

AUGMENTED AND VIRTUAL REALITY TECHNOLOGIES IN CULTURAL SECTOR: EXPLORING THEIR USEFULNESS AND THE PERCEIVED EASE OF USE

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ABSTRACT

Augmented Reality (AR) and Virtual Reality (VR) Technologies offer new challenges and opportunities for mediated communication and aspire to reshape business environment and everyday life in terms of user's experience, enrich content, access and user-friendly capabilities). In this work, we focus on cultural sector and aim to discuss and present sector challenges and opportunities for AR/VR implementation. Cultural sector is already facing the need to implement such technologies aiming to: (a) to reuse its exclusive digital content, (b) to exploit its content for mass markets in global level such as gaming and (c) to further enrich users experience. Even though, the introduction and implementation of such technologies are important for cultural industries, little research has been done in cultural sector for aspects such as: a) how users will get benefit from rich content available anywhere, anytime and at the lower possible price (usefulness) and b) how cultural content providers could benefit from AR and VR introduction (ease of use). The present study aims to conceptualize these aspects by using existing case studies and success stories and by exploiting academic research. A methodological framework for AR/VR project selection and appraisal based of this information along with authors' experience in implementing AR/VR technologies will also be introduced and discussed. Specific results regarding AR/VR perspectives for cultural industries (with a special discussion for Greek cultural industry), technology appraisal criteria as well as the perceived ease of use from both content – providers and end – users will also be presented. Concluding remarks and discussions will summarized the study which aims to contribute to AR/VR development in this sector

Keywords: Augmented Reality, Virtual Reality, Cultural Sector.

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INTRODUCTION

It has not been a long time ago since Museums and archaeological places influenced by New Museology's trends. In the mid-80s the importance of the cultural item itself begun to be considered equal to the cultural artefact's context (Pearce, 1986; Washburn, 1984; McDonald & Alford, 1991). The first source of innovativeness came from World Wide Web and the development of Web Pages (and social media in a second stage) capable to deliver content and context to the wide public, leading to increased accessibility and attractiveness. What was initially introduced by Marlaux (1947) as an "imaginary museum" has started to be developed to a "virtual museum" described as:

"(. . .) a logically related collection of digital objects composed in a variety of media, and, because of its capacity to provide connectedness and various points of access, it lends itself to transcending traditional methods of communicating and interacting with the visitors being flexible toward their needs and interests; it has no real place or space, its objects and the related information can be disseminated all over the world" (Schweibenz, 1998).

The first digital steps have been done via Web to personal computers as a mean of (a) low-cost, (b) fast and (c) effective (user-friendly) communication tool (Sylaiou et al., 2009). This communication was mainly focus on static context including texts and photos. Mobile devices created an even more dynamic environment while technological advances in eras of crucial interest permitted the development of approaches closer to reality. Mobile phones and tablets enabled a series of dynamic and interactive applications (Hin et al., 2003), while "educated" users in using them in various everyday aspects (including cultural and educational activities). Especially the smartphones are nowadays incorporate hardware features and software capabilities, wide enough to support VR & AR platforms and applications (Kim et al., 2014).

The overall technological development made it feasible to re-examine digital technologies' s usages and potentialities. The last 5 years, already existing technologies, such as Virtual Reality (VR) and Augmented Reality (AR), emerged as beyond the state of art sophisticated tools to design virtual museums, to exhibit cultural content and context and to enrich users experience. VR and AR market is expected to grow the next years as quickly as tablets and smartphones, while their entrepreneurial perspectives is increasing alongside with improvements in location services and image recognition technologies (Cognizant, 2018).

Digital technology evolvement enabled cultural organizations and businesses to continually reinvent themselves. Technological innovation led to the so-called "digital convergence" which brought "older" cultural industries to mass market global economies and facilitated the born of new cultural and creative sectors (e.g. computer games, web design). Significant changes occurred in terms of "what" Cultural Sector includes. Only recently European Union (European Parliament, 2003) made the first attempt to identify a list of accepted activities, while a new approach soon arose in order to expand cultural industries' definition and to include a list of their characteristics and contribution to economic and social development (European Parliament, 2008). Nowadays the term

“cultural and creative industries” is used to describe a wide variety of organizations and private companies enabling in an even wider list of activities:

- Advertising and marketing
- Architecture
- Crafts
- Design: product, graphic and fashion design
- Film, TV, video, radio and photography
- IT, software and computer services
- Publishing
- Museums, galleries and libraries
- Music, performing and visual arts.

Cultural sector (incorporating all the above-mentioned activities) is already facing the need to implement such technologies aiming to:

1. to reuse its exclusive digital content,
2. to exploit its content for mass markets in global level such as gaming and
3. to further enrich users experience.

Even though, the introduction and implementation of such technologies are important, little research has been done in cultural sector for aspects such as: a) how users will get benefit from rich content available anywhere, anytime and at the lower possible price (usefulness) and b) how cultural content providers could benefit from AR and VR introduction (ease of use). The present study aims to conceptualize these aspects by using existing case studies and success stories and by exploiting academic research. A methodological framework for AR/VR project selection and appraisal based of this information along with authors’ experience in implementing AR/VR technologies will also be introduced and discussed.

In the following sections the related work on VR & AR in cultural sector will be presented, while their definitions and characteristics will be presented in Section 3. Moreover, aspects of implementing such technologies in the cultural sector and an existing case study will be presented in the same Section. Finally, at the last section a brief discussion of the results coming from the case study will be conducted.

RELATED WORK

Existing research on VR & AR technologies in Cultural Sector can be divided in two categories: (a) theoretical and methodological research (mainly before 2010) and (b) case studies analyses about developed applications in the field. Both, theoretical and practical research is mainly focused on traditional approaches consisting of one-room or one exhibit approaches, as a result (Ciolfi & McLoufhlin, 2010). For example, Sparacino et al. (2000) and Grinter et al. (2002) studied interactive technologies in museums, while

Brown et al. (2003) and Bowers et al. (2007) explored interactive exhibits using ubiquitous displays with augmented reality.

Sylaiou et al. (2009) compared various forms of emerging technologies, such as VR, AR and Web3D (back in 2009), used to develop virtual museums / exhibitions, both in physical and Web environment. Their results revealed how these technologies can become an engaging medium and how they enrich the museum experience through the interaction with the virtual artefacts. As main target – groups recognized to be tourists, students and specialists, with different needs to be fulfilled. A rather interesting topic is about the relationship between real and virtual museums, with the latter being characterized as “digital reflections” that do not exist per se (Sylaiou et al., 2009).

VR’s main advantage is the possibility to re-construct and make accessible to visitors, sites that no longer exist or sites that are inaccessible. Accessibility obstacles can be physical, geographical, legal or even matters of choice (e.g. cultural items belonging to private collections). Examples of VR applications used to overcome such obstacles can be found (among others) in the work of Valtolina et. al. (2005) about the reconstruction of an ancient theatre, in the work of Fineschi & Pozzebon (2015) developing a 3D virtual museum tour of the Santa Maria Della Scala, as well as in Ferrari & Medici (2017) about the creating a virtual experience of the no more existing Geguti Palace.

One of the first AR implementations has been ARCHEOGUIDE (Augmented Reality-based Cultural Heritage On-site GUIDE) system (Vlahakis, et al., 2001) which provided a series of uses such as AR reconstructions of ancient ruins, based on user’s position and orientation in the cultural site, and real-time image rendering. Miyashita et al. (2008) developed an AR guide for navigation to exhibition and to support basic information about the cultural items. Mohammed-Ammin et al. (2012) presented Arbela Layers Uncovered (ALU), a mobile AR tour guide for visitors of the archaeological site of Arbela, Iraq. They used a two-dimensional map interface to present user’s location and geo-tagged content (such as 3D models), while one of the most challenging aspects was the navigation through mobile interface when a large amount of content is required. Angelopoulou et al. (2011) presented an iOS, AR application used on the archaeological site of Sutton Hoo (UK) created for educational purposes. Gamification techniques have been used, while the tour to the archaeological place was given with a team-oriented puzzle game. Gutierrez et al. (2015) developed an AR application supporting historical information for the Temple of Debod. Finally, Galatis et al. (2016) presented a guide for the archaeological site of Knossos in Greece (called KnossosAR), addressing to various challenges such as the occlusion problem and revealing the (dis)advantages of AR vs. map-based mobile interfaces.

A different topic is explored by a series of researchers that are more interested in intangible aspects of digital technology’s usage, such as evaluation of the VR or AR experience in cultural sites. Higget et al. (2016) after implementing AR and VR applications, for Visualising and Interpreting Roman Leicester 210AD (Ratae Corieltavorum), have proceed with gathering evaluation from museum visitors. Their

result revealed problems, such as immersion, inconvenience and a reduced visitor experience reflecting GPS inaccuracies. Apart from technological problems, the applications found to be engaging and exciting for children in terms of heritage interpretation, while the high levels of interaction provided by the application enriched their experience. Another paper, from Izzo (2017) investigates customer experience using as case study BOSCH exhibition ("Four Visions Afterlife"), VR immersive experience, implemented by Palazzo Ducale in Venice. Author aimed that using virtual reality, enriched by a series of original visual and sound experiences, may provide a valuable experience with customers as well as cultural heritage's management in terms of: marketing, culture, knowledge, entertainment, personalization, satisfaction.

AR & VR IN CULTURAL SECTOR

There are many descriptions and definitions about what AR & VR are. Most of them are taking into consideration aspects that are in first priority in the field of the researcher – author. Even if small or large similarities / differences occur, it is wide accepted that both AR & VR can be placed on a virtuality continuum (described in Figure 1) ranging from real to virtual environment.

From the one side lies the real world as we face it, while to other one lies a total virtual environment. Augmented Reality brings (with the use of special glasses or cameras – mobile devices) to the real environment, additional structures (e.g. 3D models) and rich content. A step nearer to virtual environment is the Augmented Virtuality. In this case, the user is in a virtual environment which is enriched with digital content from the real world. The difference between these two cases, lies on the "environment" which is enriched. In both cases, Augmented Reality and Virtuality, the user has always conscious about the existence of both real or virtual world (representatively) and the borders between real and virtual are clear in terms of environment and content.

Virtual Reality or Virtual Environment is a pure artificially created environment without any elements or content from the real world (e.g. the various worlds created for gaming purposes). In this case, the environment is created to move user in a new world, totally different from the known and the used graphics lead him to deepen his experience in the borders of forgetting the real world.

VR Video or Video 360 (degrees) supports the experience of selecting the direction to look when watching a video. Even though there is no other interaction (e.g. moving around) than watching around as video plays, its importance is that supports VR on real environment. Such an aspect leads to understand Mixed Reality as a spectrum that encompasses all the above forms of "reality and virtuality".

For the purpose of the present paper our analysis is mainly concentrated on AR and VR. The following definition is used to interpret AR and its practical usage in the real environment's era:

Augmented Reality (AR) is the technology that integrates digital information with the real world in a way that enhances graphics, sounds and 3D objects over the natural

objects. AR technology focuses on the enriched experiences of the users, presenting visual information complementary of the natural environment through users' devices. The digital augmented content interacts with the user actions as most of the time the AR content is touchable and quite responsive on user's input.

As far as VR is concerned the following definition describes the new form of technology and

Virtual Reality (VR) is the technology that creates 3D scenes, places and worlds where users, through headset devices are connected and participating in. These environments are computer generated, capable to interact with users' actions and allow them to discover fantastic worlds by using most of their senses as living in the real world. VR experiences depends on system's capabilities, as the visual quality is directly related with the graphics rendering hardware and the simulation software.

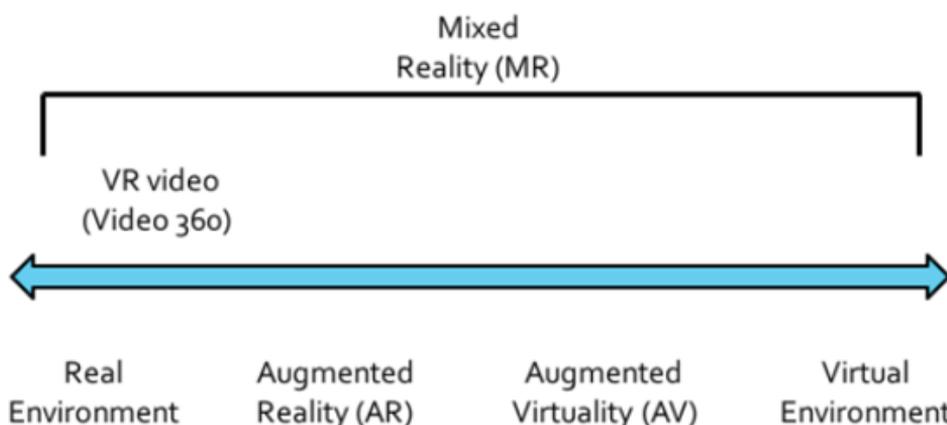


Figure 1 Defining VR (Source: Muikku & Kalli, 2017)

VIRTUAL REALITY AND AUGMENTED REALITY CHARACTERISTICS

The VR and AR technologies were not so familiar to end users mainly due to the cost of the required end user hardware device. This cost has been dramatically reduced and nowadays it is quite easy to buy and use these devices. Leaders such as Google, Facebook and HTC have invested huge amount of money on the above cutting-edge technologies by creating software and hardware and developers are implementing relevant applications in all sectors. AR and VR are expected to reach mass adoption and change the everyday life and reshape the business environment, in the same way computers and mobile phones did the previous decades.

The strongest characteristics of these two immersive technologies are:

- User's Experience: The user is facing something extremely new and fancy but at the same time lively and interactive. A 'first time' user, initially, is feeling a bit strange as he could not believe the progress of the technology in terms of visual

quality and integration of human senses into the digital virtual world of the application.

- **Content:** The digital content on VR and AR technologies is quite impressive as it is design in great detail and rendered through powerful graphics hardware and software systems. The content should be differentiated per device in order to provide the most appropriate solution based on device requirements. Mobile devices are expected to manage low poly 3D models in VR technology, unlike computed connected VR headsets which are capable to high rendered 3D models with extremely detailed level of design.
- **Access:** The access of the VR and AR content is possible through the applications that are published in several popular stores, either in mobile platforms or in specific platforms for these technologies. As the mobile devices are part of our daily life, applications with emerging technologies will grow rapidly and help users to work, consume and entertain in a more interactive way. Most of the times, high speed Internet connection is required due to the size of the 3D models and the need for real time rendering process on the virtual or augmented environment.

IMPEDING VR & AR TO CULTURAL SECTOR

Cultural Sector (CS) is consisting of different categories of professionals, from artists to nonprofit organizations up to large institutions and museums. Each one has different needs and technology should provide tools and services to fulfil them and give them access to communicate their audience through their masterpieces. Information technology (IT) companies are working on this direction by implementing specific solutions focused on user friendliness and lack of administrative support processes. The Technological Readiness Level (TRL) of the specific sector is not considered as high as possible, and the IT specialists should consider this as a fact and as a challenge too.

Cultural sector professionals are usually open minded and high creative so to have the skills, with the appropriate aid and consultancy, to turn this disadvantage into advantage and pre-competitive in the next decades. Most common IT processes that take place in the CS is the digitization of the cultural assets, the installation and parameterization of digital repositories and the implementation of web solutions to promote the exhibits (e.g. digital viewers, timelines, maps, exhibitions). All these systems were mainly implemented for the web, but they are currently updated with responsive design or with new native mobile applications, as smartphones are the main communication channel in the recent years.

Additionally, technology is used to organize and optimize business processes in the institutions and the museum, where the workload is significantly bigger, and the failure is critical in specific cases (e.g. preservation, restoration, loans).

Challenges and Opportunities for AR & VR in the Cultural Sector: The most important challenge for the incorporation of the AR & VR technology into cultural sector, is to convince the key persons for the potentialities and the prospects of such implementations. The fear of the unknown aspects and characteristics should be

overwhelmed by enhancing the innovative characteristics and the 'wow' factor of an AR and VR experience. Only, these technologies can 'travel' the end user to imaginary worlds and reveal hidden meanings and thoughts of the creator. This opportunity is what the modern artists are looking for and are not afraid to experiment on these pioneer tech solutions by using and learning new platforms and tools.

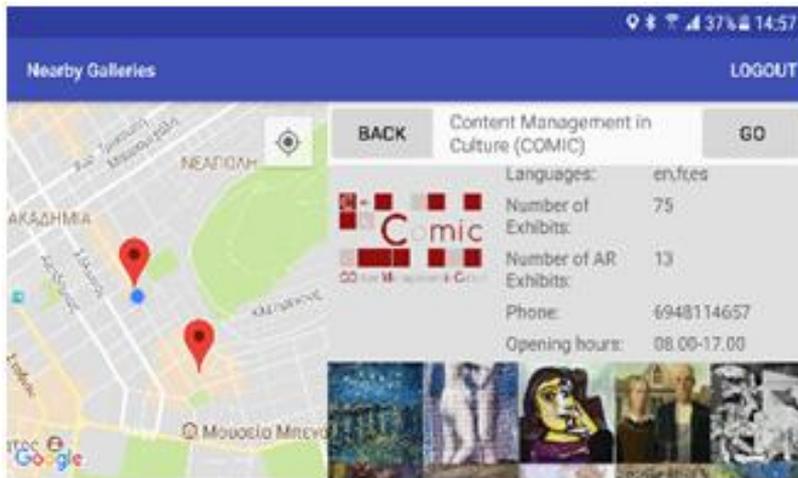
Although, learning curve of these technologies is not extremely short, the final result will justify their efforts by allowing them to show up their inspiration and present impressive creations. IT companies and experts should also prepare several pilot cases to help artists understand the way for developing new ways of interacting with their audience. These pilot cases should cover all areas of cultural asset life cycle and the needs of an artist and, if possible, should be designed in co-operation with them.

	User's Experience	Content	Access
VR	Believable and explorable	3D Models 360 photos & videos	VR Headsets
	Lively & Interactive movements	High quality analysis	High Speed Internet connections
	Integration with human senses (sight, hearing, touch)	Level of design detail depending on device	Mid to Low Priced Equipment
AR	Similar to mobile UX methodology	Images, Sound, 3D models & Holograms	Mobile Devices & Hi-Tech AR Headsets
	Simple but impressive. Emphasis on visual aspect	Information and Visual Representations	Average Speed Internet
	Need of sensors and cameras	Augment the physical object on camera	Mid to Extremely High Priced Equipment

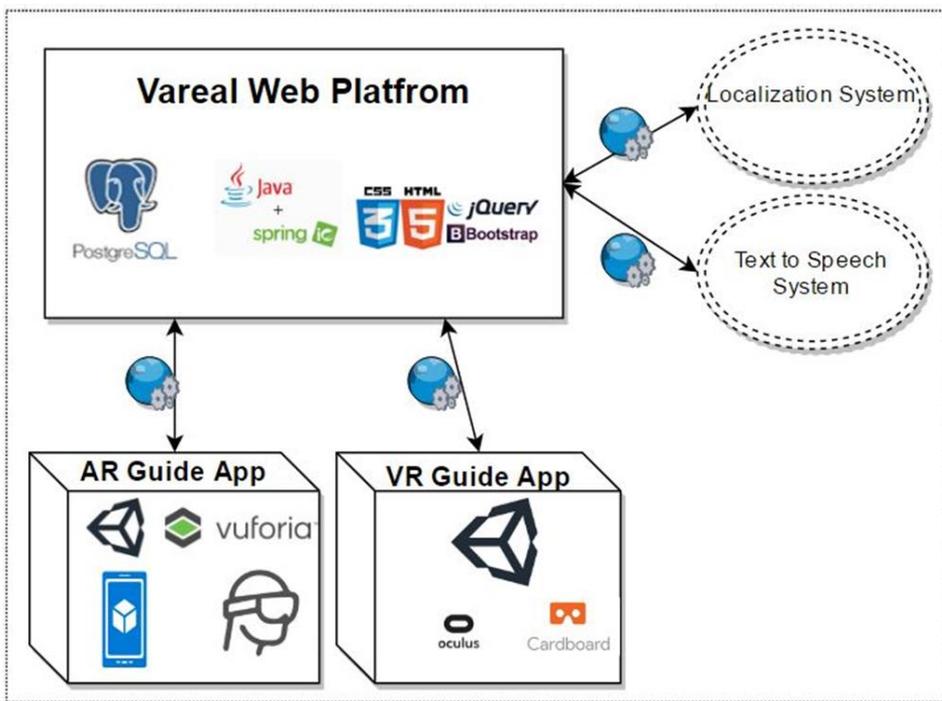
CASE STUDY

The implementation of VR and AR projects in the cultural sector are growing fast and several solutions are developed as pilot cases initially and some of them are expected to be launched commercially on the following years. The fact that Software as a Service (SaaS) is, nowadays, the strongest trend in the digital products' distribution, is expected to help the growth of these solutions as more and more professionals from the cultural sector will be interested in looking at and eventually using them.

The focused case that is currently examined and presented is named VAReal (Virtual and Augmented Reality) platform and is a combined attempt from the R&D department of COMIC and a few team members of the Cultech Laboratory. VAReal is designed for museums and galleries in order to provide them a solution to present their exhibits, mainly painting, to their audience through the VR and AR technologies. It consists of a Web platform and of two end user applications (one VR and one AR).



VAreal Web Platform: The VAreal Web Platform acts like a digital repository for the curators and the artists where they will insert the selected digital masterpieces that they want the visitor to get in touch with. The start by creating the gallery profile and then they move on with the digital cultural assets by uploading a high-quality image file and documenting the cultural asset with few important information (title, creator, a small description, creation date and dimensions). All this information is displayed through the mobile applications to the visitors, either by virtual or physical visits.



Finally, they choose if they want to include the asset to the Augmented Reality (AR) or/and the Virtual Reality guide application. When this process is finished, the image file is stored both to VAreal file system and to Vuforia Cloud and a text to speech process is taking place in order to produce an audio file by the text to speech external subsystem. Furthermore, the curator can either select a different language for documentation or select the translation service which is provided by an external localization subsystem.



AR Guide App: The Augmented Reality guide is a mobile application for the visitors of the Gallery's exhibition. The visitors will find the application to the Android and IOS stores, they will install it and then they will either create a user profile or they will sign in as a guest. In both cases, the application will ask them to use their GPS location in order to show them in a digital map, the galleries that are around and the application will provide information for some of their exhibits. The user is able to review the provided exhibits through the app, to find information regarding the gallery and select his preferred language from the available ones regarding the exhibits' information. When the visitor is in front of an exhibit may scan it and get useful information regarding the exhibit or the exhibit's creator. The scan process is extremely short and the information is instantly displayed on a subsequent screen. The user may also choose to hear the provided audio file regarding the exhibit or the creator.



VR Exhibit App: The Virtual Reality exhibition application is a mobile application for VR visitors on a fantastic world of gallery or museums exhibitions with their paintings or other masterpieces. Each gallery or museum is able to create his own exhibition by setting up and placing the selected paintings on the spots and rooms that is most suitable. The curator's freedom of movement and choice is quite remarkable and at the end the exhibition is finalized, saved and published. Then the exhibition is available to end users to select and visit any published exhibition and specific filters have been designed to support this selection. All the metadata (information, images, sound) are online transmitted from the back end web platform via web services. The end user selects the preferred exhibition and visiting language and then is free to move over the painting and guided as if it were present in a physical gallery space.



DISCUSSION

VAReal as a typical example of a VR & AR application, has been used to investigate aspects of Cultural Sector's, such as reuse of content and end-user's experience enrichment. During its trial implementation and pilot-cases phase, a series of challenges and opportunities arise. The first challenge had to do with the difficulties to convince the key persons, in museums and galleries, for the potentialities and the prospects of such solutions. Usually coming from non-ICT sector these persons are sceptical about implementing such technologies, having second thoughts about: (a) the internal capability to maintain, economically and technologically, long-term use of such applications and (b) the need to change the existing organizational culture and operational character. As a consequence, the second recognized challenge is to persuade the curators and the personnel for the ease of use and the impressive result. The application's design permits an effective usage from personnel with basic IT skills. The existence of pre-defined rules ensures that curators can select artefacts with few possibilities of making mistakes when design their virtual spaces. Moreover, from an artistic point of view, the personnel should understand that VR technologies cannot replace physical places, but aim to approach new target audience, expanding existing capabilities a step forward.

Moreover, it is clearer than ever that at this point the whole VR industry is in a transitional phase where: (a) existing technologies and tools are rapidly evolving, permitting more and more features to be added and (b) cost acquisition of special access equipment is constantly being reduced, leading to forecasts that soon enough headsets will cost as much as regular pair of glasses. Taking into account the forthcoming events to cost and technologies' combination, seems rational to invest "today" to VR technologies in order to be pioneer in a new era, the VR era. Supporting this idea, giant enterprises, such as Google, Apple and Facebook, have invested and continue to invest huge by creating capital powerful frameworks for developing VR & AR apps.

When the above-mentioned challenges are achieved, the results are more than encouraging. Using the experience from case studies where VAReal was implemented in cultural organizations, the results for VR technologies' implementation indicate:

- Increased capabilities on re-using existing content and link it with specific cultural items (e.g. older videos of extravagations with specific items).
- Mobile devices and VR-AR application can support cultural context of various forms (e.g. text, images, video, audio) leading to user's experience enrichment.
- Getting closer on the idea of virtual exhibitions consisting of items not-existing (destroyed or lost) or even with cultural items for which there is not enough physical space to exhibit.
- Implementing digital technologies lead to a general re-thinking and reshaping organizational structures, operational strategy, marketing orientation e.t.c.
- Increased capabilities to segment their visitors according to their own interests and to support them with customized / personalized information – context.

- Supporting activities related with giving access to their cultural content before – during – after visiting their exhibition.
- Supporting education and learning activities through digital technologies.

From the other side, as far as end-users' concerns, the results for for VR technologies' implementation in cultural organizations indicate:

- Increased interest on cultural items and improved learning capabilities.
- More interested to get extra information and supplementary (multimedia if available) content.
- Greater involvement in learning procedures (getting learning context in an amusing way).
- More autonomy in the way additional information is reached (as a result of using mobile devices and especially mobile phones).
- Greater flexibility in aspects such as "where to go", "what to see", "what to pay attention on".
- Reaching an accepted lever of integration between Culture – Technology – Amusement when visiting a cultural organization.

Finally, even though there is a growing interest from AR/VR technologies' developers for cultural sector, there are still many aspects to be investigated. Solving issues such as users' isolation and lack of mutual interaction, keeping the interest on cultural items rather than on digital artefacts, expanding educational character of digital technologies, creating sustainable business models that could financially support the further expansion of digital technologies, are some of them.

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