions, concerns and perspectives and led to the institutionalization of World Museum Day and the dedication of the year 1987 to Museum Education.²⁵

The meeting the following year of the organization of the Annual International Meeting of the CECA on the subject of the Foundation, organization and operation of educational departments in museums held in the city of Nafplion was the basis for the initiation of seminars aimed at the training of teachers. The now obvious development of museum pedagogy indicates the shift of educational policy towards the connection of cultural heritage with the school. Subsequently, museums begin to give their exhibitions an educational dimension and create spaces suitable for educational activities. All this activity affected the institutions of the state resulting in the passing in 2002 of Law 3028 on the Protection of antiquities and cultural heritage in general, in article 54 of which the ICOM definition of museums and their educational role is adopted.

In order to turn the museum visit into an educational and entertaining experience, educational programs take advantage of the dynamics of interpersonal communication and attempt to effectively involve the public and to form dialogic relationships of familiarity and interaction with the exhibits, but also between participants and mediators, providing an environment which contributes to the understanding of the historicity of material culture and at the same time to the strengthening of multiple readings, personal meaning and self-awareness.²⁶

These actions are characterized by broadness and clarity of predetermined aims and objectives, flexibility of organization of structure and content, timely planning and specific duration (1:30-2

²⁴ Nikonanou, 2012

²⁵ Giaferri, 2005:48-50, Hadjinikolau, 2010:121

²⁶ Gotsis, 2002:19, Tsitouri, 2002:23, Tziaferi, 2005:44, Nikonanou, 2015:52

hours), appropriate preparation and variety of activities, materials and means. A basic condition for their smooth operation is the limitation of participants.

The mediation of appropriately trained human resources (animator, performer, museum educator) is necessary to support the approach to the exhibits by coordinating team-collaborative processes, encouraging discovery, expression and meaning through personal aesthetic criteria and cognitive structures.

In general, regardless of the target audience and the theme, all museum educational programs move under some common axes, which are: the adoption of an attitude of respect towards the institution and the space of the museum, the shaping of socio-political consciousness, the cultivation of a spirit of respect, understanding and acceptance of culturally diverse, the increase and repeat visitation, entertainment, enhancement and self-efficacy of the visitor through a combination of cognitive and affective goals and the enhancement of social and interpersonal skills.

1.5 Digital museum

Nowadays many museums include new technologies. These new technologies (devices) serve numerous needs of museums, as for example, they offer more interaction between the museum and the visitors. Therefore the whole experience becomes more personalized, interesting and immersive.²⁷

Firstly, they serve the educational role of the museum in a more contemporary, modern, entertaining and often practical way, when museum collections cannot be present for reasons of, for example, maintenance or transport. The new technologies are also very practical when it comes to multicultural, heterogeneous audience with diverse cognitive backgrounds. Many museum applications (which for example navigate the visitors through museum space and explain the exhibits) easily and quickly solve the problem of the language of communication by immediately being available in many, different and often rare languages. In this way, the visit of the museum from a multicultural environment, by tourists or immigrants, becomes easier and more direct, without the need for the presence of a specialized guide, which can often be a costly and distracting service.

Also many applications and technology packages contain images and games, making the museum space understandable and more enjoyable for specific groups of people and younger people. Their attractive presence and their identification with the modern world through technology, often attract people – visitors to the museum space. The new technologies have entered our lives significantly, therefore they could not be absent from the museum space. People – visitors and mainly the younger ones (children, teenagers, young people) are attracted in a different way from museum collections and exhibitions when a contemporary device or application is involved. The museum space automatically becomes less serious and drained of every contemporary and entertaining aspect.

However, this digital transformation is not something that took place suddenly and quickly. Years of technological developments, innovations and discoveries introduced new technologies into our lives and later into the museum space. This ongoing process is clearly not over, since each museum enters the digital transformation gradually and at its own pace. A costly but

²⁷ Pujol & Lorente, 2013

continuous process, since it evolves as both technology and man evolve and progress. Virtual and digital museums serve the same functions as their ancestors (collection, research, exhibition, etc.), while they operate in a complementary and auxiliary way, either when it comes to a visit to the museum itself or when it comes to a remote visit, via the computer.

2. Virtual and Augmented reality

2.1 The history of virtual and augmented reality

Human efforts to create virtual reality environments had already begun almost a century ago, many years before computers actually existed! Many steps were taken as well as many stages until virtual and augmented reality reached the level we know it today. Some of the most important ones are mentioned below:

In 19th century, round rooms with realistic historic murals on all walls made viewers feel as if they had a journey in the past. In 20th century, Edward Link built the first mechanical flight simulator for pilot training in confined spaces.

In 1933 *Hugo Gernsback*, an American scientist, visualized the idea of “teleyglasses” (Figure 1). The glasses included two small screens for each eye, they weighed about 140 grams and had small buttons on the front and a TV antenna. Current was drawn from small low-voltage batteries.



Figure 1. The idea of teleyglasses, Source: [Teleyglasses]

The *sensorama* (Figure 2) was a machine, considered as the first virtual reality simulator. Its technology was introduced in 1962 by *Morton Heilig*²⁸. Its structure was about the size of a modern arcade video game. A person sat in the attached chair, held onto handles and looked into

²⁸ Morton Heilig: American pioneer in virtual reality technology and a filmmaker.

a display that showed a film. The chair vibrated and moved, speakers delivered sound and smells were created to match the movie.



Figure 2. The idea of sensorama, Source: [Sensorama]

Later, in 1968, *Ivan Sutherland* created the first augmented reality system, which is also the first virtual reality system (Figure 3 and 4).



Figure 3



Figure 4

First augmented reality system, Source [first AR system]

When computer scientist Jaron Lanier popularized the phrase in 1987, virtual reality became more widely used. Lanier was one of the pioneers of virtual reality and founder of the company VPL Research. Among the virtual reality accessories created by Lanier's company was a head-mounted display. However, the prohibitive cost prevented regular customers from using it. The

early 1990s saw virtual reality move into video game arcades. People wore virtual reality goggles to play immersive three-dimensional games.

Two years later Nintendo²⁹ released the *Virtual Boy* (Figure 5), a game console with which the users were able to look into the eyepiece and see three-dimensional graphics. Although the product didn't meet the expectations, it was one of the first, decent, completed attempts of virtual reality product / game. The main problem that didn't become popular was the lack of advanced technology, poor quality screens and therefore image. Other similar products in this decade met the same fate.



Figure 5. Virtual Boy, Source [Nintendo]

In 1992 computer scientists *Tom Caudell* and *David Mizell* invented the term “Augmented Reality” to refer to a material presented on the computer based on the real world.

In 1993 J. Loomis et al. create an outdoor navigation system for the visually impaired. Meanwhile G. W. Fitzmaurice creates “Chameleon” (Figure 6), a device which displays spatially positioned information via a traceable handheld device.



Figure 6. Chameleon, Source [Chameleon]

²⁹ Japanese multinational electronics and video game company

In 1994 S. Mann started wearing a portable camera from which he broadcast live images, while walking, to his website. In 1995 J. Rekimoto and K. Nagao create the ‘NaviCam’, a device similar to the “Chameleon”. In 1997, Ronald Azuma, a famous today computer scientist, because of his contribution in Augmented reality field, presented the first research related to Augmented Reality, attributing three characteristics: It combines the real and the virtual, it is interactive in real time and it is recorded in 3D. In the same year T. Starner et al. explore wireless augmented reality, creating a small community of users with wireless computers connected to a network. In 1999 H. Kato and M. Billinghurst present the ARToolKit device, an open source computer monitoring library for building augmented reality applications, while T. Höllerer et al. develop a mobile augmented reality system (mobile AR system), through which users have access to a tour guide.

In the 2000s, there has been a rapid development of these technologies. In 2001 V. Vlahakis et al. present “Archeoguide”, a mobile augmented reality system for cultural heritage sites. In 2008 the company METAIO presents a mobile commercial augmented reality museum guide for an Islamic art exhibition. In 2012 the glasses of Google, Google Project Glass, (Figure 7) are presented, which work with a touch sensor or with verbal commands.



Figure 7. Google Project Glass, Source [Google Glass]

Augmented reality became popular in 2016 with the smartphone game *Pokemon Go* (Figure 8). In this game players were able to see a view of their location while creatures appeared nearby

and users could interact with them. The creatures then appeared on screen, interacting with the real world!



Figure 8. Pokemon Go, Source [Pokemon Go]

Nowadays better product designs (smaller, more comfortable) and more powerful computer are able to offer realistic, convincing graphics. But graphics alone today are often not enough. People need more to feel immersed in a virtual world. Headphones and special controllers help to improve the illusion (Figure 9). Users hear sound effects all around them and are able to grab and interact with virtual objects. Some devices even use haptic technology, a technology where users feel pressure or force through the controllers when they touch something. As immersive as virtual reality is today, the improvements don't stop here. Computers become more powerful and virtual reality designers become more experienced. As technology improves and costs come down, amazing virtual reality experiences will become widely available.



Figure 9. Equipment, Source [Equipment]

2.2 Virtual and Augmented reality

Nowadays many sites, educational digital programs, applications and games use *virtual reality*. Virtual reality shares similarities with another technology called *augmented reality*. Virtual reality creates entirely virtual worlds to explore and augmented reality combines computer graphics with the real world.

Virtual and augmented reality are some of the most neoteric techniques applied. As a result it is difficult to give a clear definition for each one.

During the 1970s the term “Artificial Reality” was appeared. The term “Cyberspace” was followed and right after the term “Virtual Reality”.

One of the first definitions for virtual reality was formulated in the 1980s from Jaron Lanier: «*virtual reality is an interactive, three-dimensional computer-generated environment in which one can immerse*». Immersion is the illusion the user experiences of being in a virtual environment. This immersion is particularly successful when it manages to isolate the user from his natural environment. However, according to new positions, immersion is not the only characteristic to achieve a virtual environment. The structure plays an important role, as well as the ability to navigate. Based on this approach, virtual reality is defined as a computing system used to create virtual worlds in which the user can navigate and interact with objects.

In 1991, the following definition by M. Krueger was given: “*Virtual reality is a term that has recently become known but also one of the most widespread in the field of computers, which transports the user or users to a synthetic, artificial, virtual, made from the computer environment*».

Another definition is that virtual reality uses computers to create environments that they don't really exist but the user has the illusion that he and his senses are real and exist in the real world. A digital illusion environment experienced in three dimensions (3D): width, height and depth.

In order to achieve the goal of immersion and the illusion to be as realistically as possible, the image should be of high definition, the sound should match and support the image, the

movement of the head (if virtual reality devices are used) should be smooth and realistic to avoid problems of dizziness and the interaction to be generally continuously and obvious. For a satisfactory immersion, specialized devices are used, which we will study in the continuation of this paper. Some of them are virtual reality helmets or glasses, full-body suits, gloves, headsets, etc.

In conclusion, all the definitions that can be found and compiled for virtual reality so far agree more or less on a common point: virtual reality is described by the three I's – immersion, interaction, imagination. Virtual reality as a science has as its object the representation of worlds with the use of electronic computers. The worlds that result from the operation of such a system are called virtual worlds and serve many purposes such as: communication, research, education, etc.

On the other hand, the path of augmented reality began after virtual reality. The idea of augmented reality came from virtual reality and one is a continuation of the other.

The first person who formed an idea about augmented reality was L. Frank Baum in 1901. This idea involved a kind of electronic glasses (Character Markers) that would project data into the real world. Many years later, in 1990, the term “Augmented Reality” was finally established by Tom Caudell, research of Boeing.

Augmented reality, like virtual, is defined differently by many people. According to Tom Caudell: *«augmented reality is the interaction of greatly improved graphics, sound and other senses in a real environment and in real time»* (Casella, 2009). Ronald Azuma³⁰ also mentioned that: *«augmented reality is a variant of virtual reality, but we should not confuse them because augmented reality complements the real world and does not replace it»*.

In general, augmented reality is an innovative idea in computer graphics. As indicated in its name, augmented reality «augments» information, it does not replace the real environment, but enhances it. It enriches the human senses by adding virtual information to the real world with the help of the computer. According to Azuma et al.(2001), there are three characteristics of

³⁰ American computer scientist, widely recognized for his contributions to the field of augmented reality.

augmented reality: it integrate real and virtual objects into reality, collaboration between real – virtual objects and real-time interaction between real and virtual objects.

Although both virtual and augmented reality are equal popular and present in various different fields of human activity, as we are going to study, augmented reality is becoming more and more popular because it provides a more personalized content and more interactive and dynamic experiences.

2.3 Virtual and augmented reality applications in various fields today

Virtual reality and augmented reality applications have gradually infiltrated our daily lives and many aspects of human activity. Although initially they were used only in the field of entertainment, as time passed, they proved to be useful and were used in other, various, diverse and different fields, as in the fields of architecture, military, medicine, and of course education and culture.

Businesses started using augmented reality technology many years ago. For example, a free application from Ikea allows shoppers to place virtual furniture from Ikea stores in their homes to understand if they really like them, before buying. Moreover new professions were created through the development of technology. Graphic designers create visual concepts (advertisements, brochures, magazines) by using computer software to communicate ideas and attract costumers.

In architecture, virtual reality is used for the purpose of visualizing the architectural effect before the actual construction and early detection of imperfections. Architects often use augmented reality to see how a proposed building will look in a given space. Google with the *StreetView* application since 2010 has introduced the use of stereoscopic projection (Stereoscopic 3D Mode). This 3D map navigation makes it easy to navigate in the real world.

Virtual reality applications have entered the military sector many years ago. Soldiers train and improve in various military engagement situations (combat simulators, driving vehicles and aircraft, using weapons and aids etc) through applications and virtual simulations. This way they learn how to react and train in realistic situations, with zero risk. In this way we would say that virtual reality supports professional training of soldiers with a large variety of military training.

Virtual reality in medicine has developed rapidly in recent years, particularly in fields such as surgery and psychiatry. In surgery, virtual reality presents objects as realistically as possible and with human sensations in a way that they look almost real. Doctors have been using VR to assist in surgeries and pinpoint ailments. In psychiatry, it is used for the prevention and treatment of psychological disorders, such as for example in the treatment of phobias. Nevertheless, virtual reality is also used in the training of medical specialists by creating applications to represent the

human body. In this case, the virtual camera can move inside the human body and study the structure and function of the organs.

Virtual reality has also developed in the industrial sector. In this field we find applications that are used in the simulation of different machines or in production processes, such as the simulation of excavator operation or the maintenance of networks and facilities. It also offers valuable help in the design of spaces and the construction of objects of daily use. Finally, it is used for the training of various specialties and mechanics.

As is logical, the use of virtual reality could not be absent from the fields of education and culture.

Modern educational needs impose modern teaching methods and cultural life with the use of digital technologies. Digital technologies form an entertaining and always available virtual school that doesn't know geographical and temporal borders. Virtual reality applications provide satisfactory quality and fidelity in the representation of, for example, statues, paintings, works of art, in order to attract the student's interest and offer motivation for active learning. Educational applications have also been created for subjects such as Physics, Chemistry, Mathematics, Biology, etc. based on experiential learning and a participatory approach to the course material. Simulators were also used initially, through which micro-experiments took place. Soon came gamification, the use or integration of game mechanics and features in non-game activities, a process that gave positive results such as increasing children's participation and performance. At the same time, the educational dimension of video games was under discussion.

However, virtual reality is not limited to formal education. In the last decades virtual reality entered the field of culture such as archeology and museums. With the help of innovative and 3D technologies, virtual reality was integrated into the cultural sector and thus museums, and other cultural places, offer entertainment and educational services through applications that allow visitors to interact with the exhibits. Today, more and more museums, both abroad and in Greece, offer this possibility to the visitor. According to research, the use of applications increases the usability, immediacy and interest of visitors.

In these fields, as well as in many others that have not been mentioned or will arise in the future, virtual and augmented technology is progressively and radically penetrating and, as a

result, change completely the existing situation! Although in the same fields where we encountered virtual reality, we also encountered augmented reality, there is a key difference: with virtual reality, the user is completely transported to the environment of the virtual reality / application, which is also his / her basic environment and learning tool. As a result, he / she is trained exclusively through the application while, in contrast, in augmenting reality the applications work as reinforcements in the kind of existing environment by providing additional information.

Finally, there is one more noticeable difference between virtual and augmented reality: the digital tools each uses. A multitude of digital tools are used by users, both in virtual and augmented reality, to optimize their experience. These tools, as we will see below, are various. Masks with screens and sensors for the virtual reality environment and special glasses in combination with the smartphone or tablet for the augmented reality environment, are just some of them.

3. Digital tools in Education and Museums

3.1 Digital tools and their application in education

As mentioned before, virtual and augmented reality appear in many fields of human activity, both in the professional space and in the rest of life, covering utilitarian and entertainment needs. Virtual and augmented reality take places by using digital tools targeting key elements such as aesthetics, interaction, interest, usability, satisfaction, motivation, curiosity and enjoyment.

The use of computer visuals in conjunction with the physical world is known as augmented reality (AR). As compared to Virtual Reality, AR is less immersive. However, users have placed digital items, places, people, etc. in the actual world, where they still "exist" and interact. The cost of AR systems has recently decreased because to developments in mobile computing. A trigger image that our mobile device recognizes frequently causes the augmented reality to activate. A movie, image, webpage, or other action is overlaid on the trigger image once the device has identified it. In contrast, augmented reality frequently does not require a trigger image. Today's mobile AR applications overlay the real environment with dynamic and interactive digital content using head mounted displays, cameras, QR codes, audio guides, GPS sensors, and mobile device Internet connectivity.

Students may explore the world even if they are far away because to 360-degree videos, which allow them to see every angle. With the help of a mobile device, students may watch how the image follows them around as they move the device.

The “*Google Art Project*” is a program for online display of major museums from around the world and includes hundreds of exhibits from museums including the Acropolis Museum, the Benaki Museum and the Museum of Cycladic Art in Greece. Its advantages include the very close distance from which one can process the exhibits, a distance that would certainly not be allowed in the physical museum! The Google Art Project hosts a total of 151 museums from 40 countries!

Nowadays digital books are often about to replace “real” books. Digital books are intended for consumption on digital devices (tablets, computers, kindle etc.). Now a student can read and, while reading, simultaneously do another activity on their digital device, without leaving the

digital book. In addition, the digital book is lighter and always available, while often is free of charge.

The stylus pen is a special type of pen (Figure 10) which I write on a surface that I connect to the computer. Although it is not visible what I write on the surface, it does appear on my computer screen! The stylus pen is used by the graphic designer to draw, but it can also be used by other professionals. In the field of education, I can use the pen for remote teaching, through the computer, thus turning my computer screen into a whiteboard.



Figure 10. Type of pen, Source [Stylus]

Of course, there are also tablets on which I can use this type of pen and in this way take notes, read, after I first download the electronic version of my book, and solve my exercises, as long as they are in a digital file, or my digital book.

The video game Minecraft (Figure 11) isn't really violent or even that challenging to learn how to play. It was released in 2011 and since then became very popular. Minecraft creativity lets players build structures out of variously textured cubes in a 3D, algorithmically generated world. As it was recognized how Minecraft focuses on creativity and building, as well as its great appeal to children, it was soon used for educational purposes, encouraging the “reconstruction” of knowledge and creativity. Play-based, imaginative learning is encouraged via the platform known as Minecraft: Education Edition.

It offers practices for exploration, storytelling and digital learning, through building objects and achieving tasks in one digital “world” where children can design and build, for example, an ancient temple or a chapter of history.



Figure 11. The Minecraft Application for Android, Source: [MinecraftApp]

With new technologies and digital means, an ancient temple not only can be recreated in a 3D environment but it is easy as well people to feel like walking inside the temple, as they actually were there, without leaving the classroom. Other applications such as *virtual tours*, *360° panoramas* and simulating environment provide students with the opportunity to view on their screen exhibits and move its figure to see all its views or moving. They can even visit a whole museum or stroll to anywhere in the world or watch a human heart inside the classroom! Some applications, due to augmented reality are able to show a representation of place as it was in the past, when a user points his phone camera in the direction of an object. As a result so the visitors of a museum are able to observe, for example, how the vase in front of them in the vestibule was used or how the palace room they are in was like when the palace was still inhabited. Science teachers are using virtual reality applications in order to manage to understand better subjects such as biology and anatomy, which require students to grasp the inner workings of cells and organs that are not visible to the human eye.

Such “simple” applications are often available and easy to access like the software that Hewlett-Packard (HP) offers to create augmented reality triggers through free HP Reveal app (formerly Aurasma Studio) or website <https://studio.hpreveal.com/landing>. Other are easy to create and use only by using our smartphones, a device that we all now have. Many of them are immediately available and often free of charge through the Google Play Store. Other are more specialized and complex and therefore need a person familiar or trained in their use.

A more specialized application is “*JigSpace*” (Figure 12 and 13). In *JigSpace* students are able to observe different views of the object according their position. For instance, they can move closer or farther from the table and by that they will get to see different perspectives of the heart.

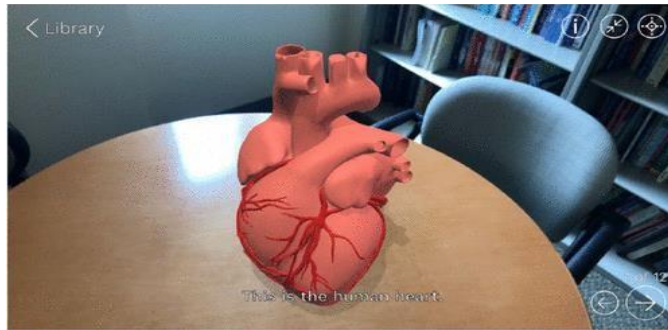


Figure 12. Heart, Source [JigSpace]

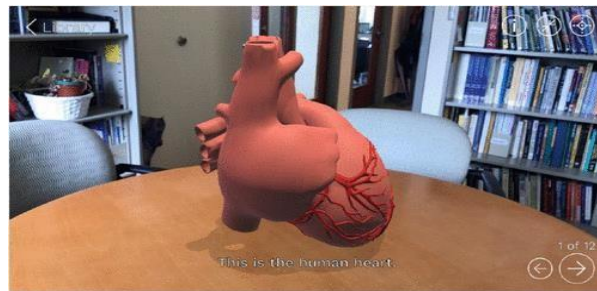


Figure 13. Heart, Source [JigSpace]

The “*Froggipedia*” (Figure 14 and 15) application represents the life cycle of a frog. It offers virtual dissection options and includes an augmented reality feature through which students can view the integumentary, skeletal, nervous, urogenital, respiratory, circulatory, and digestive systems of an augmented reality frog that virtually appears on their desk.



Figure 14. Frog, Source [Froggipedia]



Figure 15. Frog, Source: [Froggipedia]

zSpace is a technology company that combines virtual and augmented reality by using a computer. *zSpace* offers its services to the educational community. With mixed reality computers from “*zSpace*” and 3D glasses or applications such as “*Cyber Science*”, “*zSpace studio*” and “*Human Anatomy Atlas*”, students can actually “see” their “lesson” as for example the cells and organs of human body to “come off” the screen thanks to VR/AR technology. (Figure 16).



Figure 16. Computer, Source [*zSpace*]

Platforms like “*Peer*” aim, as well, students. They have developed compelling visual models of difficult physical science theories such as gravity, molecular bonds, and force.

The platform “*CoSpaces Edu*”, provides users the opportunity to create their own virtual reality experiences. It offers many options to students and educators such as storytelling, exhibitions, simulations etc. Students are able to animate a colonist in history class, head out to sea for trade and so many more options! As a result, students are able to understand history better and also explore how life in the past was. At the same time, they develop digital literacy, creativity, collaboration and critical thinking. Headsets and gloves they may achieve a better and more realistic contact with the virtual environment but are not necessary.

3D printing is the construction of a three – dimensional object (Figure 17). A 3D printer can create the object in many different ways. The objects are being created due to cooperation of 3D printer and electronic computer. The computer gives the printer the order to add some material to the object (such as liquids, plastics or powder grains being fused). This process has many advantages, but one of the most important is the opportunity to create objects that normally would have been very difficult to manufacture by humans due to the complexity of their

construction. 3D printing has been used within museums and art galleries to create objects of different exhibits (Hess and Robson, 2013), replicate objects (Klein *et al.*, 2014) and to study, educate and preserve (Neumüller *et al.*, 2014).

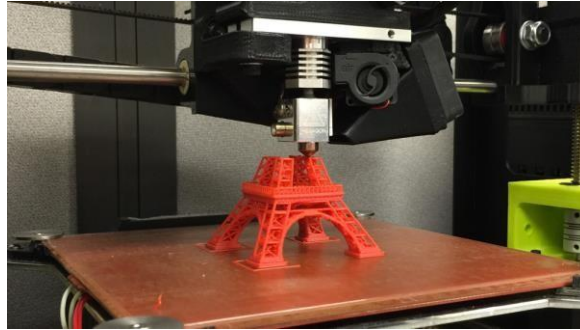


Figure 17. 3D printing, Source [3D printers]

The nonprofit “*Global Nomads*” piloted the “*One world, many stories*” program. This program unites, thanks to virtual reality, twenty classrooms in the United States of America and the Middle East. Through virtual reality the students are able to explore other cultures and experience daily life in other corners of the planet. Therefore, some students in a high school in Campton were able to experience an explosion, which helped them gain perspective about life during war. Nonny de la Peña, the creator of the simulation said: “*I never dreamed that I was going to take it to high school students, who might be able to make changes in the lives of Syrian children refugees*”.

These are just a few of the opportunities that technology presents for the educational sector. Many more new and revolutionary tools are going to be developed in the future as man and technology evolves. These tools help not only learning be more understandable, but also more enjoyable, interesting and creative for students of all ages. These tools will certainly not be able to be included in the educational process and used (correctly) if the necessary structures are not created, if the equipment used by the students is not modernized and if the teachers are not properly trained. These are parameters that we should take into consideration and try to fix in order to benefit to the maximum from the progress of technology.

3.2 Museums all over the planet that use digital tools

With the aim of increasing their visitors and offering a satisfactory museum experience and learning process to the entire public, there are more and more museums around the world today, which have undergone a partial or complete technological modernization. A radical and, admittedly, expensive renewal that, for each museum completes at its own pace.

Google Art project provides the opportunity to visit virtually a museum. Online visitors have access to more than 300 cultural institutions all over the world. The users of Google Art project are free to visit the exhibits in their free time, without any restrictions such as distance from the museum, expenses or restrictions of opening hours. A few well know museums that can be found in Google Art Project is the Metropolitan Museum of Art in New York (The Met Museum), the Doge's Palace in Venice and so on.

Given that the examples are innumerable, in this chapter an attempt will be made to record some, in my personal opinion, valuable examples of museums in Greece and abroad, which have partially or fully included the new technologies in their operating program.

The [Archaeological Museum](#) of Athens, one of the most important and modern museums in Greece, near the rock of the acropolis, could not ignore the technological transformation. Following international trends and practices, it implemented the complex and multidimensional work of creating the Acropolis Digital Museum. The scanning of a large part of the archival material of its collections significantly enriched its digital repository, ensuring the long-term preservation and effective management of this valuable material and forming the base for the creation of multimedia applications. At the same time, modernized its equipment (personal computers, printers, 3D scanners, touch screens, media players, video, digital games) for a more enjoyable and interactive visit to its collections. Moreover it renewed its website, where audio tours are offered, and all the works of the Museum's permanent exhibition are presented digitally, as well as part of those kept in its warehouses, and it created a specially designed for children website with games, videos and creative activities connected to the museum and learning. This purpose is also served by the applications it has developed such as "a morning in Ancient Athens", "a strange walk in the Acropolis" and many others.

A newly founded museum, a rather innovative idea that introduces a new image of technology in the mind of many people who experienced technology at its beginning: technological achievements, already a few decades in the foreground, acquire history and their rapid evolution making preservation and conservation necessary of some of their “ancestors”. This is exactly what the [Greek IT museum](#) aims for. Unique of its kind in Southeast Europe, it presents older generation computers and game consoles, mobile phones, electronics and other accessories straight from the past. Beyond the physical space, in which there are its exhibits, it offers a virtual tour and remote tours through the online platform of Museotek. It also offers a virtual reality game, an interactive application compatible with Android and iOS, through which children, using VR glasses, are encouraged to get to know computers by playing. In the end, it offers the Smartify augmented reality service, which you can use by physically visiting each Museum to get additional information about the exhibits you see in the Museum’s showcases.

A small museum, but rich in material, is located in a small provincial area of Greece, but big in history and importance. Kalavryta is a mountainous town in Peloponnese (Achaia) in Greece. It was one of the areas that experienced in the harshest way the German imposition during the occupation (1941-1944) with mass executions of men and the total burning of the city. The [Municipal museum of Kalavryta’s Holocaust](#) (Figure 18) keeps alive this dark page of the history and pays tribute to the fallen. For several years now, it has adopted audio-visual material in its collections, with which the visitor can see on screens people from Kalavryta who experienced or heard the horrors of the executions and hear their words. The screens are interactive which offers, as a result, to visitors the opportunity to choose which stories and which part of each story are interested to hear. At the same time, visitors can watch documentaries about the execution in Kalavryta and observe as well photographs with evidence of the fallen, those who have at least been identified. The Museum has also digitized a large part of its audio-visual material and collection, in Greek and English as well, with the support of the Stavros Niarchos Foundation, to meet the information-knowledge-research needs in matters related to the Kalavryta’s Holocaust during the Second World War.



Figure 18. Municipal museum of Kalavryta's Holocaust. Source [Kalavryta's Museum]

From 2016 the [History Museum of the National and Kapodistrian University of Athens](#) (Greece) has developed an application that offers a digital tour, both remotely and in the Museum area. Through a digital journey to the 19th century, the application guides visitors through the exhibits of the Museum. Following a young man of the time, Emmanuel, the visitor answers questions such as: what could one study at the newly founded University of Athens in 1840? What were the first textbooks like? What did the new capital look like? How was the life of a young person of that time?

A unique, amazingly technologically equipped museum is located in the capital of Germany, Berlin. The [DDR Museum: Berlin's interactive museum](#) (Figure 19). The DDR museum or museum of the German Democratic Republic is an interactive museum, in which the visitor learns in a straightforward and experiential way about everyday life in East Germany. Objects (an entire car and motorcycle) and decoration (an entire East German apartment and more) that gives the visitor the impression that is actually transported in another decade! Interactive screens, some offer to visitors information, some other help him/her see themselves on clothes of this period.

A real television with a touch – remote control with East German's channels. Video and representations from projectors everywhere. Countless objects, some of them interactive, and automations. Headphones, music and sounds everywhere. The whole sound system that runs throughout the museum gives visitors the feeling of being watched, transporting them into the atmosphere of East Germany.



Figure 19. DDR Museum: Berlin's interactive museum, *Source [DDR Museum]*

The [Museum of Fine Arts in Lyon](#) uses an application called “*Musée des Beaux-Arts de Lyon*”. It is a mobile application which offers information about the museum such as prices, bookings, opening hours. The application is also available as a guide for everyone who wishes to visit the museum virtually. Five more tours are offered on the application for everyone who wants to visit the museum without a human guide. The application provides the museum's collection in high definition, including text, video guides, 3D map of the museum and 360° virtual tours.

The [Museum of London](#) (Figure 20) offers the “*Street Museum*”, an augmented reality application. This application uses black and white photographs of the museum's collections, which are laid over the real streets so people are able to experience how London was in the past!



Figure 20. Museum of London, Source [Street Museum]

In [Museum of Modern Art](#) (MOMA) in New York applications are used to introduce museum objects. One such an applications is the online game “Destination Modern Art”, an interactive online gallery which offers an introduction to the Museum of Modern Art.

[Smithsonian National Museum of Natural History](#) in Washington deployed an augmented reality mobile application. This application gives people the ability to see an animal come to life on the screen of their device, simply by pointing the device at the exhibit (the skeleton) located in the Museum. The museum also offers virtual self-guided tours for the application users.

[The Rijksmuseum](#), dedicated in Arts and History, is the national museum of the Netherlands and is located in Amsterdam. The museum has developed an application called “*Family Quest*”. “*Family Quest*” is a game which can be played by two or four players. The only requirement is each player to own a digital device inside the museum and the goal of the game is to find secrets within museum objects!

A similar approach is used by the [Yorkshire museum](#) and the [National Museum of Scotland](#) in Edinburgh. The museums offer to users who have a mobile virtual games. The purposes of the games is to reveal additional information for the exhibits, while exploring museum’s collections and solve riddles along the way.

The significant impact of virtual reality technology encouraged many museum, cultural tourism organizations and online projects to use augmented reality for enhancing their visitor’s

experience. An example of an online project is *Europeana*. Europeana gives museums the opportunity to integrate their artifacts into a digitally accessible European cultural heritage collection. Europeana collects exhibits of cultural heritage from galleries, libraries, museums and archives all around Europe and make them accessible online.

It's obvious that technology gave visitors a more active role during their visit. The visit became more interesting, interactive and playful. Technology mainly improved museums visits for every member of the family!

3.3 Technology and museum education

Over the past few years, teaching and learning using augmented reality (AR) have advanced quickly. The use of AR offers the opportunity of improved learning experiences in formal teaching (e.g., in classrooms) and in informal learning environments (e.g., museums).

Mobile learning can enhance these benefits by enabling teaching via wireless networks and mobile devices. As a result, the learning process can take place anywhere, and at the same time ensuring teacher–student interaction.³¹ The use of touch screens, smartphones, and tablets equipped with 3G, global positioning system (GPS), and long-life batteries developed new acquisitions of technological and pedagogical skills and methods.

A natural activity that might happen in our daily lives from numerous and various motivations is interaction as informal learning. The interaction of the devices encourages students to become more active learners, according to previous study on interactivity in learning.³² When using a gadget, a student's autonomy encourages participation in the learning process and improves knowledge assimilation. The mobile devices as museum handbooks³³ and learning systems³⁴ are so far liked by public and very successful. This fact shows the interest in the use of interactive devices as learning tools.

The use of virtual reality for educational purposes is consistent with the constructive learning theory (constructivist approach), as the participant in similar applications is called to act in order to acquire knowledge, but also with the experiential approach, because learning through experiences is promoted.³⁵ It is based on the theories of J. Dewey, J. Piaget, I. Vigotsky, W. Dithley and H. Gardner and argues that knowledge is formed by the individual himself during his interaction with the environment for himself, individually and socially.³⁶ Typically, virtual visitors wish to engage in a “learning experience” or learn for fun.

³¹ Moreira & Ferreira, 2015; Tsvetozar, Evgenia, & Smrikarov, 2004

³² Looi et al., 2010

³³ Hsi 2003; Sung et al., 2010

³⁴ Hwang et al., 2008; Huang et al., 2010

³⁵ Barbatsis, Oikonomou, Papamagana, & Zozas, 2010

³⁶ Nikonanou, 2012, p. 82-83

Informal learning, which means out of classroom learning, with real world experiences offers many advantages. Mobile device's portability and functionality make them suitable for learning in different environments such as home, outdoors and museums. Moreover students are nowadays more interested in mobile devices than, for example, books. The engaging with a mobile device could motivate them and make knowledge acquisition more enjoyable (Sung et al., 2010). Therefore, many researchers have employed new technologies and customized mobile devices (Cabrera et al., 2005) for gaining the interest and transform the experience of museum visitors.

Maya Georgieva is the co-founder of Digital Bodies – a group studying the combination of virtual reality and education. As a supporter of this combination, she states that although virtual reality is currently considered complementary to the learning process in classrooms, the benefits are so many that this is going to change in the future.

For the open-air preservation of knowledge and culture, the museum is a vital resource. Chun-An Chen and Hsin-I Lai, students in universities of Taiwan examined the ARCS model (Attention, Relevance, Confidence, and Satisfaction) in application of augmented reality in museums. As they were exploring the factors influencing the learning motivation and effectiveness in museums, their research showed up that the use of augmented reality in museum has an important influence since motivates people to learn.

Augmented reality technology combines learning, teaching and autonomy, all factors that benefit the educational process and provide a faster, easier, and more joyful learning experience. This fact shows that is very likely augmented reality to be adopted more and more in the near future.³⁷

«Tell me, I'll forget, show me, I'll remember, Involve me, I'll understand»

- Chinese Proverb

³⁷ Wu et al., 2013; Johnson et al., 2016)

4. Advantages and Disadvantages of Virtual – Augmented reality

4.1 Advantages of VR / AR in museums

As we have already established, virtual and augmented reality are two relatively recent technologies that have entered our lives with remarkable speed. It is not about two completely different technologies, but on the contrary, about two types of technology that complement each other. Although they were originally designed for the game industry, they quickly entered other fields of everyday life, such as in education and training, as it is very immersive. Their use has changed in many ways a lot of aspects of human activity, and as with everything, positives and negatives result from their use.

But what are the advantages in the field of education and museums?

With virtual or augmented reality, people have the opportunity to immerse themselves into environments in which they are not physically present. People can, for instance, explore the great museums of the world without leaving their country or their home! Virtual or Augmented reality technology allows visitors to fully explore the museum contents without restrictions such as space, time and language. In addition, are easily accessible again after visit. Technology can help museums to overcome many of the restrictions that they cause problems to provide their services to visitors..

This positive aspect of museum access with new technologies has been more useful and relevant than ever, in the recent past. The global phenomenon of the corona virus and the quarantine closed dozens of museums and cultural spaces and forced people all around the world to remain in their home. New technologies have helped the world overcome this difficult period of isolation and feel less alone. They offered communication, entertainment and a form of ``normality" to whoever wanted it, by making museums and other places of culture potentially and digitally visit able.

Therefore technology allows visitors to restricted objects or heritage sites and makes transmitting knowledge easier and more pleasant since modern ways and technologies have been

used. These technologies are easily accessible from average people who nowadays are familiar with the use of a tablet or a smartphone and most of the times are free of charge. These factors help their rapid establishment of their use by the general public.

Moreover virtual, augmented and mixed reality technologies are used widely to multiple target groups. They are not only benefited the average visitors, by making the learning progress easier and more interesting, but can also help visitors with special needs, difficulties to cope with environmental factors (humidity, temperature, steps etc) or other health issues to reach difficult for them or inaccessible areas and provide them with a personalized cultural heritage experience.

Another target group from which virtual and augmented reality it is well received are children and young age groups. Virtual and augmented reality can offer interaction to a static museum experience and make the experience a lot more interesting, especially for kids. Therefore a lot of museums use applications especially to attract their younger audiences.

The use of these technologies could be particularly useful for children (and adults) who face learning difficulties. In this way, virtual and augmented reality applications will not only give a pleasant and interactive aspect to learning, but will essentially help these target groups contact easily with information and its understanding. Students with dyslexia, for example, will not need to read a text with the information and students with attention deficit or hyperactivity can use virtual reality glasses with which they get concentrated, excited and they absorb the content. Technologies like these can be beneficial for students with any kind of difficulties in any subject.

Virtual and augmented reality use has motivated visitors to visit the real sites and gain more knowledge, which enriched their visits. By using virtual and augmented reality the “visit” in Museum's collections became easier. This not only helped the visitor, but also the Museum, which often found that many users of the virtual tours decided to visit the museum later in person. In addition, virtual visits can support visitors after the visit and help them deepen their knowledge. In this way, museums that use virtual or augmented reality applications succeed in increasing income, visitor engagement and intentions to return.

Virtual and augmented technologies can contribute to the learning progress as they can make studying more interesting. Education aims of each museum and the ability to teach or introduce concepts and themes can be made more effectively. Students can, for example, virtually observe extinct animals. Moreover these technologies can “bring” to students environment parts of (human) body and organs in order students to examine them and learn. In the end, students are able to conduct hazardous science experiments without being injured.

Furthermore, not only for educational purposes but for other beneficial for museums reasons as well, technology can be used. Museums have the opportunity to develop services such as online courses, virtual recreations of exhibits or online store. Moreover museums could demonstrate through technology the museum’s value to potential funders such as government entities, philanthropic foundations etc. They can create connections that can be mined during fundraising such as participation in virtual fundraising events and build income streams through advertising, fees, or opportunities to donate.

In the end, technology serves purposes of communication between museums and public. This can be done through social media tools such as Instagram, Twitter, Facebook, Pinterest, Flickr, Tumblr or similar. Thus potential visitors are always informed about museum news and museums have easy ways of communication to keep the public’s relationship and interest for the museum alive.

All these technological services can in general help in the learning process and in viewing the museum as a contemporary and interesting place. These services can increase visitor spending, provide visitor more information / knowledge about museum exhibits and museum in general, attract new target markets and make people to visit the museum again in the future. As a result the use of an augmented reality application that allows the sharing of content with the wider social media network could be an important part of a museum visit.

4.2 Disadvantages of VR / AR in museums

Despite the undeniable advantages in the use of new technologies in all fields of human activity, there are, as with everything, disadvantages. New technologies and their use is a new, constantly evolving field, which we still know very little about. Its use, as much as it makes our life easier, should not be done recklessly, but in moderation.

Virtual and augmented reality refers to technologies that dynamically mix real-world environments and context-based digital information.³⁸ This, as interesting and enjoyable as it may be, is at the same times a very immersive and time consuming process. People can really sink and get lost in a digital environment, completely cut off from the real world. The limits are difficult to set even by the older ones (so it's even more difficult for the younger ones) since this environment can become very addictive and as a result the user lives more in this virtual world, than in the real one. Since most of the times have been designed for a single user, participants consider VR and AR technologies to isolate them from the rest of the environment.

Another disadvantage is the fact that virtual and augmented reality can become a potential threat to travel and tourism. By serving their purpose very well, providing an enjoyable museum experience, really close to the real visit with accurate and realistic museum exhibits, these new technologies might replace the actual visits, which are more expensive and less convenient. This is of course a negative and unwanted perspective for museums in which the driving force is people. Moreover, visitation is certainly of vital importance for museums, which base a big part of their operation on the profits from their visitors.

An interesting topic for discussion is whether or not can museums monetize digital income to fill the gap of actual visits. Although is quite difficult, is not impossible. Problems occur because consumers want high quality products that are worth the money they will spend. This presupposes a high cost for the museums to provide these products. Marketing strategies that will attract the public and bring in advertising income, as well as the use of social networking media that frequently change their terms and policies, require a high cost and time for Museums. Thus,

³⁸ Azuma, 1997

it is often doubtful whether the Museum will be able to cover these costs over time, even if these approaches were initially financially affordable.

Another crucial factor is the technological literacy of the visitors. Is it intuitive and easy for visitors to find and use the technological adds? And more specifically, are all visitors able to do it or is it extremely difficult, even impossible, for the older community who were never actually familiarized nor trained in the new technologies. This is a community that the museum must approach in a careful and different way, taking care not to exclude it from its technological modernization, which, however, must be easy and accessible enough to satisfy this part of the population.

This could happen with the help of suitably trained staff, who would assist the disabled in using the new technological visitors. Unfortunately, this is often difficult to impossible. Insufficient resources are often a main reason why many museums cannot invest in sections that will favor their reputation and attendance in the long term. Recruiting new people with specific knowledge or training existing staff is a difficult venture. At the same time, some employees might thinking that technology threatens their work because they believe that it will replace them if it is used.

There is a lack of adequate research on the impact of virtual – augmented reality. Most frequently, the common recommendation of some manufacturers for these technologies is to be used by children older than 12 years old. This fact excludes a large part of the public at these younger ages. It also excludes older people, such as the parents of these children, who would not wish during their visit to be in the unpleasant position of preventing the younger children from using new technologies.

The restrictions that are applied as a precaution to the younger and more fragile ages, concern health limitations and medical limitations, such as dizziness, nausea, headaches, eye problems caused by the VR-AR, which can, however, affect any user. Damage to their vision, disorientation, seizures, even a real risk of injury. Players have suffered from broken bones, torn ligaments, and even electric shocks. As the wide use of new technologies is very recent, their immediate and long-term consequences, as well as the frequency and rate of their occurrence in each person have not been sufficiently studied. The data so far, however, set limits and restrictions on the time of their use.

In addition, VR and AR technologies are unfriendly to users with specific disabilities. Blind or deaf users may not often be in a position to enjoy a VR-AR experience, which can intensify social racism and stigma against these minority groups. This is of course unwanted, especially in places such as museums, which aim to convey knowledge to all people regardless of their background and other characteristics. However, similar issues are systematically investigated and more and more friendly technologies are developed for the purposeless use of all people.

Another health issue that is raised very often is the issue of hygiene. The necessary equipment requires frequent and regular cleaning every day, which can be extremely difficult due to the large number of visitors.

Visitors can be easily distracted by VR - AR technologies, resulting in the technology becomes more interesting than the actual museum. The main reason for the use of technologies is to make the information more understandable to the public, as well as to make the visit more pleasant and interactive through the use of modern tools, images, sounds, video, etc. However, what happens if the visitor immerse very deep in the realism and immediacy that these technologies offer? If he / she is so absorbed in the magic of the technological world or in winning in that game, immerse in the digital world and forgets the reason for which he /she came in contact with them in the first place! Forgets the educational goal and neglects the information that the application seeks to give to him/ her..

Another obstacle facing the use of technology is the building of museum itself. Some museums consist of buildings, palaces, or castles built for centuries and are considered preserved archaeological buildings. In these buildings it is difficult for anyone to interfere, not only for moral and reasons of protecting their uniqueness, but also for practical reasons and their maintenance / protection. As the years passed, it became possible for some of them to have electricity and water extensions, but the placement of technologies can sometimes damage these buildings.

The cost to design a program or to adapt a digital tool / machine and make it work as an organic part of the pre - existing exhibition costs. Due to the high expense of delivering technology in these situations, the responsible authorities' lack of financial assistance for the implementation of such technology will be a barrier. In many instances, a lot of money has been spent on building

incredibly powerful platforms, but relatively little on the creation of digital content. Investment is necessary for the creation of content for augmented and virtual reality, for the provision of hardware, and for the acquisition of 3D printers. However, it is anticipated that these expenses will go down as technology progresses. Due to the ubiquitous use of smartphones even today, cultural heritage sites can provide simple applications for visitors' own devices, resulting in an interactive experience with minimal outlay of funds.

In the end, little research has been done on the effects of virtual and augmented reality on a variety of levels, some of which are frequently ignored: from the visitor experience to museum logical approaches to organizational concerns. The perspectives of museum professionals are presented here show that there are numerous concerns that we often overlook while examining the possibilities of these technologies but that are nonetheless very crucial for museum professionals and the sector as a whole.

Advantages & Disadvantages of VR / AR in Museums
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Advantages	Disadvantages
Have access in environments without been actually present	Very immersive & time consuming
Explore museum contents without restrictions such as space, time and language	Difficulties for people who are not familiar with technology
Have access all the time	Age restrictions
Easily accessible	Health issues such as dizziness, eye problems etc
Easier learning progress and more Interesting	Hygiene issue: frequent cleaning
Helpful for people with special needs, learning difficulties or health issues	Not friendly to specific disabilities for example blind people
More attractive for the younger audience who are more engaged to technology	Inadequate investigation of the effects of virtual and augmented reality at many levels

Museums could demonstrate through technology the museum's value f.i to potential funders, participation in virtual fundraising events etc	Employees in museums are not accustomed to use technology and therefore unable to help visitors. They might even fear that technology is going to replace them
Advertising	Threat to travel and tourism
Communication with visitors through social Media	High costs

4.3 How other technologies serve museums

Nowadays museums use technology not only to improve the experience of visitors, as we already have seen, but in order to make contact with them before the actual visit. Sometimes before visitors actually think or decide to visit the museum, social media implant the idea and the desire in their mind and equip them with all the information they need for the visit. More and more marketing strategies are being used by museums to increase their audience, expand their offerings, increase awareness, and generate revenue. In this process of public relations, organizations communicate with their target audiences in the environment through goal-driven communication methods.

Social media such as Facebook, Twitter, Instagram etc are some of these marketing tools. The past years they have been used as a digital road between museums and audience. Museums can easily, by using social media, inform /advertise exhibitions and events, post pictures and videos of exhibits, share information about new events, organize gallops etc. The public is given a voice by the museum when social media users respond to its posts. Visitors can ask questions and provide the museum feedback, and the institution can answer them instantly.

The communication through social media is more vibrant and interactive than it is through other means of communication or through the museum site. As much as informative the museum site is, it can only give specific information, usually the most important and common things that a potential visitor should know, and rarely changes it's content. A museum's social media account is daily up to date with new content in order to inform and convince the followers that they have to give this museum a change. Not only a useful but a marketing tool as well, museums have realized to such an extent the offer of social media that even hire properly qualified employees in order to manage these platforms.

Because every organization has its unique interests, a museum's successful social media approach for reaching and engaging audiences may not be successful for another. The platforms chosen and the ways in which these platforms are used is different between different institutions and depends on an institution goals. Each museum can change its social media strategy and the platforms that is using depending on the change of its need.

It is widely common nowadays for museums to use social media. Because social media can instantly reach a large number of people, museums are encouraged to use it. The main objective of the majority of museums is to draw visitors inside. Each institution has a different ideal amount of visitors, but it is important for a museum to have regular visitors who allow the business to continue operating. Social media continuously lowers barriers between establishments and visitors, strengthens the public voice, and enables people to participate in the history of the institution.

5. Museum designs

5.1 Design of model of the use of digital technologies: The Acropolis Museum

After the presentation of the theoretical knowledge and the bibliographic research regarding museum and new technologies, next is, in this final chapter of this thesis, to present a case study.

The case study was chosen as the investigational strategy. It has been successfully used to record and tell others on how information technology is created, tested, and assessed by users in a variety of settings. This specific case study has the purpose of verifying - or refuting - what was theoretically, through the bibliography, mentioned about the relationship between public - museum and digital world.

The museum chosen for this purpose is Acropolis Museum. This particular museum was chosen because of its importance and popular character. It is one of the best known Greek museums, both in Greece and abroad. The museum is not open space, but is housed in a big, recently built, modern building. Its exhibits are covering a wide time period from the Mycenaean period to Roman and Early Christian Athens and are of great importance, thousands of years old. It is located in a historical area, near the rock of Acropolis. As is natural, it gathers a large number of visitors every day of the year, from different countries, cultural environments, educational levels and ages. This popular museum, therefore, perhaps more than any other, must implement ways to successfully transmit its knowledge and messages to all these target groups. And of course, following the developments, to integrate the new technologies and use them to its advantage.

Some of the technological means that we saw in this thesis could be used successfully in this museum, while others are considered inappropriate. A website, for example, is one of the easiest technological achievements. Through internet and with basic equipment (computer, mobile phone, tablet) most age groups are able now to explore many of the museum's exhibits which are also available in digital form, giving continuous and free access to people who live far away or do not have the opportunity / do not wish to visit the museum. Additionally, another multitude of technological means upgraded the museum-visitor relationship: touch screens, media players, video, 360 video, digital games, applications. All of them have great appeal to the general public as they acquire a basic knowledge of technology and make the visit more enjoyable and interactive. The case of virtual reality glasses, which is examined in detail below, is another case

of easy use of the technology by the most Museum visitors. 3D printers are also a fairly economical solution. They can be used for the purposes of the Museum, such as for example temporary replacement or representation of some exhibits or simply in other areas such as donation/purchase of a souvenir that will have been created in 3D printing.

Less widespread and beloved seem to be more complicated applications that require specialized knowledge both for their construction and their use. Some of these applications that we encountered in this work are JigSpace and zSpace, with the latter including specialized equipment. High construction costs can also be a discouraging reason for museums to adopt any modern technological means.

A relatively accessible, both in its implementation and in its use, technological mean for the Museum is virtual reality glasses. After a visit to the museum everyone may easily locate some of the exhibits that are of interest: the caryatids, parts of the gables of Parthenon and vessels. Of course numerous other exhibits are equally important but not chosen for this specific action. Here the selection of the following exhibits were made according to the goals of the museum and the target group. Exhibits were photographed and edited in the Windows Movie Maker program, adding recorded material in parallel. The resulting file was viewed on the mobile through the VR Player application, while the device was placed in the virtual reality glasses.

For the creation of this file it was necessary to take into consideration certain factors: First, the selection of exhibits. The selection of exhibits must be done carefully, considering the message the museum wants to communicate and the profile of the public. Here they were firstly selected the caryatids (Figure 21) because they are an important and widely known ancient relic. Caryatids are female statues, “kores” (daughters) as they are called in Greek - which supported, instead of columns, the roof of the southern prostrate of the Erechtheum, an ancient temple on the hill of the Acropolis. Today they have been transferred to the Acropolis Museum, so that they can be protected, preserved and displayed in the best possible way. While most of them are in Acropolis Museum, one of them is in British Museum in London. However unfortunate this situation may be for Greek culture, this is also a main reason that this specific exhibits is so well know and therefore was chosen.



Figure 21. Caryatid, Source [Caryatid]

Consequently, the gables of Parthenon were chosen (Figure 22). Gables are the spaces that form the cornices of the roof, on the two narrow sides of a building. On the two pediments of the Parthenon, a total of 50 statues compose mythical scenes. For the same reasons as the Caryatids, many representations are now in the Acropolis Museum. The representations were chosen, as they are part of the Parthenon, the most famous temple in Greece.



Figure 22. Statues of Parthenon, Source [Gables of Parthenon]

Finally, different vessels were chosen (Figure 23 and 24). Numerous vessels were used for different purposes: amphorae, loutroforos, lekythos, aryvallos, ascos etc. The concealment of their names may be procedurally difficult and is not considered necessary. The purpose of their selection was for the visitor to learn the ingenuity of the people of the time to design the corresponding vessel according to its use. Thus we will see vessels in different shapes and sizes, with different capacities and mouths. Finally, we will see great varieties and differences in their decoration.



Figure 23. Vessels, Source [Ascós]



Figure 24. Vessels, Source [Amphorae]

Another factor that was taken into account was the choice of presentation methods: the goal was to create an easy-to-use, inexpensive application that would serve the majority of the public. It was desirable to include various technological means including: photographs, audio material for a better learning and aesthetic result. In addition, the right amount and level of information to be included were taken into account: the target group of the Acropolis museum is numerous. It consists of visitors of all ages and educational levels / previous knowledge. The goal was for most people to feel that they learned something important from using the virtual reality glasses,

regardless of their background. Finally, another factor that was taken into account was the level of knowledge and familiarity needed to understand and use the virtual world. Knowing that we address a large and diverse target group, the aim was to make the application as simple as possible so that it is easy to use.

As already mentioned, the target group is diverse. Children, young students, adults of all ages. This quickly made the use of technology a different challenge for each one.

After the use of virtual glasses the outcomes were multiple and diverse. It was found that the use of virtual reality glasses was unsuitable for kids. Their development did not allow the proper use of glasses (disproportion of head / glasses sizes and weight of equipment). At the same time, they were not in a position to understand the sequence of steps for using the equipment and coordinating it through the smartphone. In the end, they were not able to understand the knowledge / information that the museum wanted to convey, since there was no appropriate intellectual and cognitive background. In any case, however, it was a first familiarization with the museum's technological equipment and exhibits.

The results were more positive in older children. Although their development may not yet have made the use of the glasses so convenient, their familiarity with technology and smartphones was better, as was their perceptual ability to prepare the equipment almost on their own and perceive the information provided by the application. It was found to have a particular resonance mainly among the ages between 9-13 years old as the content of the application is connected to the school teaching material.

The results from the use of the adults were also quite positive. The majority had the basic knowledge required for the use of the equipment and familiarization with the technological means. In addition, the popularity of the selected exhibits resulted in most visitors, Greeks and non-Greeks, having a level of knowledge of the information material, which made the transition of the information easier.

The results for older visitors were less promising. As it turned out, the use of the equipment was difficult for the largest percentage of those aged 60+ due to their limited familiarity with the technology, while some of them had old-style mobile phones and were excluded from the

process. Another population group that had difficulty and / or was excluded from the use of virtual reality glasses were the visually impaired and myopic.

However, the goals and outcomes from this creation were multiple. The museum will not be a boring old - fashioned place but it can be modern, equipped with contemporary technological means and equipment that attract the interest of visitors and especially the younger ones: a population group that tends to discredit the museum. At the same time, the transfer of knowledge will be more interactive, enjoyable and probably more understandable. Visitors will not get lost in a multitude of information and exhibits - knowledge will be more targeted. It is also expected that the cultivation of observation is aimed at learning to recognize key exhibits. Finally, maybe this is an opportunity for the older ones to familiarize themselves with technology, since they will try to understand it through a topic that concerns their interests.

Moreover, educational goals can be set. This particular technique of creating virtual tours can prove to be very useful as it does not require a physical presence in museums and monuments. Schools in very isolated areas that do not have the possibility to visit museums and archaeological sites can benefit, while teachers can, in an easy and fast way, create appropriate video-virtual tours and post them online for educational purposes. Additionally, the cost of getting a pair of VR glasses is now extremely low, so a school might invest in this way of "visiting" museums. These tours, depending on the planning that has been done, can be addressed to different ages of students. Each student can choose how much of the tour to watch, but also focus on what interests them, or even repeat. The creation of such a video can, even, yield the project of a class, or the occasion for the collaboration of classes that are at a physical distance, both at home and abroad. In the end a similar process of composing a virtual tour or a virtual museum could offer the possibility to the public worldwide, to see objects that are not on display.

In the end we came to the conclusion that this specific case study mostly confirmed the information gathered from the literature regarding the use of technology in museums. The use of technology can certainly enhance the learning experience and bring about better student outcomes. It resonates with the majority of the public, while it can familiarize those who are still struggling with technology. However it is certainly not a one-way street and for this reason the

individual difficulties faced by some population groups must be taken into account so that they do not feel excluded.

5.2: Museum operational design:

As has already been said, the proper design of a museum in order to serve the needs of its diverse audience is difficult. Many parameters will have to be taken into account and many professional specialties must cooperate in order to achieve its smooth operation, the correct encoding of its messages and its smooth public attendance. This task is even more complicated during the digitization of museums, where there are more parameters of thought and professionals who must cooperate for the smooth functioning of digital media. The purpose of the current chapter is to present the sequence of actions and the logic behind the establishment and operation of different types of museums:

Case: The operational design of a museum

Step 1: Operation of the museum: application for the establishment of the museum (with information on its characterization).

Step 2: Identification of museum type.

Step 3: Record of the museum's collections and description of the way of recording and documenting them. The collection must be characterized by unity, be recorded in accordance with scientific rules and be proven to have been acquired in a legal way.

Step 4: Locate an ideal location and an appropriate building for the Museum. The building should follow specific regulations in accordance with current laws. It should also satisfy both the housing and display needs of the exhibits

Step 5: Define the target group of the Museum. The location / building or the general structure of the museum might be relevant to the target group.

Step 6: Ensure appropriate scientific (and not scientific) employees to achieve the museum's goals.

Step 7: Creation of interior space: placement of exhibits.

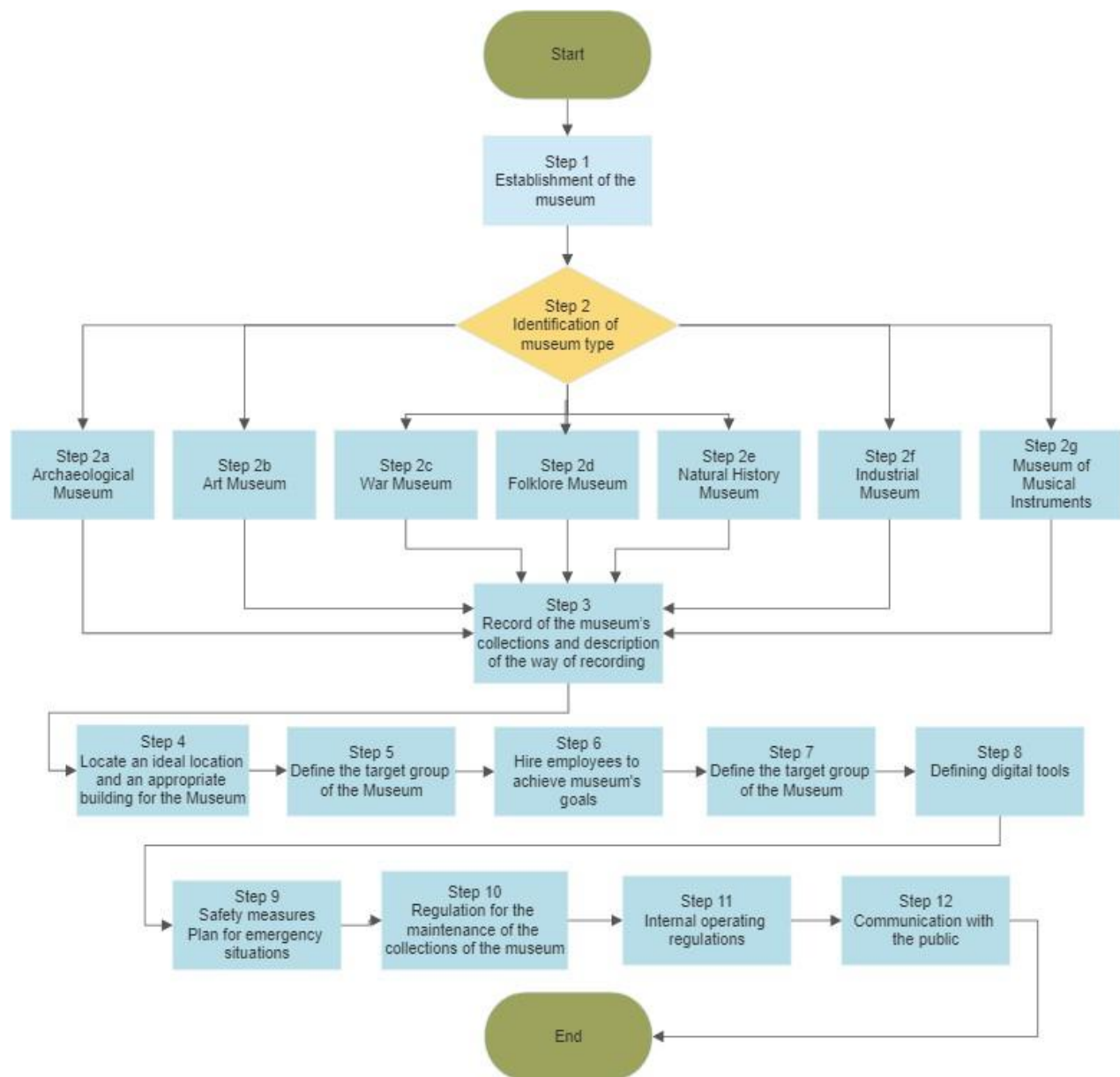
Step 8: Defining digital tools.

Step 9: Create a plan for dealing with emergency situations and establishing required safety measures

Step 10: Definition of a regulation for the maintenance of the collections of the museum.

Step 11: Draft of the museum's internal operating regulations.

Step 12: Ensure that there are open channels of communication with the public with the aim of improving the types of services it offers.



Flowchart Steps

Let's see now an example of an Archaeological Museum operational design:

Museum type: Archaeological Museum	
Museum collections:	Vessels, statues, tombstones, jewelry, tools
Way of collection's recording:	Digital collection management system (database)
Ideal location:	Easily accessible area near main roads and public transport
Suitable building:	Owned building or with a long – term lease. Safe and suitable for the fulfillment of its proposes. Respect the valid town planning ordinances of the area. Accessible to people with disabilities.
Target group of the Museum:	Children, adults, elderly, foreigners, schools, families
Employees:	Historians, conservators, archaeologists, philologists, exhibition employees, researchers, tour guides, museographers, museum educators, translators computer scientists, graphic designers, game designers, copy editors electricians, engineers, automatists, plumbers administrative officers, accountants, lawyers, consultants HR department, social media management (content creator), psychologists, photographers Interior decorator, warehouse clerks, securities
Interior space:	Placement of exhibits by type and / or chronological order. placement of maps / paths, digital media (such as screens, QR codes), multilingual signs.
Digital means:	Screens, touch screens (for information of exhibits) Digital glasses, digital game: "Life of a young ancient Greek" QR codes (for information during the exhibition and in coffee / restaurants) Cloud based ticketing (paperless ticketing, contactless entry, timed entry slots)
Emergency situations / safety measures:	Danger exits. Illuminated traffic exit maps and signs. Security employees. Plan in case of earthquake / fire / flood / theft.

Maintenance of collections	Creation of workshops for the maintenance of the exhibits (or find external laboratories for the maintenance).
Internal operation regulations:	Open specific days/ hours that are known to the public. Ticket and help service. Security service. Necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc)
Improving types of services / communication with the public	Monitor public reactions: questionnaires, gallop, book of complaints and rating of museum / services within the Museum and online. Update through digital communication channels for Museum activities / exhibitions. Encourage visitors to sign up for e-mail newsletters & follow social media accounts. Purchase a membership online or make donation.

The table above describes some of the steps for the operation of an archaeological Museum. After determining the type of Museum (archaeological), the collections of the Museum are recorded such as: vessels, statues, tombstones, jewelry, tools. Their recording method is digital (database). Then the ideal location for the placement of the Museum is identified, which will be easily accessible, next to main roads and public transport. Then a suitable building for the Museum should be identified: an owned building or with a long-term lease. The building must be safe, respect the building regulations of the area and be easily accessible to people with disabilities. Then the target group of the Museum must be defined. For the specific Museum we have: children, adults, elderly, foreigners, schools, families. The following step is the recruitment of employees: skilled and unskilled employees. Some of them are: historians, conservators, archaeologists, philologists, exhibition employees, researchers, tour guides, museographers, museum educators, translators, computer scientists, graphic designers, game designers, copy editors electricians, engineers, automatists, plumbers, administrative officers, accountants, lawyers, consultants HR department, social media management (content creator), psychologists, photographers, interior decorator, warehouse clerks, securities. Next step is the setting of the interior space of the museum: placement of exhibits by type and / or chronological order, placement of maps / paths, multilingual signs, digital media. The digital media that will be installed must serve the purposes of each Museum. For the archaeological museum screens and

touch screens were chosen such as “Samsung Galaxy Tab S6 Lite 10.4”. This specific product was chosen because of the good relationship between quality and price. In addition, it was chosen among other products of the same cost, due to the good resolution and graphics, a desirable element to represent the exhibits with excellent precision and detail. Finally, a tablet was chosen, instead of a larger screen, as it was considered more friendly and easy to use for “young” visitors (children, teenagers etc). Moreover digital glasses were chosen for a virtual representation of important exhibits (vessels, gables of Parthenon, Caryatids). The digital glasses that were chosen was “SHINECON 6 Generation G04E 3D VR”. They were chosen due to their low and therefore affordable cost, their lightweight design and comfortable fit. Moreover, they support IPD function for those who have a myopia problem and have a special filter against radiation and anti blue ray. In the end, a digital game called "Life of a young ancient Greek” was used. Moreover it was considered important to be placed QR codes (for information during the exhibition and for menus in coffee / restaurants) and cloud based ticketing (paperless ticketing, contactless entry, timed entry slots). The next step was to establish protocols in case of an emergency. Such cases are earthquakes, fires, theft etc. It was deemed necessary to place emergency exits, emergency stairs, illuminated traffic exit maps and security employees all over the building. Subsequently, the preservation and maintenance of the collections had to be ensured. The Museum is required to create laboratories within its premises for the maintenance of its collections or enter into agreements with external laboratories for this purpose. The next step is to establish internal regulations for its smooth operation and to make them known to the public: Open specific days/hours that are known to the public, have ticket, help service and security service and necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc) Finally, the Museum should ensure its communication with the public before, during and after the visit. This communication will not only ensure the Museum's attendance, but will also measure its impact on the public and offer feedback on ways to improve. This communication can be achieved through digital channels and through social networking, questionnaires, complaint books etc.

Let's observe now a summary table of different museums:

Summary table of different Museums			
Museum type:	Art museums	War museums	Folklore Museums
Museum collections:	paintings, statues, portraits, sculptures, photographs, architecture, three – dimensional works	Swords, weapons, cannons, helmets, bullets, shields, tanks, war planes, flags, busts, uniforms / cloths, medal, awards, war manuscripts, maps, photographs, painting, statues	Wefts, clothing, jewelry, furniture, books, household – agricultural tools, weapons, ceremonial – personal use objects, decorations, pictures, coins, crosses, works of arts, photographs
Way of collection's recording:	Digital collection management system (database)	Digital collection management system (database)	Digital collection management system (database)
Ideal location:	Easily accessible area near main roads and public transport	Easily accessible area near main roads and public transport	Easily accessible area near main roads and public transport
Suitable building:	Owned building or with a long – term lease. Safe and suitable for the fulfillment of its proposes. Respect the valid town planning ordinances of the area. Accessible to people with disabilities.	Owned building or with a long – term lease. Safe and suitable for the fulfillment of its proposes. Respect the valid town planning ordinances of the area. Accessible to people with disabilities.	Owned building or with a long – term lease. Safe and suitable for the fulfillment of its proposes. Respect the valid town planning ordinances of the area. Accessible to people with disabilities.
Target group of the Museum:	Children, adults, elderly, foreigners, schools, families	Children, adults, elderly, foreigners, schools, families	Children, adults, elderly, foreigners, schools, families
Employees:	Historians, art historians, philologists, painters, sculptures, exhibition employees, researchers, tour guides, museographers, museum educators, translators computer scientists,	Historians, philologists, exhibition employees, researchers, tour guides, museum educators, translators computer scientists, graphic designers, game designers, copy editors, electricians, engineers,	Historians, conservators, philologists, exhibition employees, researchers, tour guides, museum educators, translators computer scientists, graphic designers, game designers, copy editors electricians, engineers, automatists, plumbers administrative officers,

	<p>graphic designers, game designers, copy editors electricians, engineers, automatists, plumbers administrative officers, accountants, lawyers, consultants HR department, social media management (content creator), psychologists, photographers Interior decorator, warehouse clerks, securities</p>	<p>automatists, plumbers administrative officers, accountants, lawyers, consultants HR department, social media management (content creator), psychologists, photographers Interior decorator, warehouse clerks, securities</p>	<p>accountants, lawyers, consultants HR department, social media management (content creator), psychologists, photographers Interior decorator, warehouse clerks, securities</p>
Interior space:	<p>Placement of exhibits by type and /or chronological order. placement of maps / paths, digital media (such as screens, QR codes), multilingual signs.</p>	<p>Placement of exhibits by type and / or chronological order. placement of maps / paths, digital media (such as screens, QR codes), multilingual signs.</p>	<p>Placement of exhibits by type and / or chronological order. placement of maps / paths, digital media (such as screens, QR codes), multilingual signs.</p>
Digital means:	<p>Screens, touch screens (for information of exhibits – close observation), multi touch tables. QR codes (for information during the exhibition and in coffee / restaurants) Cloud based ticketing (paperless ticketing, contactless entry, timed entry slots)</p>	<p>Screens, touch screens (for information of exhibits – close observation), virtual museum navigation through its website, QR codes (for information during the exhibition and in coffee / restaurants) Cloud based ticketing (paperless ticketing, contactless entry, timed entry slots)</p>	<p>Screens, touch screens (for information of exhibits – close observation), , educational game for children on the museum website (“<i>Dress up the figures in the costumes of each village</i>”), QR codes (for information during the exhibition and in coffee / restaurants) Cloud based ticketing (paperless ticketing, contactless entry, timed entry slots)</p>
Emergency situations / safety	<p>Danger exits. Illuminated traffic exit</p>	<p>Danger exits. Illuminated traffic exit</p>	<p>Danger exits. Illuminated traffic exit</p>

measures:	maps and signs. Security employees. Plan in case of earthquake / fire / flood / theft.	maps and signs. Security employees. Plan in case of earthquake / fire / flood / theft.	maps and signs. Security employees. Plan in case of earthquake / fire / flood / theft.
Maintenance of collections	Creation of workshops for the maintenance of the exhibits (or find external laboratories for the maintenance).	Creation of workshops for the maintenance of the exhibits (or find external laboratories for the maintenance).	Creation of workshops for the maintenance of the exhibits (or find external laboratories for the maintenance).
Internal operation regulations:	Open specific days/ hours that are known to the public. Ticket and help service. Security service. Necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc)	Open specific days/ hours that are known to the public. Ticket and help service. Security service. Necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc)	Open specific days/ hours that are known to the public. Ticket and help service. Security service. Necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc)
Improving types of services / communication with the public	Monitor public reactions: questionnaires, gallop, book of complaints and rating of museum / services within the Museum and online. Update through digital communication channels for Museum activities / exhibitions. Encourage visitors to sign up for e-mail newsletters & follow social media accounts. Purchase a membership online or make donation.	Monitor public reactions: questionnaires, gallop, book of complaints and rating of museum / services within the Museum and online. Update through digital communication channels for Museum activities / exhibitions. Encourage visitors to sign up for e-mail newsletters & follow social media accounts. Purchase a membership online or make donation.	Monitor public reactions: questionnaires, gallop, book of complaints and rating of museum / services within the Museum and online. Update through digital communication channels for Museum activities / exhibitions. Encourage visitors to sign up for e-mail newsletters & follow social media accounts. Purchase a membership online or make donation.

Museum type:	Natural history museums	Industrial museums	Museums of musical instruments
Museum collections:	Fossils, scarfs, skeletons, bones, minerals, gemstones, rocks, photographs, paintings	Industrial tools, equipment, machinery, buildings, maps, designs	Musical instruments, photographs
Way of collection's recording:	Digital collection management system (database)	Digital collection management system (database)	Digital collection management system (database)
Ideal location:	Easily accessible area near main roads and public transport	Easily accessible area near main roads and public transport	Easily accessible area near main roads and public transport
Suitable building:	Owned building or with a long – term lease. Safe and suitable for the fulfillment of its proposes. Respect the valid town planning ordinances of the area. Accessible to people with disabilities.	Industrial buildings most of the time. Otherwise an owned building or with a long – term lease. Safe and suitable for the fulfillment of its proposes. Respect the valid town planning ordinances of the area. Accessible to people with disabilities.	Owned building or with a long – term lease. Safe and suitable for the fulfillment of its proposes. Respect the valid town planning ordinances of the area. Accessible to people with disabilities.
Target group of the Museum:	Children, adults, elderly, foreigners, schools, families	Children, adults, elderly, foreigners, schools, families	Children, adults, elderly, foreigners, schools, families
Employees:	Historians, archaeologists, biologists, chemists, physicists, philologists, exhibition employees, researchers, tour guides, museum educators, translators, computer scientists, graphic designers, game designers, copy editors, electricians, engineers, automatists, plumbers administrative officers, accountants, lawyers, consultants HR department, social	Historians, philologists, exhibition employees, researchers, tour guides, museum educators, translators, computer scientists, graphic designers, game designers, copy editors, electricians, engineers, automatists, plumbers administrative officers, accountants, lawyers, consultants HR department, social media management (content creator), psychologists, photographers Interior decorator, warehouse	Historians, musicians, philologists, exhibition employees, researchers, tour guides, museum educators, translators, computer scientists, graphic designers, game designers, copy editors, electricians, engineers, automatists, plumbers administrative officers, accountants, lawyers, consultants HR department, social media management (content creator),

	media management (content creator), psychologists, photographers Interior decorator, warehouse clerks, securities	clerks, securities	psychologists, photographers Interior decorator, warehouse clerks, securities
Interior space:	Placement of exhibits by type and /or chronological order. placement of maps / paths, digital media (such as screens, QR codes), multilingual signs.	Placement of exhibits by type and /or chronological order. placement of maps / paths, digital media (such as screens, QR codes), multilingual signs.	Placement of exhibits by type and /or chronological order. placement of maps / paths, digital media (such as screens, QR codes), multilingual signs.
Digital means:	Screens, touch screens (for information of exhibits – close observation) Audio – guided tour QR codes (for information during the exhibition and in coffee / restaurants) Cloud based ticketing (paperless ticketing, contactless entry, timed entry slots)	Screens, touch screens (for information of exhibits – close observation) Audio & video with worker testimonials, digital tour guide (animated video for pc – tablet - smartphone), QR codes (for information during the exhibition and in coffee / restaurants) Cloud based ticketing (paperless ticketing, contactless entry, timed entry slots)	Screens, touch screens (for information of exhibits – close observation) Set of headphones to hear each instrument’s sound, QR codes (for information during the exhibition and in coffee / restaurants) Cloud based ticketing (paperless ticketing, contactless entry, timed entry slots)
Emergency situations / safety measures:	Danger exits. Illuminated traffic exit maps and signs. Security employees. Plan in case of earthquake / fire / flood / theft.	Danger exits. Illuminated traffic exit maps and signs. Security employees. Plan in case of earthquake / fire / flood / theft.	Danger exits. Illuminated traffic exit maps and signs. Security employees. Plan in case of earthquake / fire / flood / theft.
Maintenance of collections	Creation of workshops for the maintenance of the exhibits (or find external laboratories for the maintenance).	Space & equipment maintenance. Creation of workshops – if necessary - for the maintenance of the exhibits (or find external laboratories for the maintenance).	Creation of workshops for the maintenance of the exhibits (or find external laboratories for the maintenance).

Internal operation regulations:	Open specific days/ hours that are known to the public. Ticket and help service. Security service. Necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc)	Open specific days/ hours that are known to the public. Ticket and help service. Security service. Necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc)	Open specific days/ hours that are known to the public. Ticket and help service. Security service. Necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc)
Improving types of services / communication with the public	Monitor public reactions: questionnaires, gallop, book of complaints and rating of museum / services within the Museum and online. Update through digital communication channels for Museum activities / exhibitions. Encourage visitors to sign up for e-mail newsletters & follow social media accounts. Purchase a membership online or make donation.	Monitor public reactions: questionnaires, gallop, book of complaints and rating of museum / services within the Museum and online. Update through digital communication channels for Museum activities / exhibitions. Encourage visitors to sign up for e-mail newsletters & follow social media accounts. Purchase a membership online or make donation.	Monitor public reactions: questionnaires, gallop, book of complaints and rating of museum / services within the Museum and online. Update through digital communication channels for Museum activities / exhibitions. Encourage visitors to sign up for e-mail newsletters & follow social media accounts. Purchase a membership online or make donation.

Similarly, for the establishment and proper functioning of other types of museums, it is necessary to follow specific steps. These steps are usually common for all museums, however, they might differ according to the museum type. For instance collections in an Art museum include: paintings, statues, portraits, sculptures, photographs, architecture, three – dimensional works etc while in a War museum include: swords, weapons, cannons, helmets, bullets, shields, tanks, war planes, flags, busts, uniforms / cloths, medals, awards , war manuscripts, maps,

photographs, paintings, statues. Accordingly a Folklore's museum collections include: wefts, clothing, jewelry, furniture, books, household – agricultural tools, weapons, ceremonial – personal use objects, decorations, pictures, coins, crosses, works of arts, photographs etc and in Natural history museum collection include: fossils, scarfs, skeletons, bones, minerals, gemstones, rocks, photographs, paintings etc, An Industrial museum collections include: industrial tools, equipment, machinery, buildings, maps, designs etc while in a museum of Musical Instruments collections include Musical instruments, photographs etc. Nowadays all - or most - of the museums should record their collections digitally. Moreover, all of them should find an ideal location (easily accessible area near main roads and public transport) and a suitable building (owned building or with a long – term lease, safe and suitable for the fulfillment of it's proposes, respect the valid town planning ordinances of the area, accessible to people with disabilities). Then each museum should identify its target group so it will be able to better plan its politics, the tactics of approaching the public and the formation of its space. The target group of all the museums mentioned may be: children, adults, elderly, foreigners, schools, families. Employees can vary in different types of museums. Although some employees will be common to all museums such as: administrative officers, accountants, lawyers, electricians, securities, computer scientists etc some employees might or might not being used according to museum type or museum strategy. For example a museum of natural history is going to hire historians, archaeologists, biologists, chemists, physicists while the art museum is going to hire historians and art historians, philologists, painters, sculptures etc. Similarly, the more technologically equipped the museum is, the more professionals in the field of technology it will hire, e.g. graphic designers, game designers, copy editors, engineers, automatists etc and the more open / accessible to its audience it wants to become, it will hire professionals who can attract a wide audience through different methods, e.g. tour guides, museum educators, translators, HR department, social media management (content creators) etc. All museums will pay attention of shaping their interior spaces in the best possible way for visitors to observe their exhibits and gain knowledge (placement of exhibits by type and/or chronological order, placement of maps / paths, multilingual signs) and ensure that they will create protocols to avoid dangerous situations (danger exits, Illuminated traffic exit maps and signs, security employees all over the building, plan in case of earthquake / fire / flood / theft etc). In reference to the technological means that will exist in each Museum, each Museum will choose those that best serve its theme and its

purposes. For instance an art museum would might rather to choose large, high- definition screens such as LG Monitor 34" 34WR50QC-B whose curvature will offer better observation and viewing of all works of art. Moreover a museum of musical instruments might find it more useful and practical for its purposes to use audio devices, such as a set of headphones so the visitor will be able to hear each instrument's sound. A good suggestion could be the "Sony WH-1000XM4" which stand out for their ability to isolate sound from the environment and for their good sound. In addition, they are available wireless or wired and have 30 hours of continuous operation. On the other hand, it would be more useful for a folklore museum to use digital glasses, with which visitors will have the opportunity to transport themselves to an old household! Similarly, a war museum might choose to use screens and video to show real interviews and testimonies from war survivors. Choosing a screen of small size, moderate characteristics, with conventional definition and low cost like "F&U FL20107 HD" is perhaps the best choice for this purpose. Although some digital means tend to appear more suitable for some types of museums, almost all museums today can successfully use screens and touch screens, audio, videos, guided tours, QR codes and other technological means. In the end, regardless of the type of museum, all museums upon their establishment must take care of the maintenance of their collections (creation of workshops for the maintenance of the exhibits or find external laboratories for the maintenance), take care of the establishment of regulations, known to the public, for their smooth operation (open specific days/hours, have ticket, help and security service, create necessary facilities for public and employees needs (eg resting area, toilets, cafe, souvenir shop etc) and create ways of communicating with the public (monitor public reactions: questionnaires, gallop, book of complaints and rating of museum / services within the Museum and online. Update through digital communication channels for Museum activities / exhibitions, encourage visitors to sign up for e-mail newsletters & follow social media accounts, purchase a membership online or make donation etc.

6: Statistics charts

In this present thesis, the change of the character of the museums over time has been mentioned. This resulted in a change in their relationship with people and an increase in their traffic and their income. This activity, both in Greece and in the rest of the planet, it is represented in the diagrams below:



Diagram 1 The World's Most Visited Museums, Source [Most Visited Museums]

Attendance in Europe Museums 2019 (blue), 2020 (black), 2021 (gray)

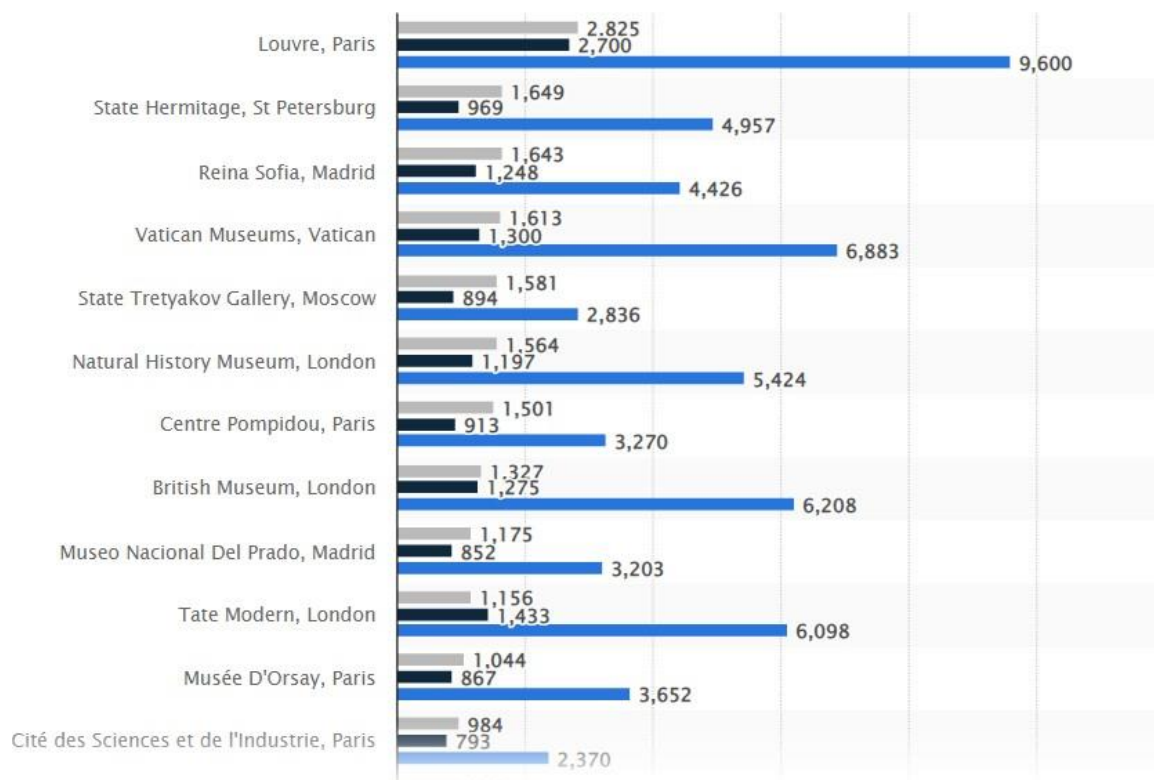


Diagram 2. Attendance in Europe Museums 2019(blue), 2020 (black), 2021 (gray), Source [Attendance in Europe Museums 2019 – 2021]

COLLECTIONS (EURO)	2021	2022	January		Change 2023/2022
			2022	2023	
Total collections (A+B)	54.735.194	121.535.113	794.240	2.257.189	184,2%
A. Museums	10.385.644	23.361.465	272.876	764.253	180,1%
B. Archaeological places	44.349.550	98.173.648	521.364	1.492.936	186,4%

Diagram 3. Elstat, Source [Collections in Euro]

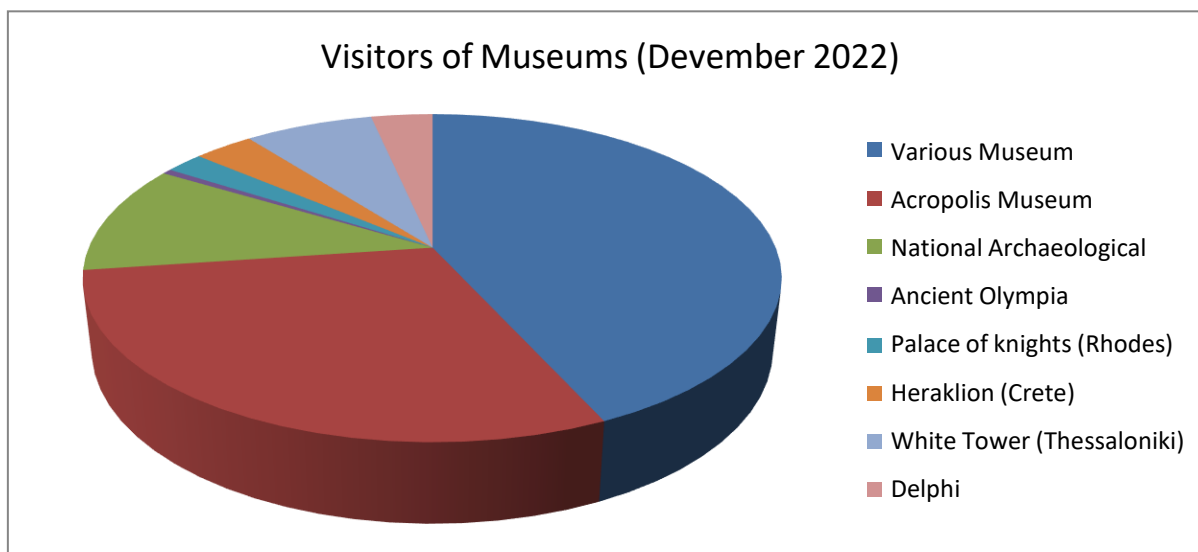


Diagram 4. Statistics, Source [Visitors of Greek Museums December 2022]

Museum visitors - earnings (2021,2022, January 2022,2023)					
Museum	2021	2022	January 2022	2023	Change 2023/2022
Total visitors	7.357.026	15.583.552	216.828	458.543	111,5%
Museum	2.047.481	4.636.901	90.288	208.707	131,2%
Acropolis Museum	547.908	1.397.353	23.326	65.832	182,2%
National Archaeological	189.208	474.821	7.918	22.201	180,4%
Ancient Olympia	34.367	85.179	921	794	-13,8%
Palace of Knights	142.530	263.521	758	2.078	174,1%
Heraklion (Crete)	127.574	249.715	1.479	4.781	223,3%
White Tower	77.983	193.916	4.072	14.988	268,1%
Delphi	58.102	151.512	3.847	6.826	77,4%
Various Museum	869.809	1.820.884	47.967	91.207	90,01%

Diagram 5. Elstat, Souce [Museum visitors & earnings 2021 – 2023]

i. Online presence

Almost **70%** of the museums increased their online presence since they were closed due to social distancing measures. **After 3 weeks of closure to the public, already 80% of the museums had increased their online activity,** reacting to the general increased visibility of digital cultural heritage on the internet.



Diagram 6. Online activity of Museums due to covid -19, Source [Museums online activity]

Conclusions

Virtual / augmented reality is the combination of the digital world with the physical world. It became real with the progress of technology, computers, advanced processors and graphics, after many years of tests and efforts. Today it is widespread in several fields of human daily life. One of them is education and museums. Museums, after a long period of evolution in time, have developed today an educational character and a main educational purpose: to transmit knowledge, freely, to every single person from all socio-economic and political backgrounds.

For this purpose, they recently have adopted new technologies with the aim of increasing their audience and benefits from its advantages in the learning process. New technologies such as 3D printers, virtual reality glasses, interactive screens and sound systems are used for a better learning experience. Even new applications and educational games are designed to serve educational purposes.

In a world in which more and more people nowadays are more familiar with technology and they use it in their daily life, how can we ask from these people to stay old fashioned when it comes to education? And it is true. How more evolving and entertaining at the same time can learning become with these digital tools?! Either we like it or not, either if it is right or wrong hardly the educator will gain the interest of the learner nowadays only with traditional means.

Although these technological means are incredibly alluring, incorporating them into the educational system and adapting to them can be challenging as long as some individuals, whether educators or students, have trouble seeing that this is a new way to communicate, educate, and learn. Additionally, some visitors to museums seem dubious about their use there. Professionals working in museums are faced with a difficulty in trying to balance the needs of their various guests.

Similar concerns and dichotomies are likely to exist since these technologies are still very recently developed and several studies on the effect of these and digital tools have not been carried out. However some notable advantages and disadvantages of their use have already been identified, with the advantages outweighing the disadvantages. Virtual reality is changing how people experience and perceive heritage, and it can help museums break through many of the

barriers that may prevent them from offering their services to visitors. For these reasons it is easy to say that new technologies definitely worth adopting.

However, despite the advantages so far, it is definitely necessary, in order new technologies and digital tools to improve their applications and results, in order to better provide their services to the educational community and their continuous development, to do additional research and testing in the future. Further research on these fields is considered to be necessary in such a recent, innovation technology to ensure the correct design and judicious use of it in learning environments as well as their benefits in the pedagogical process.

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