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Augmented and Virtual Reality for the promotion of the cultural heritage: analysis of museum mission and visitor experience

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Introduction

In 2018 the European Year of Cultural Heritage is celebrated with projects, initiatives, events and debates about the role of museums and cultural heritage sites in the current global and changing society.

Museums are no-profit permanent institutions that preserve over time and exhibit the cultural heritage, including the tangible artifacts (such as monuments, works of art, botanical specimens etc.) and intangible resources (like oral traditions and rituals) to the benefit of present and future generations (Marini Clarelli, 2005).

In the 21st century, museums deal with rapid societal changes, with the decline in public funding, and they compete for the audience against other cultural leisure services (Ross, 2004; Bearman & Geber, 2008; Stephen, 2001; Ballantyne & Uzzell, 2011). In such context, museums should adopt strategies to pursuit their mission and maintain their relevance for the society (Black, 2012).

The introduction of new technologies in museum represents a strategy to follow the audience-centred trend. Indeed, museum managers recognize the need for tools and resources tailored to visitors' needs and demands, to better promote the cultural heritage and better engage the audience.

Nowadays, the most promising tools are the mixed reality technologies: by superimposing virtual objects on reality (Augmented Reality - AR) or by creating immersive virtual environments (Virtual Reality - VR), this kind of technologies allow the museums to convey the heritage-related information and enhance the visitor experience.

The successful implementation of the technology does not rely only on the technical properties, rather it depends on the benefits perceived by the visitors who use it to reach specific objectives (Triberti & Brivio, 2017), and on the way the technology is embedded into the museum context, with its specific identify, collection and mission (Tallon & Walker, 2008).

In light of the above, this thesis aims at investigating the role of Augmented and Virtual Reality technologies for the promotion of the cultural heritage.

Besides the amount and relevance of the literature about this topic, there are still some open issues that need to be addressed in order to better understand how technological innovation supports museum mission and enhance the visitor experience.

First of all, the technological innovation should be considered in the light of the strategies the museums adopt to promote the heritage they conserve and exhibit, and to engage regular and potential visitors within a wider strategy of audience development (Damala & Stojanovic, 2012).

Moreover, in order to design innovative solutions for a successful visitor experience, the mediation of the technology needs to be investigated considering the interaction between the visitors (i.e. their previous experience, interest and motivation), the technology (i.e. its features and mode of interaction) and the peculiarities of the museum context (i.e. mission and strategies, physical environment and display of the artifacts).

To address these open issues, I designed and carried out two complementary studies.

Study 1 is a qualitative investigation performed at the Ara Pacis Museum of Rome, in order to evaluate an application that integrates AR and VR technologies. The value of such solution is analysed according to both the museum mission and the visitor experience, considering the distinction between the design-for use and the design-in-use (Folcher, 2003; Kaptelinin & Nardi, 2007).

This study has laid the groundwork for **Study 2** that is a survey on museum audience performed through an online questionnaire, with the aim of collecting data from frequent, occasional and non-visitors (Hood, 2004) and about different kinds of AR and VR solutions.

This thesis is structured in four chapters.

Chapter 1 describes museum mission and strategies as they evolved over time through changes in perspectives and models. Indeed, the shift from the "old museology" to the "new museology"

(Vergo, 1989; Hein, 1999, 2002; Hooper-Greenhill, 2000; McCall & Gray, 2014) laid the groundwork for the diffusion of the audience-centred approach that motivates the technological innovation of museums.

Thereafter, I discuss the literature about visitor experience by referring to the Contextual Model of Learning elaborated by Falk e Dierking (1992, 2000, 2016), since it is a valuable and comprehensive framework to consider the personal, socio-cultural and environmental factors that determine the whole visitor experience.

Concluding the chapter, the Augmented and Virtual Reality technology are presented with some examples of best practices implemented in the cultural heritage domain.

Chapter 2 conceptualizes the technology-mediated experience and discusses the different factors that shape the visitor experience mediated by AR and VR technologies, in the light of the cultural-historical Activity Theory (Leontiev, 1974, 1978; Engeström, 1987, 2000; Kaptelinin & Nardi, 2007).

Chapter 3 presents the Study 1 performed at the Ara Pacis Museum, by discussing the methodology adopted and the results gained.

Chapter 4 presents the Study 2 by describing the design of the questionnaire and the results gained.

Finally, the *Conclusions* integrate the results from the two studies to provide explanations and suggestions that I hope will benefit museum managers and designers for the development of successful experiences.

Part I

This thesis is a contribute to the technological innovation of museums, by investigating the function of Augmented and Virtual Reality technologies for the promotion of the cultural heritage.

The technological innovation of museum needs to be considered in the light of the evolution that over the years changed the conception of museum, its functions to serve the society, as well as the epistemologies guiding its organization and strategies.

In order to investigate the impact of innovative technologies on the museum and on the visitor experience, a comprehensive theoretical framework is necessary to consider the different factors resulting in the whole visitor experience.

The most valuable theoretical framework elaborated in the field of Museum Visitor Studies is the *Contextual Model of Learning* (Falk & Dierking, 1992, 2000, 2016). It conceptualizes the visitor experience as resulting from the integration of personal, socio-cultural and environmental factors. It represents a fundamental step to enhance our understanding of the complexity of the visitor experience, and to guide the design towards audience-centred solutions.

Nevertheless, this model does not help to understand the function of digital technologies designed as interpretative tools, to convey the information related to the museum identity and the artifacts it conserves and exhibits.

To fill this gap, I refer to the *Activity Theory* (Leontiev, 1974, 1978; Engeström, 1987, 1990), a framework developed in the field of cultural-historical Psychology, that allows me to conceptualize the museum visit as an activity mediated by the technology, and to better identify the factors that shape the interaction with AR-VR technologies.

1. Museum mission and technological innovation

The technological innovation is often introduced in support to museum mission so as to meet the needs of its heterogeneous audience, by designing effective tools with a positive impact on the visitor experience.

Considering the evolution of museum's functions over time, the technological innovation represents a strategy to apply the *audience-centred* perspective and to drive the museum towards the 21st century (Tallon & Walker, 2008).

1.1 The evolution of museum mission

The name "Museum" comes from the Greek term *Museion* (μουσείον), meaning the temple of the mythological Muses, daughters of Zeus and the memory-goddess Mnemosyne, who were considered as the sources of inspirations for poets and artists.

The first museum in history was founded between the IV and III Century B.C. in the royal palace of the Egyptian city of Alexandria. It included the famous library, the astronomical observatory and the botanical garden. Until it was destroyed by the fire in 272 A.D., *Museion* was the institution that brought together some of the best intellectuals and scholars of the Hellenic world (Marini Clarelli, 2005).

It was not the museum as we know it today: it did not preserve art works because it was devoted to the study of astronomy, anatomy and philosophy.

The modern meaning of the term "museum" dates back to the Renaissance, when it was used to define private collections of *naturalia* and *artificialia* (natural objects and artifacts). Collections of natural specimens were gathered during travels around the world, and they were formed to support the investigation of scholars interested in natural sciences. The human-made objects, such as ancient coins, medals and fragments of epigraphy were collected due to the

fascination for the antiques. Collections of painting and statuary aimed for conveying the refinement and power or serving the intellectual interest of their owners (Macdonald, 2006).

Later on, during the XVIII Century, some museums across Europe were established thanks to donations of private collections and archaeological excavations, and they permitted the access to the public: Ashmolean Museum in Oxford (1713), Palazzo Poggi in Bologna (1714), British Museum in London (1759), Museum Fridericianum in Kasselthe (1769), Uffizi in Florence (1769).

In particular, the case of Musée du Louvre is the prime example of heritage appropriation by the population. Indeed, the French revolutionaries in 1789 appropriated the property of the church, the monarchy and the royal academies with the purpose of creating a national patrimony that in 1793 was displayed for all to see in the Grand Gallery of the Louvre Palace, renamed the *Muséum Français* (Macdonald, 2006).

This is how the museum became the institution devoted to the conservation and exhibition of the heritage to the benefit of the society. Nevertheless, at that time and during the next decades, the public was mainly composed of art students, scholars and the upper class of the society (Macdonald, 2006).

After the Second World War, when national governments took responsibility for social services and education, museums acquired the status of institutions in charge of the education of the masses (Hein, 2002).

The formal definition of museum mission was established in 1961 by the *International Council of Museums*[1] (ICOM), specifying that it had to be inclusive of both education and enjoyment: museum is «any permanent institution which conserves and displays, for purposes of a study, education and enjoyment, collections of objects of cultural or scientific significance».

[1] The International Council of Museums is a Public Interest Organisation, founded in 1946 as a network of museum professionals who represent the global museum community. It sets standards for museums in design, management and collections organisation. The different versions of the ICOM definition of museum are available at the following link: http://archives.icom.museum/hist_def_eng.html

This formal definition led to the development of educational activities and specialized museum staff.

However, during the subsequent years much has been debated about whether museums should emphasize education or entertainment, treating these two variables as mutually exclusive (McManus, 1993; Packer, 2006).

In such debate, Falk and colleagues (Dierking & Falk, 1992; Falk, Moussouri & Coulson, 1998) pointed out that both learning and leisure are relevant motivations for visiting: visitors expect to enjoy themselves and learn new things, benefiting from the free-choice learning provided by the museum context. Thus, what the visitors desire is education and entertainment in unison.

Finally, in 2007 the ICOM proposed the most accurate definition of museum mission, recommending to maintain the focus on both education and enjoyment.

> «Museum is 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» (ICOM statute, 2007).

Therefore, the museum of the 21st century should provide the visitors with facilitating context and appropriate resources to enable them to experience educational leisure (Packer, 2006).

In addition to this established mission of education and enjoyment, Graham Black (2012) highlights that museums have the opportunity to pursuit several functions to the benefit of the society: they can act as a source of local pride, a memory store for the local community as well as a meeting place of the community; they can celebrate the cultural diversity, by fostering dialogue and toleration, and promote social inclusion.

To pursuit their mission(s), museums are becoming more *audience-centred* and such trend requires to consider the needs and demands of the audience (the regular as well as the potential visitors) when planning activities, services and exhibitions (Black, 2005).

The audience-centred perspective has direct implications for the museum management: museums need to thoroughly understand their audience in order to offer them effective resources tailored on their needs, such as educational activities and digital tools.

Furthermore, museums need to adapt themselves to the social and cultural changes, by finding new ways to meet the emerging demands related to learning and enjoyment.

This current trend derives from a fundamental turn related to the perspective that guides the museum organization and the way the visitors are conceived and studied.

The following paragraphs describe the shift, that is still ongoing today, from the old to the new museology and how it affects the methods and models to study the visitor experience.

1.2 From old to new museology: a change in perspective and methods

The evolution of the museum is not only related to its formal mission, but it also concerns the strategy to pursuit the mission.

The external forces that encouraged such evolution are several, ranging from demographic and social changes in education and leisure activities, to political and economic pressures (Ross, 2004; Bearman & Geber, 2008; Black, 2012).

In particular, Ballantyne and Uzzell (2011) explain the audience-centred approach as a strategy that museums adopt in response to the decline in public funding, as well as to compete with other leisure services in engaging consumers. Relying on donors and ticket incomes, museums tend to place visitors and their satisfaction at the center of the institutional strategic planning.

In addition to the external pressure, an "internal" force needs to be considered: a change in perspective based on new epistemology and the contamination with different disciplines, especially the social sciences.

This internal change is conceptualized as the shift from the *old museology* based on the positivism-behaviourist approach, to the *new museology* based on constructivist approach, as well as from the collection-centred to the audience-centred focus.

The old museology conceived the museum as an institution devoted to the education of the masses (Hein, 2002). The model of communication expert-to-novice placed the museum curator in charge of defining the information to be transmitted, while the visitors were expected to absorb and retain the message (Macdonald, 2006).

The museum collection was the focus of attention, in order to find the most effective way to convey the inherently and legitimate meaning of the displayed artefacts (Hooper-Greenhill, 2006).

By introducing the *New Museology*, Vergo (1997) pressed the need for a re-examination of the role of museum and its relationship with the visitors and the society.

The new museology came from the failings of the traditional approach and it raised the reflection about the social and political roles of museums, encouraging new forms of communication in contrast to the collection-centred approach (McCall & Gray, 2014).

The shift from the old to the new museology was part of a broader development in many social disciplines that took place during the 1980s and 1990s.

Specifically, the diffusion of the *Constructivism* (with the fundamental contributes of Kelly, Bruner, Mead, Piaget, Lewin, Vygotskij) fostered "reflexivity" among the museum community – in the form of greater attention to the processes by which knowledge is produced and disseminated, and to the partial nature of knowledge itself. Museum community started to think about the way meanings are inscribed and by whom, and how some come to be regarded as legitimate or taken as given (Macdonald, 2006).

From the perspective of the old museology, the curator has the power to select the artifacts to be exhibited, the message to convey and the curatorial voice is the only one to be heard as legitimate (Hooper-Greenhill, 2000).

The new museology poses two main issues: the first issue concerns "what is said" and "who says it", dealing with narrative and voice; the second one is relates to "who listen it", as a matter of interpretation, understanding and the construction of meaning (ibid.).

Furthermore, the new museology and the constructivist approach stimulate the discussion about the traditional conceptualization of the visitors and the learning process: visitors cannot be conceived a "clean slate" or a jar to be filled with information by one-way process of stimulation (from the museum-emitter to the visitor-receiver); they are active and pivotal factor in the construction of meaning about the heritage (Hooper-Greenhill, 2004, 2006).

> «In terms of how visitors are conceived, there was a shift from thinking about visitors as an undifferentiated mass public to beginning to accept visitors as active interpreters and performers of meaning-making practices [...] And in respect to the theoretical approach, there is a move from a narrow, backward-looking paradigm based on behaviorist psychology and a transmission or expert-to-novice model of communication to a more open and forward-looking interpretative paradigm that employs a cultural view of communication involving the negotiation of meaning» (Hooper-Greenhill, 2006, p. 362).

However, today the constructivist turn of the museum is far from being complete and widespread since some museums still adopt traditional approaches.

George Hein (1999, 2002) analysed the different models of museums based on the epistemology and learning theory they adopt – even tacitly and unknowingly. Indeed, the author recognized that educational practices in museums follow some pattern, adhere to some theory and reflect the beliefs of the staff and the larger culture in which they are embedded.

As promoter of the new museology, Hein points out the need for reflecting about the assumptions that guide the educational practice of museums, by posing some fundamental questions.

> «What do we think knowledge is and how is knowledge acquired? […] Do museum exhibitions show the world "as it really is", do they represent convenient social conventions, or do they provide phenomena for the visitors to interpret as

they will? […] Do we believe that learning consists of the incremental addition of individual "bits" of information into the mind or do we think that learning is an active process that transforms the mind of the learner?» (Hein, 2002, p. 16).

Hein (1999; 2002) classifies four museum models according to the specific theories of knowledge and theories of learning. The resulting schema is shown in *Figure 1*.

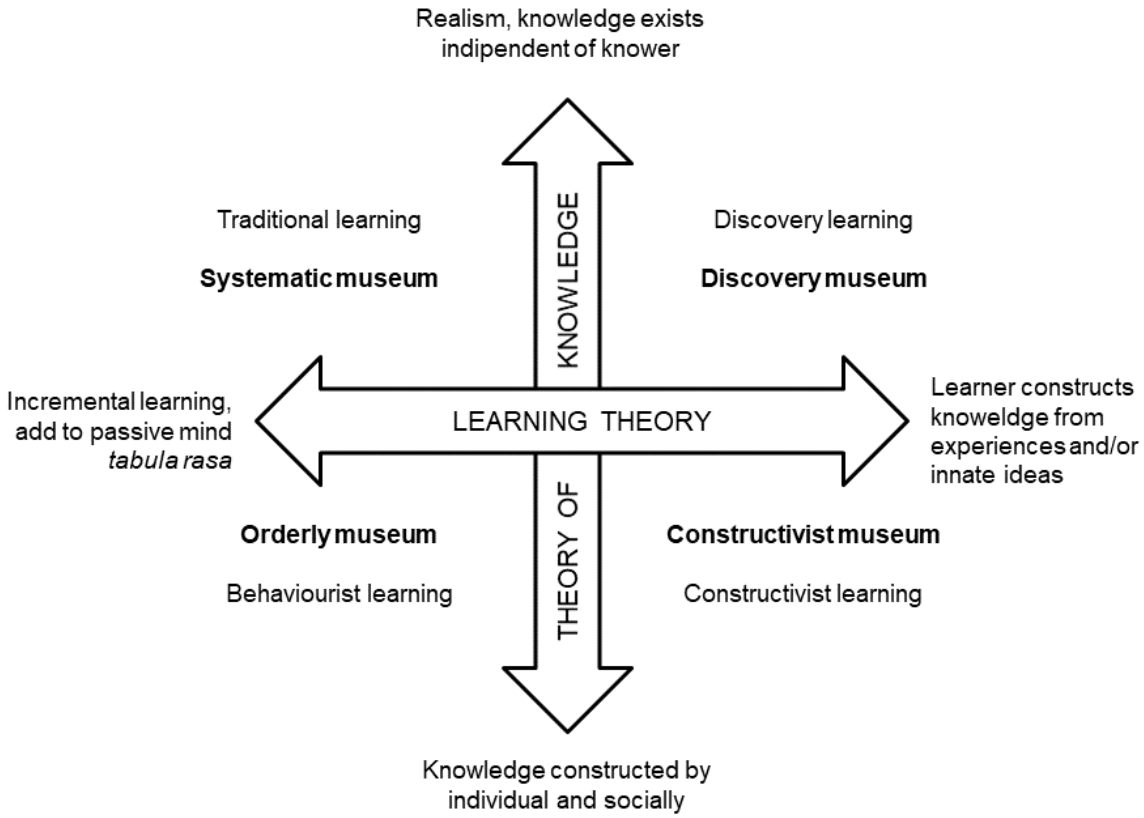


Figure 1: Epistemologies and museum models (Hein, 1998)

The **systematic museum** is based on the old museology: it tends to exhibit the "true" nature of the subject matter (i.e. the true description of historical facts), and to transmit a corpus of knowledge to be acquired by the visitor. It provides educational programs with specified expected learning outcomes according to the content to be learned.

The **orderly museum** is based on behaviourist psychology and conceives the visitor as passive receiver. Like the systematic museum, it is characterized by the didactic and expository approach, but it makes no claims for the objective truth of what is learned.

The **discovery museum** is based on the idea that learning is an active process and learners undergo changes as they learn. This kind of museum usually includes hands-on activities, experiments and interaction with physical objects.

Nevertheless, the discovery museum is still based on realism: it fosters the visitor to discover the "truth", by structuring situations so that the desired outcomes will be obtained.

The more advance model of museum is the **constructivist museum**. The basic assumption is that learners construct knowledge as they learn – individually or interacting with others - by reorganizing and creating both the understanding and the ability to learn as they interact with the world.

The constructivist museum has the following characteristics:

- it allows the visitor to construct the meaning from the exhibit;
- it offers multiple paths and modalities to acquire information;
- it provides a range of points of view;
- it fosters the active participation of the visitor through experiments, interactive exhibits and social activities.

In such perspective, the museum is conceived as a "facilitator", enabler and mediator of learning since it provides the suitable setting to foster the meaning making of the visitors, according to their specific background and needs (Hooper-Greenhill, 2006; Black, 2012).

The active participation of the visitors is further stimulated by the model of **participatory museum**, that represents an evolution of the constructivist museums.

Nina Simon (2010) introduces the concept of participatory museum as a way to connect museum with the society: she invites museums to actively engage visitors as cultural participants, by allowing them to create, share and discuss about museum-related contents.

In Simon's view, cultural institutions can benefit from the collection of contents co-produced by the visitor community, to pursuit the core mission of creation and dissemination of knowledge.

«Instead of being “about” something or “for” someone, participatory institutions are created and managed “with” visitors» (Simon, 2010, p. iii).

In this way, the authoritative voice of the institution is questioned in favour of multiple narratives and points of view of the visitors, which are integrated in the museum interpretative framework. Visitors are free to question and debate about the issues that most concern them, while museum gives them the support and inspiration to do so (Black, 2012).

The emphasis on participatory practices stimulates different forms of visitor involvement (Salgado & Marttila, 2013): people can participate not only by creating narratives about heritage interpretations, but also by being part of the design process in collaboration with museum staff – for example, to organize events, choose the exhibition topic, select the artefacts to be displayed and so on.

1.2.1 Museum as informal learning setting

Education is the traditional function of museums, but museums offer informal learning environments which are very distinct from the formal ones: visitors freely decide to visit the museum; they can choose which activities to participate in, the path to follow (with more or less flexibility based on the specific museum design), the information to seek, and they can leave at any time (Leister, Tjøstheim & Schulz, 2016).

As informal learning setting, the museum has the following characteristics (Hooper-Greenhill 2004; Anderson 1995; Falk, Dierking & Foutz, 2007; Black, 2012):

- the setting provides direct experience with real objects, people and places;
- learning is voluntary;
- learning is stimulated by the needs and interests of the visitors;
- learning is often socially mediated;
- visitors form a heterogeneous audience with different ages, expertise, learning styles and prior knowledge.

Thus, museums provide the "free-choice learning" (Dierking & Falk, 1992), meaning the context in which learners themselves have a real choice regarding what, where, when, how, and with whom they learn. Because learning in museum is a matter of free choice, the influence of motivational factors is of paramount importance.

Packer (2006) proposes the expression "learning for fun" to refer to the phenomenon in which visitors engage in a learning experience because they value and enjoy the process of learning itself, rather than for any instrumental reasons, such as the attainment of specific learning outcomes.

> «What do visitors want or expect from an educational leisure activity such as a visit to a museum, zoo, aquarium or other such experience? Is it to learn something or to experience learning? [...] What they seek from their visit is not so much to learn something as to engage in an experience of learning that is inherently valuable or enjoyable in its own right, regardless of the learning outcomes that may or may not ensue» (ivi, p. 329).

Thinking about the learning for fun emphasizes the motivational aspects: learning with no other purpose than the enjoyment of learning itself (Packer & Ballantyne, 2004).

This concept has commonalities with the construct of intrinsic motivation: a task is intrinsically motivating when it is worth doing for its own sake, and not because of any anticipated rewards from outside the activity itself (Csikszentmihalyi &Hermanson 1995). Although learning in formal settings is often associated with extrinsic rewards such as grades and career outcomes, learning in informal settings usually depends on intrinsic motivation.

Given the educational purpose of museum, the issue is related to the measurement of learning outcomes.

This issue is particularly relevant if we refuse the behaviorist models of museum learning – given the "right" stimulus (i.e. well-designed exhibition and/or label), visitors would achieve

the "right" response (i.e. learn what the museum intended them to learn) – and adopt the constructivist (Falk, Dierking & Foutz, 2007; Black, 2012).

Eilean Hooper-Greenhill is one of the major leading exponents of Museum Studies, and her contributes are of paramount importance to study the educational role of museum.

Specifically, she analyzes the museum as informal learning setting compared to the formal ones, and questions the conceptualization and measurement of learning outcomes deriving from the museum visit.

In the formal learning settings, the evaluation of learning outcomes represents a core element. Learning outcomes are generally produced on the basis of detailed understanding of the prior knowledge or experience of the specific group of learners, and they set out the standards that learners are expected to achieve at the end of any period of study. Learning outcomes are expressed in terms of "can do" verbs and they establish what learners should be able to do at the end of the study program (Hooper-Greenhill, 2004).

Learning outcomes provide a standard against which both teachers and learners can measure progress. The achievement of some or all of the pre-established learning outcomes is measured by formal examination systems where levels of achievement and standards are set.

The way in which learning outcomes are conceptualized and measured in formal setting does not fit cultural organizations like museums, especially when the experience of different people needs to be considered (Black, 2012).

First of all, it is difficult to identify a moment that can be regarded as an end-point in learning and therefore an appropriate moment for measuring learning. Indeed, several research (see for example: Ellenbogen, 2002; Ellenboge, Luke & Dierking, 2004; Rennie & Johnson, 2007) highlight that visitors reflect and discuss about the museum experience days and weeks after the visit, for example by connecting the museum-related content with other life domains.

Moreover, it is not appropriate for museums to be prescriptive about levels of learning achievement, as visitors have their own criteria for what counts as successful experience, and

the different motivations for a museum visit determine multiple outcomes (Rennie & Johnston, 2007).

Thus, without pre-determined learning standards, the challenge is to evaluate how far visitors have moved forward in their understanding and abilities thanks to the museum visit experience (Hooper-Greenhill, 2004).

The conceptual framework that identifies the dimensions of learning in museums (as well as in libraries and archives) is the *Generic Learning Outcomes* (GLOs), that can be used as a common structure for research, planning and evaluation (Hooper-Greenhill, 2002; 2004).

The model has been developed by the UK *Council for Museums, Archives and Libraries*, and it defines five learning outcomes that can be derived from the museum visit.

- **Increase in knowledge and understanding** can include learning new facts or using prior knowledge in new ways, coming to a deeper understanding. Well-known information may take on a new relevance or be made meaningful in new ways during a museum visit. Knowledge and understanding can be subject-specific as well as they can result in making connections between different domains;
- **increase in skills** may involve intellectual, practical, social or professional skills challenged during the visit;
- **a change in attitudes or values** about the self, other people, the cultural heritage as well as human and natural phenomena. Furthermore, as pointed out by Rennie and Johnston (2007), learning outcomes cover attitudinal changes towards the museum content, such as increase in interest and awareness;
- **enjoyment, inspiration, creativity** as outcomes of learning includes having fun and pleasure during the museum visit, developing innovative thoughts, exploration and experimentation;
- New **action, behaviour, progression** can also result from the museum visit, in terms of behavioral intention in different life domains (work, study, family).

Considering this latter learning outcome, Barbara Soren (2009) reports the behavioral changes of visitors who become more active participants in arts and cultural activities. She considers the new way of thinking and doing as the result of a transformational experience.

> «Transformational experiences seem to happen if we discard old ways of thinking and provide new opportunities for individuals to invent personal knowledge and explore new ideas and concepts» (ivi, p.234).

The experience of aesthetics and sublime, powerfully emotional experience and empathy with other people and situations have the potential to change ourselves, by changing our taken-for-granted frames of reference (i.e. mind-sets, meanings and perspectives to see the world) and make us more reflective and emotionally capable.

To sum up, the current approach to museum learning does not rely only on the transmission-acquisition of knowledge, but it tends to consider visitors' attitudes, intentions and emotions through the stimulation of meaning-making processes (Falk, Dierking & Foutz, 2007; Black, 2012).

1.2.2 Methods for studying visitors: from behaviours to meanings

Along with the shift from the old to the new museology, the methods to study the visitors and their experience changed over time.

The first systematic studies carried out from 1910s to 1940s were based on observations and they produced report of tracking data – for example, the total visit time, the time spent looking at the exhibits/artefacts and the number of stops during the visit (Robinson, 1928; Melton, 1935).

Considering the dominance of the behaviourist paradigm at that time, data collected through "unbiased" observation were intended to be valid and reliable, while interviews were rejected as subjective reports.

There was an interest in identifying the "hot" and "cold" exhibits according to their attracting power, that is the draw exercised by an exhibit to attract the visitors' attention, and the holding power, that is the sustaining power measured by the length of time spent looking at it (Robinson, 1928).

By studying the visitor interest towards the exhibits that decreases as the visit progresses, Gilman (1916) introduced the concept of "museum fatigue" and provided the first guidelines for the disposition of the objects and the design of text-based tools (labels and panels).

Some experiments were carried out in order to identify the environmental features that determine the fatigue, as well as best way to reduce it. For example, Melton (1935) varied the number of paintings in a museum gallery and observed that visitor interest decreased as the number of displays increased.

In this research branch, patterns of visitor behaviour were also used to define visitor profiles. Veron and Levasseur (1989) carried out extensive observations of visitor behaviour in several museums, and they proposed a classification of visitor styles based on four animals' behaviours:

- the *ant* visitors, who follow a specific path and spend a lot of time observing almost all the exhibits;
- the *fish* visitors, who move most of the times in the centre of the room without looking at exhibit's details;
- the *butterfly* visitors, who do not follow a specific path because they are guided by the organization of museum space and they stop frequently examining their details;
- the *grasshopper* visitors, whose visit contains specific pre-selected exhibits, and they spend a lot of time observing them.

This classification is used in more recent studies that nowadays can take advantage from technologies for tracking visitors' movements and positions inside the museum space (see for example: Raptis, Tselios & Avouris, 2005; Zancarano et al., 2007; Sookhanaphibarn & Thawonmas, 2009).

As reported by Yalowitz and Bronnenkant (2009), visitor behaviour is still a dominant topic in today's studies. The objective it to analyse the attracting power of the exhibits, visitors' preferences towards specific exhibits/resources, as well as obstacles and problems related to the orientation, guidance and design of the museum spaces.

Nevertheless, the reasons behind the observed visitor behaviours are rarely explained, limiting the value of such studies for the museum organization (Falk, Dierking & Foutz, 2007).

Explanations of visitor behaviour are provided by two models, the General Value Principle and the Total Interest Value.

The *General Value Principle* elaborated by Bitgood (2006) suggests that visitor movement through museums can be explained based on the relationship between benefits (such as satisfying curiosity) and costs (time and effort required to attend the exhibit). According to this principle, the value of an experience is calculated, usually unconsciously, as a ratio between the benefits and the costs which can be actual of perceived.

This means that visitors attend to exhibits/artefacts that are perceived as beneficial only if the costs are perceived as low in relation to the benefits.

According to Bitgood (2006), visitors approach exhibits/objects that are perceived as attractive or interesting for them. However, only few objects are usually perceived as attractive and many of them are approached because they are in the visitor's circulation pathway and thus require little effort and no additional steps.

Another implication of this model is that there are often differences in how much control the individual has over costs and benefits: visitors have more control over the costs than the benefits of their choices since they cannot change the quality of exhibits, but they can control the costs of their behaviour by reducing time and effort, for example by saving steps when moving inside the museum, reading only short labels or small parts of the long ones.

Total Interest Value is proposed by Round (2004) to explain the behaviour of "drifters", visitors who move in apparently random, unsystematic ways, failing to make use of the wayfinding aids and conceptual structures provided by the museum.

Round (2004) argued that such visitors use a set of simple heuristics in order to:

- quickly find interesting elements (*Search Rule*);
- know when to stop searching and start focusing attention on a specific exhibit (*Attention Rule*);
- minimize the loss of attention time when initial judgments about the interest potential of an exhibit element prove faulty, or when the initial interest potential has been exhausted (*Quitting Rule*).

Both the General Value Principle and the Total Interest Value define the decision-making process that is strongly determine by the visitor personal interest. So, the attracting power of exhibits depends on personal factors that need to be further investigated.

With the growing interest in Constructivism, new research questions raised and studies adopted different methods for studying the visitor experience. The objectivity of empirical data is now questioned and the attention is focused on the quality of the experience as perceived by the visitors (Hein, 2002; Macdonald, 2006; Falk, Dierking & Foutz, 2007). Thus, interviews and the narratives of the visitors are recognized to be valuable as much as they produce in-depth description of visitor experience. Furthermore, the interview is also used in longitudinal studies, to analyse the long-term impact of the museum visit, specifically in relation to the memories about the visit and the connections between what has been learnt in the museum and other domains of life (see for example: Falk et al., 2004; Ellenbogen, Luke & Dierking, 2007).

Although a comprehensive discussion of descriptive methods used in Museum Visitor Studies is beyond the scope of this thesis, I would like to mention two researches that took advantage from the use of particular techniques.

An interesting research is the one performed by Anderson and Roe (1993) who provided the visitors with instant cameras and asked them to take pictures during the visit. Using photographs not only focused visitors' attention, but stimulated memory and verbalization during the interviews performed at the end of the visit.

Sheng and Chen (2012) performed a research about museum experience by involving five frequent visitors who visit five museums in Taiwan, together with the researcher. Participants were asked to write diaries to describe their experience, including feelings, actions, thoughts and interactions with others. Then, content analysis was performed on the written diaries and the results were used to develop a questionnaire.

Apart from the methods used, Museum Visitor Studies are divided into two agendas (Bitgood, 2006; Pekarik, 2007).

The first agenda is focused on the audience by investigating visitors' profiles, interests and motivations, and identify specific forms of experience based on visitors' characteristics.

The second agenda evaluates museum's offering (i.e. exhibitions, educational activities, services and tools) according to visitors' response, in order to design or re-design resources tailored on their needs and preferences.

Despite the multitude and relevance of the studies performed, the literature seems fragmented and divided between visitor-centred and exhibit-centred focus. In such context, Falk and Dierking (2016) provide a comprehensive framework to integrate the literature about the visitor experience and to guide the future research towards a more holistic approach.

1.3 Towards a comprehensive model to investigate the visitor experience

Dierking and Falk (1992, 2000, 2016) proposed the *Contextual Model of Learning*[2] as a comprehensive framework to analyze the complexity of the visitor experience in museums and heritage sites.

The model conceptualizes the different factors affecting the visitor experience that results from the overlapping of three contexts interacting with one another: personal, physical and sociocultural context.

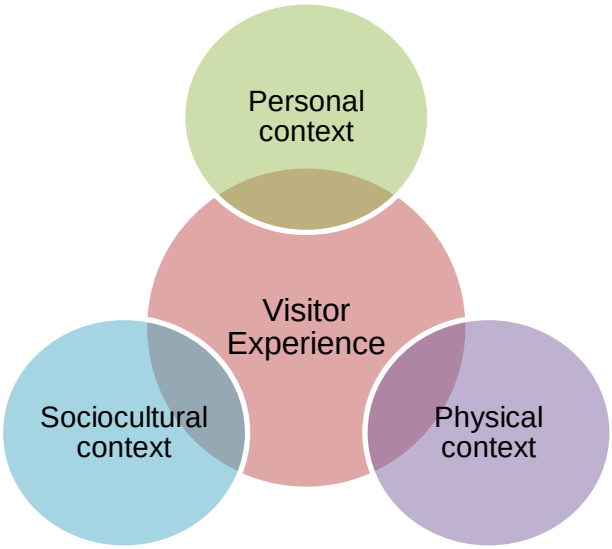


Figure 2: Three spheres of the Contextual Model of Learning (adapted from: Dierking & Falk, 1992)

The Contextual Model of Learning is a holistic framework: even though the three contexts can be considered and analyzed separately, they interact with one another to provide the whole museum experience.

In addition to the three contexts, the model includes the fourth dimension of the time during which the experience occurs. The analysis of the visitor's experience should cover «the totality

[2] The *Contextual Model of Learning* (Falk & Dierking, 2000; 2008) is a further elaboration of the *Interactive Experience Model* (Dierking & Falk, 1992) that has been refined based on the researches performed by the authors and according to the other literature produced in the following years.

of the experience, from the moment the thought occurs to someone that visiting a museum might be a good idea, through the visit itself, to the recollection of the experience days, weeks, and even years later» (Falk & Dierking, 2016, p.23).

Conceiving the museum experience over time requires to focus the attention on three time periods (Falk, Dierking & Foutz, 2007): the pre-museum phase in which visitors' prior experience and interests shape expectations and motivations towards visiting the museum; the in-museum experience that happens through the interaction with the physical environment and other people (both visitors and museum personnel); the post-museum phase in which reinforcing experiences such as conversations and readings occurs.

1.3.1 The visitor personal context

The personal context is what the visitors bring to the visit, shaping the kind of experience they seek, they enjoy and appreciate about it. The personal context is unique to each visitor, and it changes every time the same person visits a museum (Falk & Dierking, 2016).

This context includes:

- visit motivation and expectation;
- prior knowledge and experience of the museum;
- prior interest in the museum-related content;
- choice and control over the experience.

These factors are embodied in the pre-visit agenda (Falk, Moussouri & Coulson, 1998), meaning a pre-defined set of interests, beliefs, needs and anticipated expectations of what the visit would be like.

Falk and Dierking (2016) state that «the first step in understanding the museum visitor's experience is to ask why, of all the possible ways an individual or group could spend their leisure time, do millions of people freely choose to visit museums» (p.18).

- **Motivations for visiting museums**

Based on the extensive research carried out during two decades, Falk and his colleagues (Falk, Moussouri & Coulson, 1998; Falk, Heimlich & Bronnenkant, 2008; Falk, 2009; Falk, 2013; Falk & Dierking, 2016) contributed to the identification of the different motivations that drive the visitors to the museum. The result is a classification of five identity-related motivations representing the leisure attributes most people ascribe to museums and cultural contexts, which influence individual's behavior and learning in such contexts.

- The *explorers* are curiosity-driven with a generic interest in the content of the museum, they expect to find something that will grab their attention and fuel their learning;
- the *facilitators* are socially motivated, their visit is focused primarily on enabling the experience and learning of others in their accompanying social group;
- the *professional/hobbyists* feel a close tie between the museum content and their professional domain or hobbyist passions, and their visits are mainly motivated by a desire to satisfy a specific content-related objective;
- the *experience seekers* perceive the museum as an important destination, so their satisfaction derives mainly from having been there and done that;
- the *spiritual pilgrims* are primarily seeking to have a contemplative, spiritual and/or restorative experience, and they see the museum as a refuge from the routine.

Packer and Ballantyne (2002) extended Falk's work to analyze the range of motivational factors that impact on visitor experience of learning in the educational leisure context.

The authors identified a set of personal goals (visitors' reasons for visiting the site) which could be reinforced by the context beliefs (the perceptions regarding the opportunities for learning available at the site) and the situational incentives that are perceptions regarding the interest-arousing characteristics of the environment.

The personal goals that drive visitors to the museums are categorized as follow (Packer & Ballantyne, 2002).

- *Learning* and *discovery*: the desire to discover new things, expand knowledge, be better informed and experience something new or unusual;
- *Enjoyment*: the desire to enjoy oneself, to be pleasantly occupied and to feel happy and satisfied;
- *Restoration*: the desire to relax mentally and physically, to have a break from routine and recover from stress and tension;
- *Social interaction*: the desire to spend time with friends or family, interacting with others and building relationships;
- *Self-fulfilment*: the desire to make things more meaningful, challenge abilities, feel a sense of achievement and develop self-knowledge and self-worth.

The relevance of Packer's and Ballantyne's study relies on the comparison between motivational factors and the different educational leisure settings, namely museum, art gallery and aquarium.

Note that the authors differentiate between "museum" that contains a range of exhibits in themed areas covering the natural and cultural heritage, "art gallery" that displays paintings, sculptures, drawings, photographs, and the "aquarium" with live aquatic displays. The definition established by ICOM (2007) considers all these sites as museums, since they are permanent institutions devoted to the conservation and exhibition of tangible and intangible heritage.

To sum up the findings, museum visitors placed greater importance on learning and discovery goals, art gallery visitors placed equal importance on learning/discovery and enjoyment goals, while aquarium visitors placed greater importance on enjoyment.

Regarding the incentives for learning, visitors perceived the museum as a place where information important to them is presented in an interesting way, while the aquarium was perceived more as a place where learning is fun, and the art gallery was perceived as a place where learning is emotionally engaging.

Thus, visitor motivations are connected with the identity of the museum, in terms of exhibited collection and incentives to satisfy the visit agenda.

Andrew J. Pekarik and his colleagues (Pekarik, Doering & Karns, 1999; Pekarik & Schreiber, 2012) from the Smithsonian Institution in Washington (USA) carried out an extensive research about visitor expectations and motivations for visiting the different Smithsonian museums, throughout 12 years.

In addition to the learning, enjoyment and social interaction, they added the following motivations:

- seeing rare/valuable/uncommon things;
- appreciating the heritage;
- being moved by beauty;
- reflecting on the meaning of what is seen;
- recalling personal memories;
- imagining other times or places;
- being exposed to and experiencing different cultures.

Reporting the updated results of the study, Pekarik and Schreiber (2012) highlight that learning (gaining information and enriching understanding) and aesthetic experience (seeing rare/valuable/uncommon artifacts) are the most common visitor motivations.

Furthermore, these two motivations were relatively unlikely to be selected together, which suggests the possibility that the informational and the visual/aesthetic experiences represent two distinct schemas that differentiate visitors.

The historical reminiscence – in terms of getting historic content, reflecting about other times, recalling personal memories – is one of the visitor motivations identified also by Sheng and Cheng (2012), especially for families and older visitors.

In conclusion, research on visitor motivations points out several reasons for visiting museums, and given the heterogenous audience, museums should ensure that people with a particular

motivation, or a combination of motivations, can find ways to benefit from the visit according to their needs.

The recommendation of Falk and Dierking (2016) is to design exhibitions and programs that are open-ended, allowing for multiple entry points and personalization, in line with the vision of the constructivist museum (Hein, 1998, 2002).

- **Barriers for not visiting museums**

Together with the motivations that drive visitors to the museum, another relevant topic of the research – although it is rarely investigated – is related to the barriers for not visiting museums. Indeed, most of the research addresses regular visitors, whilst the wider category of non-visitors is usually neglected.

Marlyn G. Hood (1992, 2004) criticizes the traditional dichotomy of audience segments between "visitors" and "non-visitors" and she proposes a more useful distinction in terms of frequency of visit: frequent visitors, occasional visitors and non-visitors. She points out the need for investigating the profiles and barriers of the non-visitors, as well as the need for strategies to engage them.

Davies and Prentice (1995) analyzes the latent demand and distinguish among: a) those who never visit and never contemplate visiting; b) those who have visited once but never again; c) those who rarely visit.

The decision to visit or not cultural attractions is also a complex matter and it largely remains subjective; it often involves an interplay between driving motivations and constraining or inhibiting barriers (Kirchberg, 1996).

Thus, Davies and Prentice (1995) propose a model to explain the latent demand according to the relationship between motivations (positive or negative) and reaction to constraints.

Positive motivation results from the belief that expected valued consequences (experiences and benefits) will satisfy needs. Conversely, negative motivation occurs when no match exists between consequences perceived in museum visiting and individuals' leisure needs.

The authors identify three types of visitors based on the interaction between positive/negative motivations, presence/absence of constraints and reaction to constraints.

The resulting typologies can be summarized as follow:

- *potential visitors* are those who have positive motivations towards the visit, they would like to participate but they face some constraints that they are not able to overcome;
- *occasional visitors* are those who may have negative motivations but they do not perceive any constraints or they are able to overcome them;
- *non-visitors* are those who perceive negative attributes of the museum visit and they face constraints they are not able to overcome.

By integrating the literature about non-visitors (Davies & Prentice, 1995; Prentice, Davies & Beeho, 1997; Prentice, 2004; Hood, 2004; Jun, Kyle & O'Leary, 2008; Kay, Wong & Polonsky, 2009; Black, 2012), I derived a list of constraints and negative motivations that prevent people from visiting museums and heritage attractions, as shown in the *Table 1* below.

Constraints	– museum location difficult to reach – disabilities and health issues – restricted opening hours – expensive ticket cost – limited free time – lack of information about cultural attractions – nobody to go with
Negative motivations	– negative attributes of the museum experience: o boring, no fun or enjoyment o uncomfortable o too serious and intellectual o not interesting – perceived target audience of the museum o exclusively for experts o exclusively for tourists – poor quality of museum offerings

Table 1: Constrains and negative motivations for not visiting museums

All the listed factors, and the combination of them, contribute to the people's little interest in museums and their preference for other leisure activities (Kay, Wong & Polonsky, 2009).

Furthermore, Falk and Dierking (2016) mention that the lack of socialization with museums and other cultural institutions as well as negative prior experiences do not facilitate people to be engaged in.

Moreover, the perception that only individuals with specialized knowledge and a cultivated aesthetic taste can fully understand and appreciate the museum experience, represents a barrier that prevent the non-visitors from visiting the museums (Davies & Prentice, 1995; Falk & Dierking, 2016; Kay, Wong & Polonsky, 2009).

It follows that museums can, of course, address some barriers by applying effective marketing strategies (i.e. targeted advertising, partnership with other organizations, special events, free admission day etc.), but they also need to deal with the negative motivations that seem to be common among the non-visitors.

- **Prior knowledge**

The personal context that affects museum experience includes the visitors' prior experiences and knowledge, which determine the expectation of how the visit should be.

Falk and Dierking (2016) highlight that expectations are typically framed around visitors' identity-related motivations, which in turn are framed around the broader sociocultural perception of the role and value of museums in the society.

Within a cycle, «based on firsthand experience, visitors continually define and refine their expectations of what they will see and do during a visit. Each visit to a museum reveals and clarifies the scope and potential sequence of the next visit» (Falk & Dierking, 2016, p.84).

Such expectations are not only related to the organization of the museum and the displayed artifacts, but also to the social conventions, such as norms of behavior.

The source of information available are several, ranging from museums' web sites, newspapers, social media and word-of-mouth. In particular, word-of-mouth by trusted friends or relatives who have previously visited the museum or heard about it in some way, can reaches people

unexpectedly, in social situations in which they may be especially receptive to such recommendations.

Taheri, Jafari and O'Gorman (2014) investigated how preferences for cultural attractions are determined by tourists' familiarity and specific knowledge of the attractions, and past experiences. Prior knowledge of the museum influences visitors' choice towards specific museums, the activities to perform, as well as the expected outcomes.

In the context of arts consumption, Caru and Cova (2005) confirm that individuals' prior knowledge and experience contribute to the appreciation of museums. Similarly, Black (2005) shows that visitors with higher levels of museum experience and knowledge about the content of an exhibition happen to experience a higher level of engagement during their visit.

Hooper-Greenhill (2000) provides an example of how prior knowledge determines the construction of meaning from an artwork.

> «In constructing meaning from a Van Gogh painting of a sunflower, different levels of information will result in different complexities of interpretation. Someone with little prior knowledge of the artist or art history will see the painting as a flower painting. Someone with a detailed knowledge of the artist's work would be able to place the picture in relation to the rest of his work, to compare subject matter and technique with other artists of the period, and so on» (*ivi*, p. 23).

Contrariwise, gaps in visitors' prior knowledge can create significant barriers for learning, especially in the case of young visitors (Falk & Dierking, 2016).

Falk, Moussouri and Coulson (1998) found that visitor knowledge about the museum content and exhibits determine the plan of the visit, that fall along a continuum from unfocused to focused.

Visitors with an *unfocused strategy* are generally unaware of museum/exhibition opportunities and are open to experiencing whatever the museum has to offer. They come to the museum to see whatever is interesting, without a particular plan.

Visitors with a *moderately focused strategy* know something about the museum/exhibition and they may plan to see a particular exhibit during their visit, but this does not represent their sole or even primary objective.

Finally, visitors with a *focused agenda* plan their visit before they go to the museum, usually with a specific goal in mind. Typically, they have a visit routine which they follow and often this is to the exclusion of other things the museum might have to offer.

Given the importance of expectations and prior knowledge related to both initial motivations and overall satisfaction, museums can better engage the audience in two ways: first of all, by properly manage the external communication about museum content and offering, through different channels so as to reach a wide audience; and by providing the visitors with some control over the content and nature of the experience, allowing them to benefit from the free-choice learning (Falk & Dierking, 2016).

1.3.2 The museum physical context

The core of the visitor experience occurs in interaction with the physical context of the museum, that is related to the organization of the environment/physical space, as well as the artifacts and exhibits displayed. In the Contextual Model of Learning, the physical context also includes the technologies and the interpretative tools (e.g. panels, videos, interactive exhibits, digital handled guides etc.).

Nowadays, museum arrangement is designed with careful attention to aspects that enhance the visitor experience, such as lighting, rest areas, display of the artifacts and readability of text, with the aim of providing a facilitating environment and reducing the museum fatigue (Falk & Dierking, 2016).

The museum physical space determines the visitor experience through the affordances provided by both the museum space and the exhibits. The concept of affordance is further discussed in *§2.3.2* regarding the technology, but it is relevant to understand how the museum physical space invites possible actions as well as it poses constraints to other actions (Achiam, May & Marandino, 2014).

Specifically, the "affordance space" results from a relation between the visitor (with an internal representational of the museum space) and the museum environment within the visit situation. The space affordance is commonly related to the spatial structures that constraint visitor movements inside the space, while allowing a specific path to follow (Rudloff & Vestergaard, 2012). The exhibit affordance is related to the interaction with exhibits that allow the manipulation of artifacts and the exploration of natural phenomenon (Allen, 2004; Allen & Gutwill, 2004).

Achiam, May and Marandino (2014) point out that the organization of the exhibits and artifacts suggests affordance for the meaning making process: for example, the organization of artifacts based on thematic clusters invites the visitors to conceive the cluster, to compare the different artifacts within the cluster and reflect about general principles. «Although these thoughts are not actions in the usual sense, we can argue that the cluster engages visitors in a way that cognitively affords reflection and discovery» (p. 465).

Although museum designers tend to create all the exhibits with high attracting power, tracking studies show that visitors typically view only 20 to 40 percent of the exhibits/ artifacts (Rounds, 2004). Of course, visiting museums, especially those with a large number of exhibits, involves making choices to allocate the attention among the competing attractions.

Shettel (2001) argues that such partial use of the exhibits strongly reduces the educational potential of the museum experience, and museum can be truly effective only if the visitors carefully attend to all the exhibits using them in a comprehensive manner.

This view of a dysfunctional and non-diligent visit modality is questioned by Rounds (2004) who states that the partial use of the exhibits is an intelligent and effective strategy for the visitor whose goal is to have curiosity piqued and satisfied (the curiosity-driven visitors). The author suggests that the selective use of exhibits results in greater achievement of visitors' own goals than would be gained by using the exhibition comprehensively.

Falk and Dierking (2016) found that most visitors are drawn to exhibits that are both visually compelling and intrinsically interesting to them on a personal level, according to their motivations for visiting. Exhibits that attract visitors' attention are those connected with visitor's prior knowledge, interests and visit agenda as well as those that support their identity-related motivations.

The design of museum physical context deals also with orientation, in order to support the visitors in finding their way around, selecting what they want to see and do, without the need for effort to do so.

> «By providing first class physical orientation, both at the entrance and within displays, we empower visitors to select for themselves, we show them we respect their ability to do this, and we minimise their effort in working out 'what is going on' so they can concentrate their attention on engaging with museum content» (Black, 2012, p.71).

In addition to the physical orientation inside the museum space, Black (2012) suggests to consider the "conceptual orientation" that allows visitors to understand the criteria that guide the organization of the collection/exhibits (i.e. chronological order, thematic organization), and support their meaning-making in terms of connections between different artifacts and parts of an exhibition.

The impact of museum environment on visitor experience and satisfaction is also investigated by Environmental Psychology studies (see for example: Bitgood, 2002; Cancellieri et al., 2018).

According to place theory (Canter, 1977), the "place" is conceived as the interface between physical properties of a target environment, its typical activities/behaviours, and the evaluations/representations of these activities concerning such an environment. The museum-place appears to include different sub-places, such as the entrance, the exposition areas, the recreational areas, and the macro-architecture of the museum. These sub-places are interconnected and interdependent with reference to uses and behaviours that characterize the place itself.

Recently, the interest of museum designers is on tools and facilities that can meet the needs of visitors with disabilities, according to the principles of the Universal Design: for example, tactile tours for visually impaired people are offered by the most important museums across Europe. Indeed, the museum context can be facilitating as well as constraining environment when it produces sort of barriers.

Legislation on human rights fosters museums to develop their access policies and practices towards inclusion and equal opportunities for all. Given their role in society, museums are one of the clearest examples of an environment which requires a universal design approach (Ruitz et al., 2011).

The *Design for All* movement aspires to support people in several domains, ranging from everyday tasks, education, work to leisure activities (Persson et al., 2015).

The European Institute for Design and Disability (EIDD), in its declaration adopted in 2004, states:

> «Design for all is design for human diversity, social inclusion and equality. This holistic and innovative approach constitutes a creative and ethical challenge for all planners, designers, entrepreneurs, administrators and political leaders. Design for all aims to enable all people to have equal opportunities to participate in every aspect of society. To achieve this, the built environment, everyday objects, services, culture and information – in short, everything that is designed

> and made by people to be used by people – must be accessible, convenient for everyone in society to use and responsive to evolving human diversity»

Designing for all does not necessarily mean that a single solution suits all people's needs. More often, products/services/spaces are designed following some principles (Persson et al., 2015): for example, intuitive interfaces and simple instructions should be provided so to enable the use regardless of the user's knowledge, language skills or current concentration level; multichannel communication to meet diverse user's sensory abilities etc.

Regarding the museum domain, the active participation of people with disabilities involved in the co-design of spaces, exhibits and tools is essential to pursuit both the participatory museum and the inclusive museum (Sandell, 2003; Salgado & Marttila, 2013; Falk & Dierking, 2016).

1.3.3 The socio-cultural context

In the Contextual Model of Learning, the sociocultural context includes two components: a) the cultural system of values and beliefs about museum experience and cultural heritage; b) the social interactions that happen at the museum, both with other visitors and with the museum staff.

These two layers of the sociocultural context are well described in the following quote.

> «Most people visit museums in a group, and those who visit alone invariably come into contact with other visitors and museum staff. And if one takes the notions of sociocultural constructivism to its full extent, even when a visitor is alone and there is no direct social interaction, there is indirect interaction since the museum itself is a socioculturally-constructed product» (Falk & Dierking, 2016, p.148).

Marini Clarelli (2005) highlights the double nature of the museum as a system of interpretation: it reflects the culture of the present time about the culture of other times. Museum preserves

and exhibits the tangible and intangible heritage developed in the history; the way the heritage is exhibited is determined by the culture of the museum community (scholars, directors, curators and other professionals), as well as the way it is experienced depends on the culture of the visitors and the society.

Likewise, Coffee (2007) states that «museums are keepers and interpreters of signs and symbolizations created through the social practices of art, history, science» (p.378). Museum exhibitions are designed to express the socio-cultural narratives through the artefacts that are social product.

Given the nature of the museum as socio-culturally constructed, Falk e Dierking (2016) recommend the museums to address not only the way they are – defined by their buildings, collections, exhibitions and programs – but also the way they are perceived by the visitors, the communities and the society as a whole. Indeed, Davies and Prentice (1995) found that negative attributes of the museum experience as expected by people, are common barriers for not visiting the museum.

- **Social interaction among visitors**

The social interaction between visitors during the visit is widely investigated in Museum Visitor Studies.

The relation between social interaction and learning in the museum setting is analyzed based on the constructivist approach that stresses the importance of the socio-cultural context and the process of meaning-making (Hein, 1999; Hooper-Greenhill, 2000; Allen, 2003; Falk, Dierking & Foutz, 2007).

In such perspective, the meaning making occurs not only through interactions with exhibits, but also through interactions with companions. Thus, research aims for understanding the nature of learning through shared meanings that social groups construct as they visit the museums (Falk, Dierking & Foutz, 2007).

Most of the research about social interaction in museums is focused on family groups as a major audience and unique learning group of mixed ages and backgrounds. The main topics of investigation are the conversations and parent-child interactions (Ellenbogen, Luke & Dierking, 2007).

An interesting research on families' conversations is the one performed by Sue Allen at the *Exploratorium* in San Francisco (USA).

Allen (2003) investigated the visitors' conversations about the temporary exhibition called *Frogs* that included several hands-on interactive elements, terrariums with live animals, cases with cultural artifacts and videos.

The exhibition was designed with different purposes: a) to present scientific and cultural aspects of people's relationship to frogs; b) foster people's respect and appreciation towards the animals; c) provide the audience with a multisensorial and informative experience.

In order to evaluate the visitor experience with the exhibition, Allen took advantage from the analysis of learning conversations. Specifically, she focused on:

- categories of learning talks and their frequency;
- differences in children and adults learning talks;
- whether the designers' purposes of stimulate visitors appreciation and respect towards animals are reached;
- the relation between types of exhibit (or even parts of the exhibit) and learning conversations elicited;

To this end, data were collected through the observation of the participants during the visit, recording their movements, conversations and interactions with the exhibits. Then, tracking data and transcripts of the conversations are analyzed based on a coding scheme.

The coding scheme is reported in the following table, including the five categories of talks and their related subcategories.

Types of talls	Subcategories
Perceptual talks draw visitor attention to something, and they are an evidence of learning because they identify and share what is significant in the complex surrounding environment	– *Identification*: pointing out something to attend – *Naming* what is seen – *Feature:* pointing out concrete aspects and properties of the exhibit – *Quotation:* drawing attention to texts and/or reading aloud the texts
Conceptual talks are cognitive interpretations of what is attended	– *Simple inference:* simple interpretative statement – *Complex inference*: hypotesisi, generalization and/or discussion about the relationship between objects or properties – *Prediction:* stated expectation of what will happen – *Metacognition:* reflection about previous and current knoweledge and beliefs
Connecting talks make explicit connections between the exhibit and some other knowledge and domains	– *Life connection*: relating the exhibit to the personal story or to something familiar – *Knowledge connection:* declaration of knowledge gained before visiting the exhibition – *Inter-exhibit connection*: link between different elements of the exhibit, or between different exhibits
Strategic talks are discussions about how to attend the exhibit	– *Use:* how to move, where to look, how to interact with the exhibit – *Meta-performance:* expression or evaluation of one's own or partner's performance, ability and actions
Affective talks are expressions of feelings elicited by the exhibit	– *Pleasure* – *Displeasure* – *Fascination and surprise*

Table 2: Coding scheme (Allen, 2003)

To define such coding scheme, Allen refers to the socio-cultural perspective by conceiving learning as an interpretative act of meaning making that is socially mediated, and she integrates it with some cognitive concepts such as attention, inference and metacognition.

The results gained from the research provide several insights.

Regarding the attracting power of the exhibits, families spent more time attending the cases with live animals, followed by hands-on exhibits and artefacts, while the less attractive were

the readable elements that do not allow interactions. Indeed, the museum identity of the Exploratorium relies on the active involvement of the visitors, on the inquiry-based learning by allowing visitors to discover for themselves concepts and phenomena through laboratory and hands-on exhibits[3].

Allen found that visitors engaged in learning talks at 83% of the exhibits they attended, and the remaining 17% are silent stops without conversation, or with talks that cannot be coded as learning talks.

Regarding the frequency, overall the most common categories of talks are perceptual, affective and conceptual, while connecting and strategic talks occurred with less frequency (respectively 28% and 20%).

Unexpectedly, the connecting talks (discussion and reflection about the link between museum-related content and other domains of the experience) are not frequent, while they are conceived as powerful mean of meaning making and a core component of learning in informal settings.

According to other studies with follow-up interviews (Ellenbogen, 2002; Ellenbogen, Luke & Dierking, 2007), meaning making through the connecting talks occurs in the post-visit phase, and this supports the need for considering the museum experience over time.

For example, Luke, Coles and Falk (1998) found that conversations that begin in the museum continue once families are back home: the families interviewed after six weeks from the museum visit, reported that they talked about the exhibition in the following weeks, also while engaged in other activities, and described connections between the content of the exhibition and other circumstances or domains in their life.

Similarly, Ellenbogen (2002) found that connection between museum experiences and real-world contexts are frequent and pervasive after the museum visit.

Another relevant topic in this branch of research is the role played by the adult member of the family, as investigated by Crowley and colleagues in the context of science museums (Crowley

[3] More information about history and vision of the Exploratorium are available at the website: https://www.exploratorium.edu/about/our-story

& Callanan, 1998; Leinhard, Crowley & Knutson, 2003; Eberbach & Crowley, 2005; Palmquist & Crowley, 2007). The authors found that parent-child dialogues provide not only an opportunity for children to learn factual scientific information and to practice scientific reasoning, but also an opportunity to participate in a culture of learning about science and potentially form an identity as someone who is competent in science.

Museum as context to construct identity is also highlighted by Ucko (2010) who suggests that science museums allow young visitors to think about themselves as science learners and develop an identity as someone who knows about, uses, and sometimes contributes to science. To this end, the role of adults as guides and interpreters is fundamental.

Indeed, Crowley and Callanan (1998) demonstrated that children engaged in exploration with their parents have a richer set of experiences to think about, than children who visited the museum exhibits alone. This happens because parents tend to construct explanations around children's activity to help them interpreting actions in light of a theory of what is going on in each exhibit.

Parents' participation depen children's engagement with the exhibit, both at the level of parents guiding activity and at the level of parents constructing explanations around that activity.

Specifically, based on the analysis of parent-child conversations, the authors identified three distinct types of parent explanation: a) explanations focused on the mechanisms that made the exhibit working; b) explanations that link the exhibit to real-world devices and phenomena; c) explanations connecting the exhibit to formal scientific principles.

Thus, museums interested in supporting children scientific thinking should design the exhibits not just for the children but for an audience of children and parents jointly engaged in collaborative activities.

To sum up, research on social interaction in museum shows that conversations and collaboration better engage family members and foster learning, in terms of acquiring knowledge and skills and developing shared understandings (Ellenbogen, Luke & Dierking, 2007).

In examining socially mediated learning, Astor-Jack et al. (2007) refer to the concept of community of learners elaborated by Rogoff (1994) who suggests that all knowledge is constructed within a sociocultural context, that is a delimited community of learners.

Specifically, community members shared a set of beliefs, values, language, practices and learning occurs when new generations collaborate with older generations in varying forms of interpersonal engagement and institutional practice (Rogoff, 1994).

Within the community, both experienced members and novices are conceived as active, with asymmetric and complementary roles: expert-adult members are responsible for guiding the overall learning process, while novice-children participate in the management of their own learning and involvement (Rogoff, Matusov & White, 1996).

In such perspective, families are conceived as community of learners who takes advantage from the museum visit to interact with each other and be engaged in the co-construction of shared meaning, values and practices (Astor-Jack et al., 2007).

What about interactions between adult visitors?

Besides all-adult groups are numerous and a relevant target of museums, the literature about adult interactions is poor and lacking.

According to Falk, Dierking and Foutz (2007), adults conceive the museum visit as an occasion to meet peers, build new and maintain existing social relationship through the sharing of recreational experience and discussion about personal memories.

Black (2012) summarizes the way social interaction among visitors fosters learning as follow:

> «people stimulate each other's imaginations. Questions, comments and new ideas pique curiosity and encourage further exploration. Collaboration encourages discussion and social negotiation of ideas so that visitors explore alternative perspectives, methods and solutions» (p.84).

- **Social interaction with museum staff**

Museum educators and other personnel have a fundamental function to facilitate the visitor experience, both with structured interactions (i.e. during guided tours, hands-on activities etc.) and through unstructured interaction based on informal conversations when visitors ask for information or support (Falk & Dierking, 2016).

The research about this topic is mainly focused on structured interactions and demonstrates that programs involving museum staff increase visitor satisfaction, the time spent at exhibits and the knowledge acquisition (Falk, Dierking & Foutz, 2007; Falk & Dierking, 2016).

Moreover, the research aims for identifying practices and skills of the museum educators that foster visitor satisfaction.

For example, Tran (2007) investigated the teaching methods of museum educators during school trip. The author classified the staff-visitors interaction as talk, demonstration and tasks, based on the level of participation of the students.

- talks are verbal interchanges between the educator and students during a lesson, and they require the least amount of participation from the students;
- demonstrations are educator-led and address the whole group, through the use of objects, role playing, and opportunities for one or more students to participate;
- tasks involve the most participation from the students while the educators assigned the tasks, gave instructions and materials, and decided length of available time.

Tran found that educators' expertise relies on their ability to adapt the program to the needs and interest of the visitors (i.e. by adjusting activities and time allocation), and to assign a relevant role to the teachers who act as mediators between the educators and the students.

Staff-visitors unstructured interactions are rarely investigated besides they are the most common type of staff-mediated experience in the museum. They should be further analyzed to gain recommendations for improving the role of museum staff (Falk & Dierking, 2016).

Rosenthal and Blankman-Hetrick (2003) suggest that appropriately designed staff facilitation, accounting for visitor interest and prior knowledge, prompts families to engage in more learning conversations during and subsequent to the interactions. Interpretation approaches that actively engaged the whole family in a dialogue also promoted more learning conversations.

Interaction with the museum staff can also have a negative impact on the visitor experience, when the staff interferes with visitors who wish to engage individually with an exhibition, or when the interaction includes some specific behaviors: for example, employing didactic and teacher-directed instruction, using high-level vocabulary, and adhering to inflexible lesson structures (Falk, Dierking & Foutz, 2007).

This suggests that staff training is the key to ensuring that staff members are able to connect the museum's distinctive opportunities to visitors' unique interests and needs; particularly training that includes not only content, but the way to adjust the interaction according to the different visitors' agendas (Falk & Dierking, 2016).

1.4 Technological innovation of museums: state of the art and future trends

The technological innovation of museums represents a strategy to better communicate information, engage the visitors and adopt the audience-centred perspective.

The traditional way to convey heritage-related information is based on textual supports like the labels and posters. Besides such supports are still present in museums, over the years the interpretative tools evolved thanks to the advancement in the design of digital technologies (Tallon & Walker, 2008).

The first attempt to introduce innovative technologies in museums dated back to the early 60s, when the pioneer Willem Sandberg, director of the Stedelijk Museum in Amsterdam, proposed the first museum audio tour (Tallon & Walker, 2008): the *Short-Wave Ambulatory Lectures* was a handled technology based on a closed-circuit shortwave radio broadcasting system in

which the amplified audio output of an analog playback tape recorder served as a broadcast station, and transmission was via a loop aerial fixed around the galleries.

As you can see in *Figures 3* and *4* showing the first examples of audio guide, the visitors were able to observe the exhibit while listening to the audio description.

Figure 3: Audio guide of the American Museum of Natural History in 1961[4]

Figure 4: Audio guide of the Science Museum in London in 1961[5]

In *Figure 3*, the visitor used the earphone and the device with a strap to hang it around her neck, while visitors in *Figure 4* used a more advance device with embedded speaker, that was hold in one hand.

Nowadays, the audio guides are available in almost all museums and the innovation is focused on the personalized contents and engaging storytelling (Tallon & Walker, 2008; Ardissono, Kufik, & Petrelli, 2012). Indeed, given the different visit agendas (motivations, expertise, plan

[4] Source: Tallon & Walker, 2008.
[5] Source: Tallon & Walker, 2008.

for the visit etc.) museums can better engage the heterogeneous audience by providing contents and tours tailored on visitors' needs and preferences.

The new frontier relies on the use of Augmented Reality and Virtual Reality technologies that represent the most innovative and promising tools to provide new forms of communication and interaction.

In the 1960s, the idea of Virtual Reality (VR) was initially proposed by the computer graphics pioneer Ivan Sutherland to create an environment visualized by using a head-mounted device. Later on, in the 1990s the term Augmented Reality (AR) came into existence thanks to the scientists at the Boeing factory who developed an AR system that blended virtual graphics with real environment through the display, in the attempt to help the aircraft electricians with cable assembly (Cheng, & Tsai, 2013).

AR refers to a system that integrates computer-generated objects (i.e. texts, images, videos and 3D objects) with the user's perception of the real world. It provides an environment where users can view a combination of virtual and real objects, whilst the VR immerses the user into a computer-generated environment (Phon, Ali, & Halim, 2014).

AR and VR are technical wordings used to define a wide range of technologies. For this reason, "Mixed Reality" was proposed (Milgram et al., 1995) as a more encompassing term to replace the definitions of AR and VR and to set them along a continuum (*Figure 5*).

«Although both purely real environments (RE's) and virtual environments (VE's) certainly do exist as separate entities, they are not to be considered simply as alternatives to each other, but rather as poles lying at opposite ends of a Reality-Virtuality (RV) continuum» (Milgram & Colquhoun, 1999, p.2).

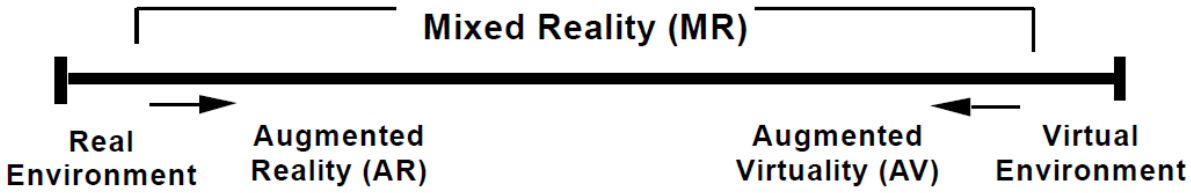


Figure 5: Reality-Virtuality continuum (Milgram & Kishino, 1994)

In the above figure, the left side of the continuum defines any environment consisting solely of real objects, and it includes whatever might be observed when viewing a real-world scene, either directly or via some sort of display. The right side defines environments consisting solely of virtual objects, computer graphic simulations or monitor-based ones.

Between the two extreme poles of the continuum, the Mixed Reality (MR) environment is the one in which real world and virtual world objects are presented together within the same spectrum.

Mixed reality is a growing field of research and development in different domains, such as military and medical training, the automotive industry and education.

With regard to the cultural heritage, mixed reality technologies are applied especially in archaeological and historical museums, with the aim of supporting the visitors who have difficulties imagining how sites or monuments could originally have looked like (Damala, Marchal, & Houlier, 2007).

Considering the devices and the modes of interaction, different kinds of augmented and virtual reality solutions are implemented in museum and heritage domain, as shown in *Figure 6*: the desktop-based interfaces of the virtual museum, portable devices (tablet and smartphone), headset, and the virtual environment of the CAVE system.

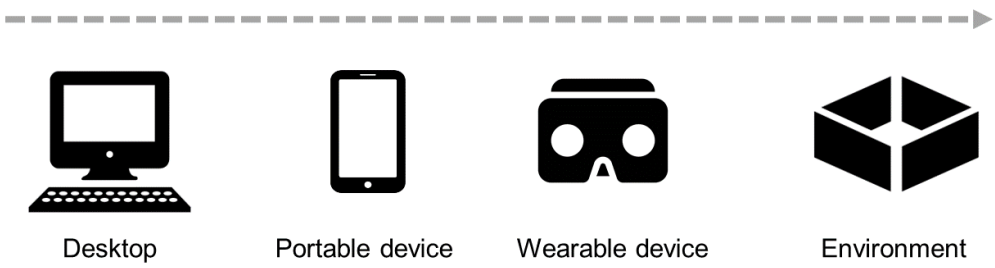


Figure 6: Devices supporting AR and VR

Given the evolution of the devices, the interface moves beyond the computer desktop to become wearable and more immersive, and this sets new design challenges (Preece, Rogers & Sharp, 2002). Indeed, the properties of the tools and the way they are implemented in the museum context affect the visitor experience, by enabling some activities while limiting others.

The table below outlines the different experiences enabled by AR-VR technologies, according to the user(s), modes of interaction and settings.

User(s)	Individual experience	The experience is lived individually
	Shared experience	The experience of the user is synchronized and/or shared with other users
Interaction	Visualization	The user can only see image/text and/or listen to audio-description
	Manipulation	The user can manipulate virtual objects or the environment
Setting	Remote	The experience can occur everywhere throughout the web
	Onsite	The experience occurs only in the museum setting

Table 3: Categorization of AR and VR technologies

Hereafter, I present some projects that I selected from the literature, in order to discuss the most relevant features and the advantages they provide to both the museums and the visitors.

- **Desktop-based virtual museum**

The virtual museum (VM) is a term used to define a virtual environment that presents digital representations of artifacts and exhibits, allowing the user to perform a remote virtual visit (Schweibenz, 1998; Schweibenz, 2004; Styliani et al., 2009; Huhtamo, 2010).

Some authors (Tsichritzis & Gibbs, 1991; Sylaiou et al. 2005) suggest that the VM can exist even without its real equivalent, while Antinucci (2007) stated that «the notion of VM makes sense only in relation to a real museum, with the "strong" definition of its cultural identity based on the specific collections it owns and displays. This identity must not be denied by the virtual object, it must be assumed by it» (p.82).

The idea of the virtual museum was first introduced by André Malraux in 1947, who put forward the concept of an "imaginary museum", that is a museum without walls, physical location or spatial boundaries, with its information accessible across the planet (Bratto, 1999; Styliani et al., 2009).

An interesting example of this kind of technology is the **Virtual Museum of Iraq**[6] (Cultraro, Gabellone & Scardozzi, 2009; Gabellone, 2009). The creation of this virtual museum was due to the need to virtually preserve and make available to the public the archaeological collection of the National Museum of Baghdad that has been looted during the 2nd Gulf War in 2003.

By taking advantage from photo-modelling techniques, interactive streaming video, laser scanning and 3D digital advanced technologies, the Virtual Museum of Iraq allows the visitor to perform a tour across eight virtual exhibitions organized in chronological sequence.

As you can see in *Figures 7* and *8*, the virtual space is organized in different rooms and it aims for recreating the familiar modality of visiting a real museum, helping the visitor to understand the distinctive characteristics of a certain period.

[6] The project Virtual Museum of Iraq is promoted by the Italian Ministry of Foreign Affairs with the scientific supervision of the Italian National Research Council.

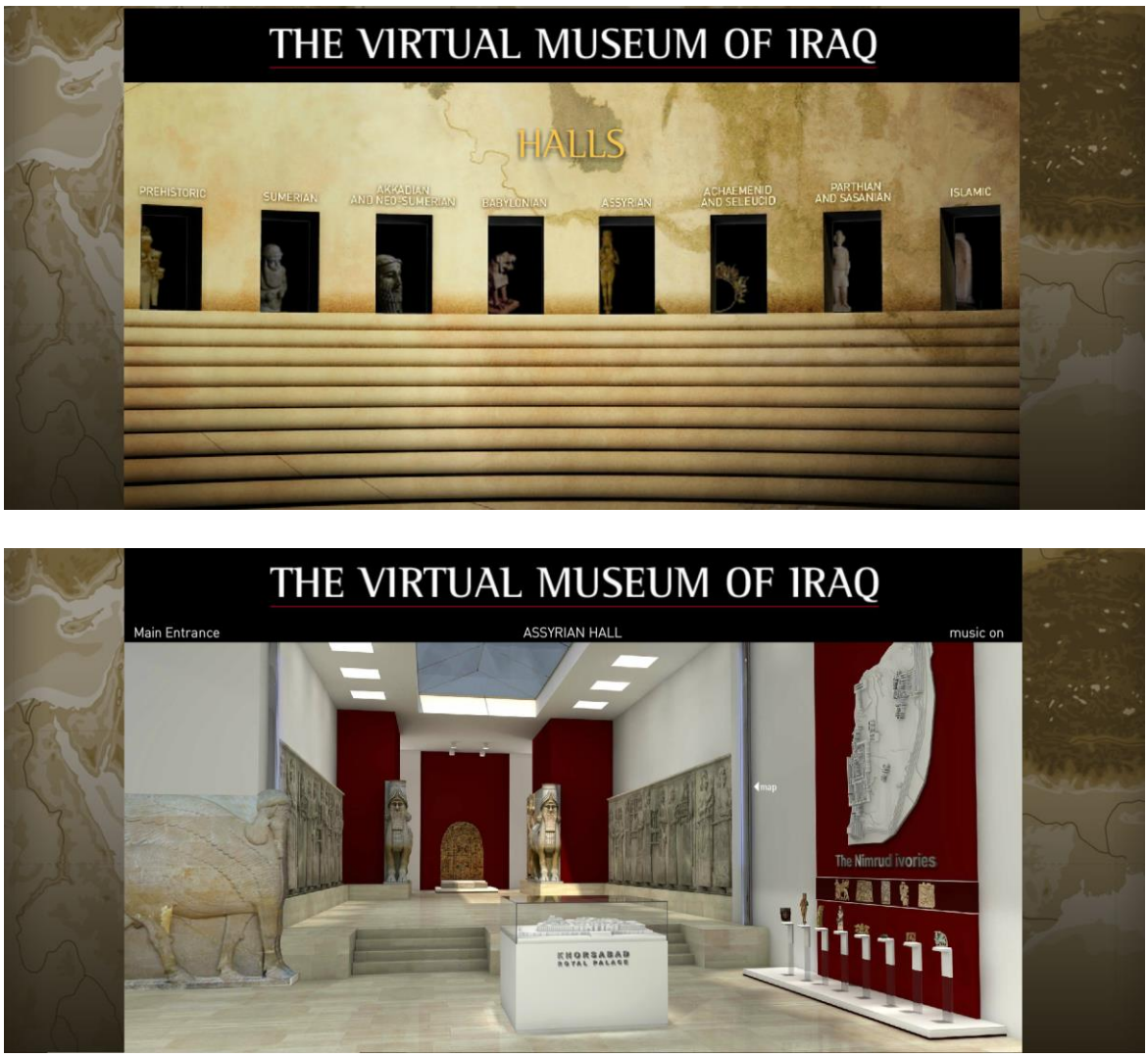


Figure 7 - 8: screenshots of the Virtual Museum of Iraq[7]

Another relevant aspect of such project is the contextualisation of the artefacts in their original environment, using animated video clips.

Indeed, the musealization of an artefact usually includes a process of the de-contextualization, from the original location to the museum setting, and then a re-contextualization to represent its original location and function, for example through scale model and computer graphics (Marini Clarelli, 2005).

Cultraro, Gabellone and Scardozzi, (2009) point out that:

[7] Source: http://www.virtualmuseumiraq.cnr.it/prehome.htm

> «the Virtual Museum of Iraq Project is not the real museum of Baghdad transposed to the web or to any electronic form. Moreover, the ordinary visitor not perceives the virtual collection of artefacts as an archive of database […] the virtual platform could be claimed as the communicative projection of the real museum» (ivi, p.25).

Francesco Antinucci (2007), member of the Virtual Museum of Iraq project, highlights that the virtual museum represents an attempt to use the great power of visual-interactive technologies to enhance the appreciation and understanding of the specific cultural patrimony of the real museum, by the greater public of (actual and potential) visitors. The strong point of the virtual museum, in synergy with the real museum, is what it can do for the physical museum that cannot be done in the physical museum – or at least could only be done with great difficulty.

The advantages of virtual museums are several, providing benefits to both the museum and the visitors.

- A museum with an online presence has a world-wide visibility that can be used to attract the visitors (Sylaiou et al. 2005).
- Virtual Reality helps in displaying objects that the museum cannot present within the physical context, due to lack of space or because of artifacts' fragility and the need for special handling (Tsichritzis and Gibbs, 1991). It can also help when there is a need for visualizing and simulating environments, constructions or objects that no longer exist (Lepouras & Vassilakis, 2004).
- In a virtual environment, exhibits can be observed from different viewpoints and virtual objects can be manipulated. Technologies such as haptic feedback may enable visitors to touch and feel valuable objects (Lepouras, & Vassilakis, 2004).
- A virtual exhibit can provide multimedia information that a physical exhibit in a museum showcase cannot provide (Sylaiou et al. 2005). Furthermore, the virtual

museum exhibitions can offer different kinds of data according the visitors' needs and interests (Bonis et al. 2009).

- The virtual visitors can have access to virtual museum exhibitions through the web anytime and from anywhere. VM provides all-day unlimited access to their visitors, which are not restricted by the opening hours of the museum (Sylaiou et al. 2005).

Thanks to the web, the museums have "opened their walls" to the great public - following Malraux's wish - to millions of visitors that can now enjoy the major works of art of the whole world at the tip of their fingers, on the monitor of their computer (Styliani et al., 2009).
Considering such advantages, it is clear that the virtual museum can act in a complementary and auxiliary manner to enhance the functions of the traditional museum (Styliani et al. 2009). Of course, the virtual museum cannot substitute its traditional form.

> «Seeing a painting or an object on the screen of a computer, even a very large one with all the definition that modern technology is able to offer, still does not create the same perceptual impression that one has viewing the object on the site, and since we are dealing with objects in which details and specific features are usually very important, this is hardly a minor drawback. Moreover, the museum is perceived also and not secondarily, with the body and not just the eyes; we move through the rooms, around and in front of the objects; we have a sense of position in space, which is crucial for the perception of volume, of size and of texture. This makes a fundamental contribution to the appreciation of the viewer's experience and is vastly different from sitting in front of a screen observing images that are scrolling» (Antinucci, 2007, p.80).

Within the Reality-Virtuality continuum (Milgram et al., 1995), the virtual museum can be placed in the pole of purely virtual environment, because it consists only of virtual objects.
But, since the virtual museum is desktop-based and the visitor navigates the multimedia contents through the web interface, the level of immersion could be questioned. An

advancement of the desktop-based virtual museum relies on the use of the head-mounted display that provides 360° immersive scenarios or the CAVE system described below.

- **Forms of Augmented Reality**

The most popular form of mixed reality technology relies on the use of headset or mobile devices such as tablet and smartphone.

An interesting example is the **ARCHEOGUIDE** project (*Augmented Reality-based Cultural Heritage On-site GUIDE*) aiming at providing a personalized tour assistant to cultural site visitors (Vlahakis et al., 2001; 2002).

The system provides AR reconstructions of the ancient Olympia archaeological site in Greece, based on user's position and orientation in the site and real-time image rendering.

The 3D reconstructions of monuments and artifacts are presented to the visitors through AR devices while they having constant visual contact with the surroundings and listening to the audio commentary.

The ARCHEOGRUIDE system includes a database that stores audio-visual and textual information concerning the site and its monuments. The database is organized thematically and it can be navigated according to attributes like geographic position (coordinates), item type (e.g. temple), time (e.g. chronological era), level of information (e.g. general, detail, scientific), theme (e.g. relates to sports), and versioning (e.g. stage in the restoration process).

The system is based on three mobile unit, each offering different features: a head-mounted display, a tablet and a palmtop mobile device.

Using these devices, the visitors can see the reconstruction of the monuments and listen the audio commentary.

The figures below provide an example of visual augmentation, showing the original image of the temple (*Figure 9*) and the augmented one (*Figure 10*).

Figures 9 - 10: Original image and augmented image (Vlahakis et al., 2001)

The pilot study performed to test the system (Vlahakis et al., 2001, 2002) collected positive opinions by the participants who better understood the site's history and use, appreciate the personalization of contents that they can navigate according to their interest and curiosity.

Furthermore, this study highlighted how the choice of the device impacts the visitor experience. Indeed, participants praised the head-mounted display for realism, but some of them felt uncomfortable wearing it while walking. The tablet is considered a good tool because it

simulated the use of the paper guides, while the palmtop was rated low because of its small screen that does not facilitate the visualization of the contents.

Another benefit provided by the ARCHEOGUIDE is related to the tracking system that provides the visitors with information based on their position within the site. Indeed, both in outdoor and indoor environments, thanks to the tracking and geolocalization capabilities the mobile device can deliver the right information on the right spot and provide orientation aids (Damala, Marchal & Houlier, 2007; Damala et al., 2008).

Other forms of Augmented Reality are based on holograms and light projections, and more advanced AR technologies allows the visitor not only to visualize augmented contents but also to manipulate virtual objects using sensors and input devices.

For example, the **ARIEL** project (*Augmented Reality for Interpretive and Experiential Learning*) developed AR applications for science museums that aim at making visible the "invisible" features and processes of natural phenomena (Yoon et al., 2012; Yoon & Wang, 2014).

The exhibit shown in *Figure 13* includes a video screen with animations and bar magnets to manipulate the simulations, the dynamic visualization that depicts changes continuously over time and represents a continuous flow of motion, in contrast to static visualizations that only depict instantaneous snapshots of the phenomenon or process.

In this way, the exhibit enables the visitors to see how the magnetic fields respond to their various actions in real time.

Figures 13: Image of Magnetic Map (Yoon & Wang, 2014)

The ARIEL project provides also an interesting example of AR-based exhibit that requires the collaboration among visitors. *Figure 14* shows the exhibit called "Be the Path" that illustrates the electrical conductivity and circuits, and it is used by a group of visitors. The system recognizes visitors' position around the device and, when the circuit is completed, the lit bulb triggers the projection of an animated flow of electricity on visitors' hands, arms, and shoulders.

Figure 14: Image of and Be the Path (Yoon et al., 2012)

By analysing the impact of such solutions on students' learning process, Yoon and Wang (2014) provide a list of AR features that support science learning:

- *Visible* feature allows users to see things that are normally invisible;
- *Dynamic* feature displays the phenomenon in motion showing changes over time;
- *Details* feature provides scientific explanation of the phenomenon;
- *Interactive* feature enables the visitors to interact with the device;
- *Scaffolding* feature provides the structures that focus visitor attention on relevant information.

Furthermore, since the ARIEL experience is designed to be collaborative, the study found that in the presence of the digital augmentation, visitors were more likely to participate with other members of the group, and be engaged in scientific discourses that finally lead to deeper understanding.

- **Cave automatic virtual environment**

One of the latest innovations is the cave automatic virtual environment (CAVE), an immersive environment where projectors are directed to three or six walls of a room-sized cube. Thanks to the sensors embedded in the room and/or in the headset, the CAVE system allows the users to interact with the virtual environment.

To date, very few CAVE solutions are implemented in museums and heritage domain – or at least, very few are those reported in the literature.

An interesting project is the **Digital Miletus** implemented by the Foundation of the Hellenic World in Athens (Tzortzaki, 2002, 2011). It is the CAVE-based reconstruction of the ancient city of Miletus, that was an Athenian and later a Roman colony on the coast of Asia Minor, now in ruins.

The CAVE is installed inside a dark room, where ten visitors together with the museum educator, wearing the stereoscopic glasses, experience a tour within a 3D environment projected on the three walls and the floor of the room.

The environment simulates the city of Miletus with its buildings and landscape, as shown in *Figures 11* and *12*.

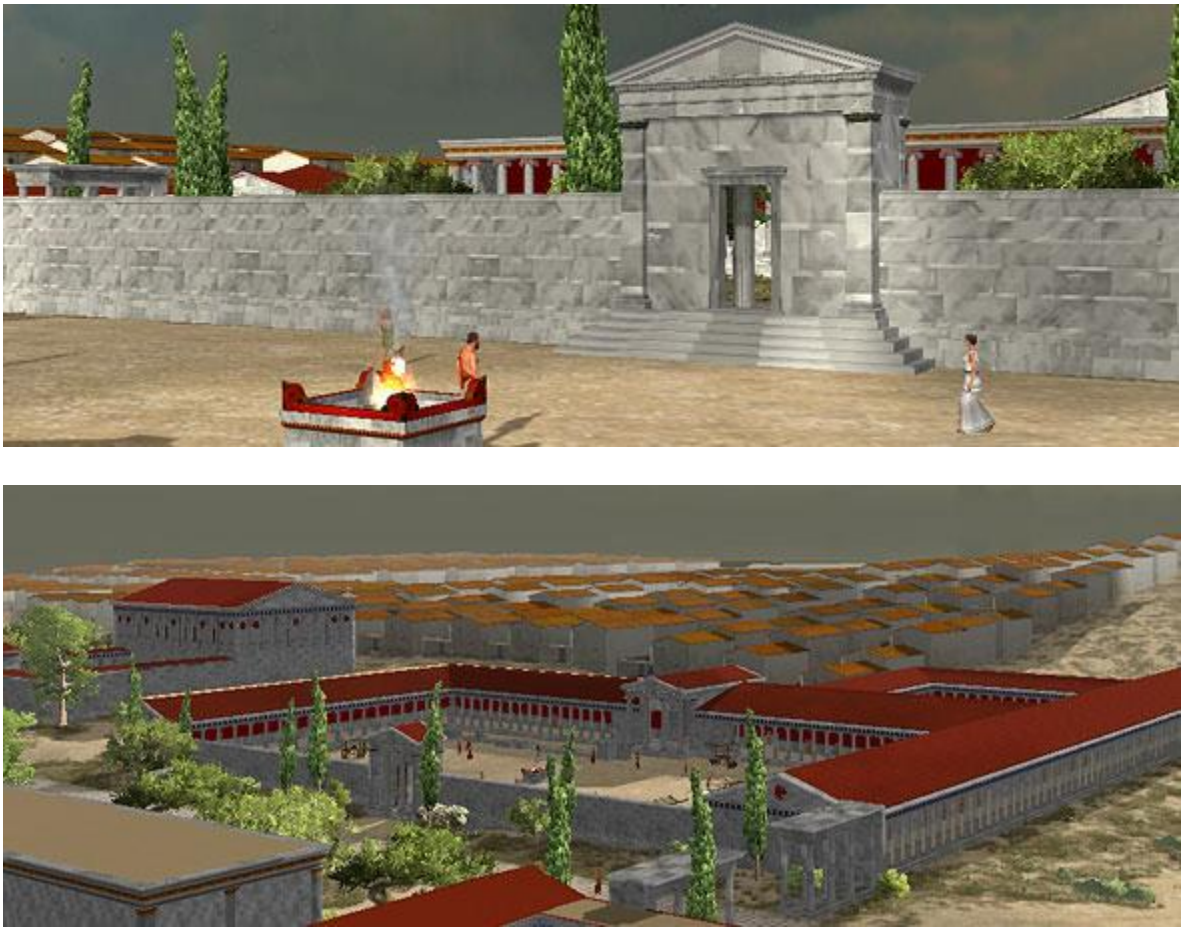


Figure 11 - 12: Virtual reconstruction of Digital Miletus[8]

During the tour, the museum educator controls the navigation by using a mouse and a wand as input devices, and guides the experience. Since the CAVE navigation has not a plot neither a story, the role of museum educator is fundamental to mediate the experience.

[8] Source: http://www.fhw.gr/choros/miletus/en/photos.php#

For this reason, Delia Tzortzaki, (2002) defines it as a guided tour into a 3D digital environment, to describe a rather static presentation of an uninhabited virtual environment by a museum facilitator.

> «The CAVE, within the institutional frame of a cultural activity known as museum visit, is a technology serving purposes of a representation. Museums are by definition spaces of representation. No matter the degree of immersion or presence the visitor feels, the 3D digital environment it creates offers an *as if* experience, a spatial illusion» (*ivi*, p.268).

Analyzing the Digital Miletus, Mosaker (2001) points out the issues of illusion and authenticity, since every reconstruction of past events, places and artifacts is a subjective representation both for the storyteller and the listener.

> «Entering Miletus in the CAVE, you have a 180° view of the virtual environment which in itself provides a unique feeling of immersion […] You are there, and you can see yourself being there. The illusion is so convincing that you find yourself accepting the surroundings nearly as if they were physical reality» (ivi, p.5).

In VR scenario, detailed and realistic graphics are crucial for making a realistic experience and provide the illusion of being in that context.

Mosaker (2001) suggests that the problem with such realism is that people tend to think of the virtual reconstruction as the truth about the past, and not just a version of what it could have been like. When the visitors are told that this is a plausible but not the exact vision of places/events, then they are invited to draw conclusions and actively take part in the exploration of how the events might have happened in the past.

Does being a representation that inevitably reduces the original context imply that the copy is of less value than the original?

Mosaker (2001) answers to this fundamental question by claiming that:

> «historical VR worlds are just that, they are copies of a lost original past. But these copies imply that the original environments still keep their high status as originals. It is because of their content that these environments are special. The representation of any town would not be as extraordinary as specific non-existent environments. Thus it is the status of the lost original that gives the historical VR worlds their value» (ivi, p.8).

To conclude this chapter about technological innovation, I need to point out that the use of AR and VR technologies should not be regarded as replacement of the more traditional tools to provide information (e.g. boards or posters), but they offer innovative ways to promote the cultural heritage and to engage the visitor with the museum collection (Heat & Vom Lehn, 2008).

The introduction of new technologies does not necessarily mean an improvement in the quality of the visitor's experience. Indeed, the value of the technology does not rely on the technical aspects of the tool (the functional properties), but rather on the benefit perceived by the person who uses it in a specific context (Triberti & Brivio, 2016).

As Kaufmann (2003) stated, the question is not about whether or not VR-AR technologies are useful, the matter is to understand how their potential can be effectively exploited.

To this end, we need to think more analytically about the mediation of the by AR-VR technologies, so as to go one step further in the understanding of the relations between people, technologies and contexts (Preece, Rogers & Sharp, 2002; Talamo & Zucchermaglio, 2003).

Chapter 2 aims at conceptualizing the technology-mediated experience by discussing the different factors that determine a successful experience.

2. Conceptualizing the technology-mediated experience

The Contextual Model of Learning (Dierking & Falk, 1992; 2002; 2016) provides a valuable conceptual map of the personal, socio-cultural and environmental issues that determine the museum experience.

But, when the museum experience occurs with the mediation of the technology, the Contextual Model of Learning needs to be further elaborated to better explain the visitor's experience.

Dierking and Falk (2008) consider the ICT, like the digital handled guide, as part of the physical context of the museum. In my opinion, technologies need to be considered as another component of the system, with their specific properties, in order to analyze how they interact with the personal, socio-cultural and physical context.

With this in mind, I refer to the cultural-historical Activity Theory (AT) as a theoretical framework to analyze the mediation of the technology that enables visitors' activity.

Activity Theory is a descriptive theory that aims at understanding people in their everyday life practices through the analysis of genesis, structure and process of their activities. The use of technology is understood in the context of purposeful, mediated, and developing interaction between the people and the world (Kaptelinin & Nardi, 2006).

The adoption of this framework to analyze the visitor experience is particularly suitable for several reasons (Kuutti, 1996): (a) the concept of activity is the unit of analysis for studying how people interact with the technology, within the situated context; (b) it conceptualizes the artifact as a medium for the activity, which derives from visitor's needs and focuses on specific objectives; (c) it deals with the developmental and dynamical nature of human practices and tools.

Furthermore, the Activity Theory provides the theoretical lens to discuss the factors related to the interaction with Augmented and Virtual Reality technologies. that determine a successful user experience.

2.1 Towards a framework to investigate the technology in use

Activity Theory was originally developed by Leontiev (1974, 1978) from the cultural-historical psychology, and then it was revised by Engeström (1987, 1990).

The Soviet psychology of the 1920s and 1930s, in contrast with behaviorist theories, questioned the traditional view of a border separating the mind and the physical world, in favor of a unified vision of mind and culture. Cultural-historical psychology postulates that human beings develop their own meanings and values not by processing sensory inputs, but by appropriating the meaning and values through the social mediation.

In particular, Leontiev elaborated the Activity Theory based on the work of Vygotskij.

Lev Vygotskij (1978) explained the social determination of mind through the notion of *higher psychological functions*, which are different from the "natural" psychological functions (mental abilities such as memory or perception).

Natural psychological functions are the result of maturation, practice or imitation, and their structure does not change; while higher psychological functions emerge as a result of the re-structuring of natural psychological functions in a cultural environment.

According to Vygotskij's *universal law of psychological development*, higher psychological functions first emerge as distributed between the person and other people (inter-psychological function) and then they are internalized to become intra-psychological.

At the beginning, the individual cannot initially perform the function alone, but over the time, she/he progressively masters the function so as to perform it without the help from others.

In the process of internalization, some of the previously external processes take place in the internal plane, and they become mediated by internal signs rather than external ones. The internalization is not a translation of initially external processes into a pre-existing internal plane, since the internal plane itself is created through internalization.

Internalization is one of the main modes of cultural determination of the mind, and it enables external mediation by culturally developed tools to effect internal processes, that become culturally mediated.

Activity Theory derives specifically from Vygotskij's conceptualization of the human activity as having three fundamental characteristics: a) it is directed toward a material or ideal object, that can satisfy the human needs; b) it is mediated by artefacts; c) it is socially constituted within a certain culture.

The mediating instruments are psychological tools or technical tools: psychological tools, like signs and language, act on the behavior and they are mean to master psychological functions; technical tools are directed on objects and they seek to modify the external world.

Based on Vygotskij's theorizations, Leontiev (1974, 1978) developed the conceptual framework that is known as Activity Theory.

It is not a theory in the strict sense of the term, since it consists of a set of principles that are used as basic framework for the development of different interpretations and theories (Engeström, Miettinen & Punamäki, 1999).

Today, it constitutes a line of research in the domain of Human-Computer Interaction, promoted by Bødker, Kaptelinin, Nardi and Kutti.

Hereafter, some of the basic principles of the Activity Theory are described, in order to conceptualize the technology-mediated experience.

- **System and structure of the activity**

The activity is a form of doing performed by a *subject* and directed to an *object* (an entity objectively existing in the world), with the purpose of transforming the object into an *outcome*. The object is a prospective outcome that motivates the activity, because it meets certain needs of the subject (Leontiev, 1974, 1978).

This interaction between the subject and the object can be mediated by the *tool*, meaning a physical artifact or an intangible tool (e.g. ideas, procedures) that allows the subject to reach the object.

Figure 15 shows the schema of the activity system, including the subject that performs the activity directed to the object, through the mediation of the tool, to finally reach the outcome.

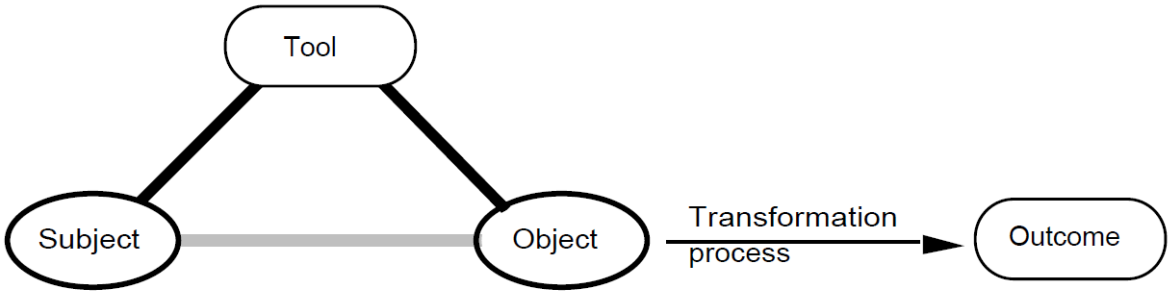


Figure 15: Activity System schema (Engeström, 2000)

This basic conceptualization of the activity system was further elaborated by Engeström (1987, 2000) so to consider the activities performed by social entities, for example teams and organizations. In this case, activities are collective phenomena in terms of their object shared by a community, and with respect to their form (as carried out by a "collective subject" rather than by an individual).

Thus, Engeström introduced in the activity system another component, the *community*, and two mediating terms: *rules* and *division of labor*.

The resulting schema shown in *Figure 16* is more suitable to analyze the work practices in organizational contexts (Engeström, 2000).

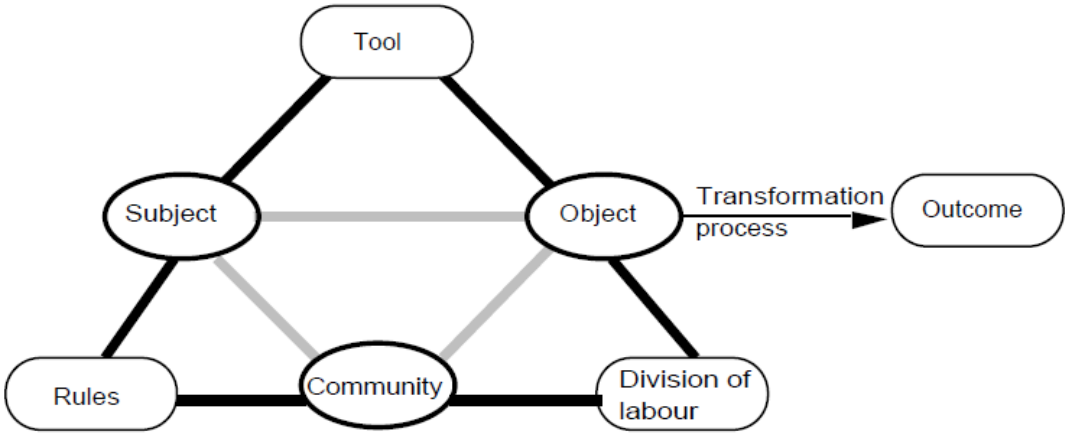


Figure 16: Activity system at social level (Engeström, 2000)

The relationship between the subject and the object is mediated by *tools*; the relationship between the subject and the community is mediated by *rules* (covering both explicit and implicit norms, convention) and the relationship between the object and the community is mediated by the *division of labour* that refers to the explicit and implicit organization of a community.

In addition to this conceptualization of the activity system, AT describes the hierarchical structure of the activity organized into three layers, as shown in *Figure 17*: an activity consists of *actions* or chains of actions, which in turn consist of *operations* (Leontiev, 1974, 1978).

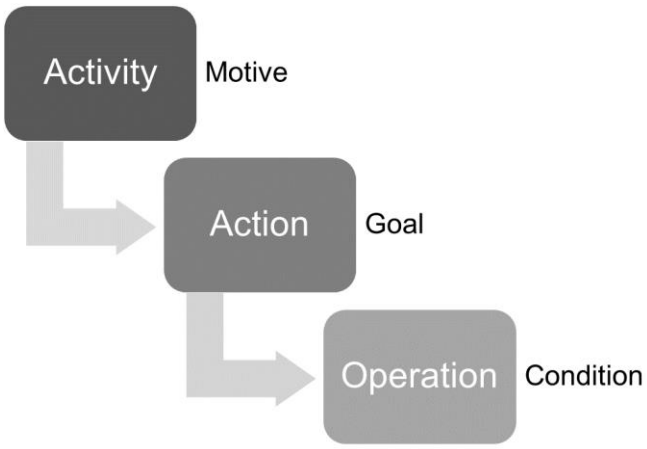


Figure 17: Hierarchical structure of the activity

One single activity may be realized by performing different actions. On the other hand, the same action can belong to different activities, and it has a different sense for the subject in the context of each activity.

Before an action is performed, it is typically planned in the consciousness using the models, that are not rigid and accurate descriptions of the execution steps but always uncomplete and tentative. This phase is called *orientation* and it is followed by the execution phase.

An action is performed through o*perations*, which are well-defined routines used subconsciously as answers to conditions faced during the performing of the action.

Initially each operation is a conscious action, consisting both the orientation and execution phases. Then, when the corresponding model is good enough and the action has been practiced long enough, the action is collapsed into an operation, which is much more fluent.

On the other hand, when conditions change, an operation can return to the level of conscious action (so that it is not a conditioned reflex).

The activity is oriented to a *motive*, while the lower-level units are not immediately related to the motive even though the sequence as a whole may eventually result in attaining the motive.

The objects at which the actions are directed are called *goals*. Goals are conscious; we are typically aware of the goals we want to attain.

The operations, considered as routine processes providing an adjustment of an action to the ongoing situation, are oriented toward the *conditions* under which the subject is trying to attain a goal. People are typically not aware of operations. Operations may emerge as an improvisation, as the result of a spontaneous adjustment of an action on the fly.

- **Artefact as mediator**

In the subject-object interaction, the mediation occurs by introducing the tool as an intermediate element.

While Vygotskij distinguished between psychological and technical tools, Cole and Engeström (1993) consider the cultural artifact as both material and symbolic at the same time: they are immaterial since they incorporate cultural symbols and meanings, as well as they are material since they have a concrete interface.

Michael Cole (1999) proposes a distinction between:

- *primary* artifacts are material tools used in concrete activities;
- *secondary* artifacts are representations of the primary artifacts and the way they can be used to pursuit goals; they allow the conservation and transmission of beliefs, norms and traditions;
- *tertiary artifacts* belong to the fantasy, art and creativity domain.

In the framework of Activity Theory, the tool is considered as culturally developed product that reflects the experience of people who invented or modified it to make it more efficient and effective. Their experience is accumulated in the structural properties of tool, such as its shape or material, as well as in the knowledge of how the tool should be used. Thus, the use of tools is an accumulation and transmission of social knowledge (Kaptelinin, Kuutti & Bannon, 1995). The tool is the vehicle of a certain method of action, that is a social method of action developed in the joint activity of people (Leontiev, 1974, 1978).

The tool as mediator of the activity can be both enabling and constraining: it empowers the subject by enabling him/her to reach the outcome, but it also restricts the interaction to be from the perspective of that particular tool (Kutti, 1996).

Thus, ICT may enable an activity that cannot be practically possible and feasible, or it may enable an activity to have an object that would otherwise been impossible to grasp (Kaptelinin & Nardi, 2006, 2012).

As mediating tools, digital technologies have the potential to enhance the human agency, the range of possible actions and objectives to reach (Triberti & Brivio, 2016).

The combination of human capabilities with the artifact to allow the individual to attain goals that could not be attained otherwise, generates the *functional organs* (Leontiev, 1974, 1978; Kaptelinin & Nardi, 2006).

In order to efficiently use functional organs, individuals need special kinds of competencies (Kaptelinin & Nardi, 2006): tool-related competencies include knowledge about the

functionality of a tool, and the skills necessary to operate it; task-related competencies include knowledge about the higher-level goals attainable with the use of a tool, and the skills of translating these goals into the tool's functionality.

- **Development of activities and tools**

Another principle of AT is the notion of development that is applied by Leontiev (1974, 1978) to the study of the personality. Personality is conceptualized as a system of relations with the world that develops through the activities.

The principle of development has direct implications for the study of technology mediated experience (Kutti, 1996; Kaptelinin & Nardi, 2006).

From a phylogenic perspective, the human activities evolve over time in a historical frame: they result from the positive and negative experiences of people who contributed to the development of the culture.

Tools are considered as a vehicle for transmitting human experience from generation to generation.

> «Artifacts carry within them successful adaptations of an earlier time (in the life of the individual who made them or in earlier generations) and, in this sense, combine the ideal and the material, such that in coming to adopt the artifacts provided by their culture, human beings simultaneously adopt the symbolic resources they embody» (Cole, 1999, p.90).

The structure of a tool itself, as well as learning how to use it, changes the structure of human interaction with the world. By appropriating a tool and integrating it into activities, people also appropriate the experience accumulated in the culture.

From ontogenic perspective, activity is considered the key source of development of the subject. In particular, developmental changes in the subject, which result from participating in activities

and are determined by the nature of these activities, may cause substantial changes in the subject's properties (Leontiev, 1974, 1978).

Technologies do not exist simply as neutral helpers out there that we pick and choose according to the demands of some task. We grow and change in intimate relation to and with technology, developing as skilled persons according to how we learn and use technology (Kaptelinin & Nardi, 2012).

- **Applying Activity Theory to the museum context**

Victor Kaptelinin (2011) derived from the Activity Theory a conceptual framework for designing technologies to support the meaning making in museum learning.

In line with the constructivist and socio-cultural perspectives in educational research and museum studies (Hein 1999), Kaptelinin considers the meaning making as the key concept to enhance the visitor experience.

Meaning making refers to an active reflection and interpretation of objects and events, through which people develop personal meanings, deeply integrated with one's own values, beliefs, feelings, and aspirations.

Kaptelinin's model describes a complex interaction between two activity contexts, the one associated with visitors' own interests, goals and expectations, and the other one associated with the design, functionality and history of an artifact exhibited in museum.

In such perspective, the key aims of using technologies in museums should be bridging these two activity contexts.

From one side, technology can allow visitors to pursuit their interests, goals and expectations, which are enacted in the activities taking place in museums. On the other side, technology can reveal the activity contexts that are explicitly or (more often) implicitly represented by museum artifacts. Indeed, museum artifacts are tools of activities, but often the activity contexts they represent cannot be perceived directly.

To sum up, supporting visitors' meaning making in museums can be accomplished by using the technology to build a bridge that connects visitors' and artifacts' activity contexts.

2.2 Second and third wave of HCI

Nowadays, Activity Theory is widely recognized as powerful framework to guide both the research on and the design of interactive technologies.

Starting from Susan Bødker's works (1987, 1990), AT was getting the attention of Human-Computer Interaction (HCI) community in line with the attempt to go beyond the cognitive paradigm.

Indeed, the cognitive paradigm has been dominant in HCI until a fundamental change occurred: it was recognized that users' behaviour cannot be explained only as a function of their individual mental activity, and the interaction with the technology is not a matter of input-output exchanges between information-processing units (the user as well as the computer).

The limitations of the cognitive paradigm in HCI were highlighted by Norman (1980), who states:

> «The problem seemed to be in the lack of consideration of other aspects of human behavior, of interaction with other people and with the environment, of the influence of the history of the person, or even the culture, and of the lack of consideration of the special problems and issues confronting an animate organism that must survive as both an individual and as a species» (p. 2).

Bannon and Bødker (1989) highlight the failure of cognitive-based theories in dealing with several issues that came out from the research, especially in the field of workplace studies.

First of all, designers tended to develop solutions based on a generic vision of the target users, without considering the peculiarities of the work environment, the division of work and the shared practices developed within work communities.

Furthermore, task analysis based on idealized and rational model of the work practices was the starting point for most user-interface design, but this approach failed to capture the complexity and contingency of real-life actions in specific situations.

According to the **Theory of Situated Action** proposed by Lucy Suchman (1987), human activities can be understood only by analysing the specific conditions in which they occur.

Based on the extensive research performed at the *Xerox Palo Alto Research Center*, Suchman (1987) suggested that plans are not general neither a comprehensive detailed description of the actions; rather, they are situated, *ad hoc* responses to the actions of others and to the contingencies of particular situations.

Given that, laboratory-based studies were limited in the analysis of real practices in situated context. Indeed, field research based on observations of real practices and discourse analysis moved the HCI towards post-cognitive theories and research methods, better accounting for complex nature of work practices and the interaction with technologies.

For example, the **Theory of Distributed Cognition** (Hutchins, 1991; Hutchins & Klausen, 1996) highlights that cognition and knowledge are not embedded in the individual mind, but they are distributed across people and tools. As a consequence, cognitive tasks cannot be analysed as processes of an isolated mind, independent from the practices to which they are applied. Expectations and models of the situations are shared among the actors and they allow to coordinate the actions and to deal with contingent situations. In such perspective, tools and technologies are means to support the distributed cognition, since cognitive processes are enacted in interaction with the social and the material environment.

The so-called "second wave" of HCI focuses the attention on the way individuals create and make sense of their experience in the situated contexts, and on the technology as a mediator between people and the environment (Kaptelinin & Nardi, 2006).

To foster this change in perspective, Bannon (1991) proposes to replace the term "human factors" with "human actors" so to emphasize the holistic nature of the person acting in the real

setting, as an autonomous and sense-making agent who has the capacity to regulate and coordinate the behavior, rather than simply being a passive element in a human-computer interaction.

Moreover, it was necessary to move beyond cognitive paradigm to find or develop theoretical frameworks to study technology in use (Bødker, 1990; Kaptelinin, Kuutti & Bannon, 1995).

> «Much of HCI research, let alone practice, does not use any theory (at least, not explicitly). Concrete user studies, as well as design or evaluation projects, often describe the methods employed but are rarely framed within a theoretical framework» (Kaptelinin & Nardi, 2012, p.1).

In such context, Activity Theory has been recognized as a useful framework to understand human activities – conceived as purposeful, transformative and developing interaction between social actors and the world – and design for them (Kaptelinin & Nardi, 2006).

Susan Bødker (1987) is one of the pioneers who recognized the value of Activity Theory to deal with new challenges of HCI and find new design methods, and this led her to propose collaborative and participatory practices. She found that «the theory is quite operational and detailed in explaining what human beings do when they operate artifacts» (ivi, p.4).

AT contributions to the field of HCI were of three types (Kaptelinin & Nardi, 2012): first of all, it is used to re-frame some basic HCI concepts, such as the affordance (see *§ 2.3.2*); it provides the framework to develop design and evaluation tools, such as the *Activity Checklist* (Kaptelinin, Nardi & Macaulay, 1999; Kaptelinin & Nardi, 2006) and the *Human-Artifact Model* (Bødker & Klokmose, 2012); it also serves as theoretical lens in empirical studies, to guide the collection and analysis of data.

In addition to the Activity Theory, Kaptelinin and Nardi (2006, 2012) identified other post-cognitive theories that represent fundamental framework in the field of HCI.

> «We observed that the development of multiple theories provides opportunities for multivoiced conversations, each theory contributing a unique set of perspectives and concepts. We call the theories "postcognitivist" because they have been brought into interaction design to remedy perceived shortcomings of cognitivist theory» (Kaptelinin & Nardi, 2006, p.195).

Theories like situated action and distributed cognition have a common ground with AT: they address the role of technology as culturally developed artifacts, they are highly critical of the mind-body dualism and they recognized the social nature of human practices.

As suggested by Susan Bødker (2006, 2015), we are now in the third wave of HCI.

> «The first wave was cognitive science and human factors. It was model-driven and focused on the human being as a subject to be studied through rigid guidelines, formal methods, and systematic testing […] Situated action, distributed cognition, and activity theory were important sources of theoretical reflection, and concepts like context came into focus in the analysis and design of human-computer interaction» (Bødker, 2015, p.24)

The second wave emerged from the workplace studies, from the need for better understanding the complexity of human practice within organizational contexts, while the third wave addresses new issues emerging from the use of technologies in everyday life (Bødker, 2006).

Furthermore, the diffusion of mobile technologies used in different situations and contexts, the combination of specialized technologies as well as the new modality of interaction (i.e. gestures on touchscreen) pose new theoretical and design challenges (Bødker, 2006, 2015).

Nowadays, the area of concern is much broader than the simple "fit" between people and technology to improve productivity (as in the classic human factors approach); it encompasses a much more challenging landscape that includes working and leisure activities, people' values and desires, and different environments that shape their everyday lives (Bannon, 2011).

In the current landscape, the research should investigate the **artifacts ecology**, meaning the multitudes of artifacts that we own and jointly use to carry out particular activities (Jung et al., 2008).

> «We increasingly interact with multiple interactive artifacts with overlapping capabilities during our daily activities […] the use of an interactive artifact cannot be understood in isolation, but artifacts must be understood as part of an artifact ecology, where artifacts influence the use of others. Understanding this interplay becomes more and more essential for interaction design as our artifact ecologies grow» (Bødker & Klokmose, 2012, p.448)

Instead of considering the use of a single technology in isolation, research should investigate how people distribute their activities across different technologies, with specific functions or overlapping capabilities (Joung et al., 2008).

The concept of artifacts ecology can be usefully applied to the museum domain, in order to investigate the juxtaposition of different interpretative tools developed over the years and the way visitors used them during the museum experience.

In just few words, entering the third wave we deal with the "experience" of people using technologies to pursuit objectives within situated contexts.

With this in mind, the guiding principles of design move beyond the technical usability for improving the work productivity, to consider the quality of the experience and to promote the well-being in everyday life.

In particular, by introducing the paradigm of **Positive Technologies**, Riva et al. (2012) suggest to orient the design towards technologies that contribute to the enhancement of happiness and psychological well-being.

The authors «suggest that it is possible to use technology to enhance three specific features of our experience – affective quality, engagement/actualization, and connectedness – that serve to promote adaptive behaviors and positive functioning» (*ivi*, p. 70).

In this framework, technologies are classified according to their objectives (Botella et al., 2012):

- *hedonic* technology induces positive and pleasant experiences;
- *eudaimonic* technology supports the user in engaging and self-actualizing experiences;
- *social/interpersonal* technology improves the connectedness between individuals, groups, and organizations.

Positive technologies can be used to manipulate the features of the experience in three ways: a) by *structuring* it using a goal, rules, and a feedback system; b) by *augmenting* it to achieve multimodal and mixed experiences; c) by *replacing* it with a virtual one.

VR and AR based technologies in museum can be conceptualized as positive technology as long as they are designed for supporting hedonic, eudemonic and/or social experience, and purposely developed to structure, augment and/or replace the experience.

2.3 Elements of the experience with AR and VR

Before the discussion about the elements that foster a successful experience of interaction with AR-VR technologies, I need to clarify what user experience (UX) mean. Indeed, the term is often misused and confused with other concepts such as usability and user interface, and a consensual definition is still lacking.

The term "experience" refers to the perception and participation to events as a basis of knowledge (Meriam-Webmaster Dictionary[9]), the present contents of consciousness (APA Dictionary[10]). The experience is a sensorial perception of an event that affect the emotional state and allows the development of knowledge. The experience can occur directly, through direct observation and participation, or as a vicarious experience through the observation of other people engaged in the event/activity (Bandura, Ross & Ross, 1963; Bandura, 1977).

[9] https://www.merriam-webster.com/dictionary/experience
[10] https://dictionary.apa.org/experience

When the term “experience” is used with “user”, the resulting label identify what results from the interaction between people and technologies.

The heterogeneity of approaches and conceptualizations of UX is analyzed by Law et al. (2009) who involved 275 professionals from the UX community to discuss this concept. The authors found that the different connotations and focuses derived from the years of work experience in the UX domain, the background (Technology and Software, Social sciences, Arts and Design) and the work domain (academia and/or industry) of the professionals.

Alben (1996) includes in the concept of user experience «all the aspects of how people use a product: the way it feels in their hands, how well they understand how it works, how they feel about it while they’re using it, how well it serves their purposes, and how well it fits into the entire context in which they are using it» (p.11). The author takes into consideration the emotional and cognitive dimensions of the experience, as well as the function of the technology to serve users’ objectives in specific contexts of use.

The holistic conceptualization of the user experience is particular evident in the definition of Hassenzahl and Tractinsky (2006) who consider the UX as a consequence of:

- user’s internal state (e.g. predispositions, expectations, needs, motivation, mood);
- the characteristics of the designed system (e.g. purpose, usability, functionality)
- the context in which the interaction occurs (e.g. organisational/social setting, meaningfulness of the activity, features of the environment).

The definition of the International Standard Organization (ISO 9241-210) points out that the experience derived not only from the actual use of a product/system/service, but also from the anticipated use, based on the users’ expectations and intentions.

Thus, the UX is not limited to the here-and-now of the interaction, because it arises before the use and cover what happens after the use (i.e. intention to reuse the technology and its adoption over time).

A further elaboration of the UX concept is proposed by Jacob Nielsen and Don Norman who consider all aspects of the users' interaction with the company, its services and products[11]. In this way, they focus the attention on the provider of the service/product, opening the discussion about brand image and reputation, trust and reliability.

Now I proceed with the discussion of the features of the AR and VR technologies that, in the purposeful interaction with the user and within the specific context, are key factors to foster a successful experience.

2.3.1 Cognitive artefacts and embodiment

In order to explain how the introduction of a new technology changes human practices and develops new experience, I refer to the concept of cognitive artefact.

Norman (1991) defines the cognitive artefact as an artificial device designed to maintain, display, or operate upon information in order to serve a representational function and affect human cognitive performance.

The mediation of cognitive artefacts expands some functional capacities of the user in performing activity, while it replaces the original task with a different task that may require different cognitive capacities than the original task.

To better explain the concept, Norman discusses the example of a to-do list.

The to-do list aims at supporting human memory but it introduces three new tasks, the first performed ahead of time, the other two at the time the action is to be done: 1) constructing the list; 2) remembering to consult the list; 3) reading and interpreting the items on the list.

This suggests that artefacts change the way a task gets done, in different ways: by distributing the actions across time (precomputation); by distributing the actions across people (distributed cognition); and by changing the actions required to carry out the activity.

[11] Retrieved from https://www.nngroup.com/articles/definition-user-experience/

Another feature of the cognitive artefacts is related to the nature of the interaction between the person and the object of the task, that varies from direct engagement to a very indirect, remote form of interaction in the case of virtual reality (Norman, 1991).

Similarly, Bødker (1987, 1990) distinguishes among several possible relationships between the person, the artefact and the objects being operated upon. Indeed, the artefact can be used to mediate directly between the person and the object, or the artefact can present a virtual object/world upon which operations are performed, eventually to be reflected onto the real object.

The introduction of innovative tools based on VR arises new form of mediated actions as well as new forms of embodiment.

The **Embodiment** of the everyday artifacts has been studied through neuropsychological and neurophysiological experiments (Maravita & Iriki, 2004), funding that the acquired ability of manipulating the tool changes the Body Schema (the map of body shape and posture) so to incorporate the tool into the body model.

The traditional research on embodiment addresses the use of everyday physical and proximal artifacts, while the digital technologies require further investigation because they allow the user to control distal virtual objects.

Riva and Mantovani (2012) analyze the embodiment related to two kinds of mediated actions, which have different effects on the user experience.

In *first-order mediated action* the subject uses the body to control a proximal tool (an artifact that is present and manipulable in the peripersonal space) to exert an action upon an external object. In this case, there is a direct spatial connection between the body of the subject, the tool and the external object.

In *second-order mediated action* the subject uses the body to control a proximal tool that controls a different distal one (a tool present and visible in the extrapersonal space) to exert an action upon an external object. In this situation, there is a spatial disconnection between the

peripersonal space that contains both the body of the subject and the proximal tool, and the extrapersonal space, that may be either real or virtual, where are located both the distal tool and the external object.

An example of second-order mediated action is the one performed by a videogame player using a joystick (proximal tool) to move an avatar (distal tool in a virtual space) to pick up a sword (external virtual object).

The effects of these two mediated actions on the user experience are different. Indeed, a successfully learned first-order mediated action produces *incorporation* – the proximal tool extends the peripersonal space of the subject (the subject is present in the tool) – while a successfully learned second-order mediated action produces also *incarnation* – a second peripersonal space centered on the distal tool.

2.3.2 Affordance

Using AR and VR technologies, the user deals with new devices and new forms of interactions. Thus, the affordance needs to be considered in order to provide the appropriate representation of the system (Norman, 1999).

James J. Gibson (1977) proposed the concept of affordance to explain the features of the environment that provide the animals with direct link between perception and action. Gibson's ontology considers that the nature of existence of an organism is always in relationship to its environment. Thus, he claimed that the objects of perception are to be understood not in terms of perceived properties of the object, but in terms of possible action relationships between the environment and the perceiver, the so-called affordances.

Gibson's affordance has three properties:

- it exists relative to the action capabilities of a particular actor;
- it exists independently from the actor's ability to perceive it;
- it does not change as the needs and goals of the actor change.

Donald Norman (1999) elaborated the concept of affordance by applying it to the study of everyday artefacts. He wondered why a person is able to use specific artifacts without any previous experience and familiarity with them. This happens because the properties of the tool suggest opportunities for the interaction.

In other words, an affordance is the design aspect of an object which suggests how the object should be used (both possibilities and limitations).

Thus, people perceive the environment and the tools directly in terms of their potentials for action, without significant intermediate stages involving memory or inferences (Gaver, 1991).

Kaptelinin and Nardi (2012) question Gibson's conceptualization because it fails to recognize technologies as culturally developed tools mediating human interaction with the world.

Based on the Activity Theory, the authors distinguish between two affordances provided by a technology, for acting through the technology and towards a certain object:

- Person-Technology (P-T) affordance suggests possibilities for interacting with the technology (i.e. handling affordances);
- Tool-Object (T-O) affordance suggests possibilities for employing the technology to make an effect on an object.

The Tool-Object affordance is similar to what Cole (1999) highlights as representations of the primary artifacts and the way they can be used to pursuit goals.

This affordance can also explain how people often change the way they use tools and interactive technologies (Kaptelinin & Nardi, 2006). As pointed out by Geisler (2003), users tend to go beyond what the designers had envisioned and they adopt tools as mediators in new activities, by creating effective ways to use a technology designed for other purposes. This happens when the technology suggests new modalities of use, according to its potential to meet users' needs and objectives. Through the affordances, it extends the capacity of the user in unexpected directions.

A further interpretation of the affordance concept is the one proposed by Alan Costall (1995; 2012) who distinguishes between general affordance (as the Gibson's definition) and *canonical affordance*, in order to emphasize the cultural aspect of an artifact. Canonical affordance refers to the symbolic nature of the artifact and the intentionality that must be learned through the use of the artifact. This affordance is a tangible sign of tool mediation and of the cumulative social influence.

Talamo and colleagues (2013) distinguish between two different layers of canonical affordance, that need to be considered for designing the interface of interactive digital technologies: a) generic canonical affordances, recognised as a "standard how to" for what concerns actions and symbols, connected to previous experiences with the technology; b) contextual canonical affordances, which include specific conditions or boundaries in potential actions and symbols related to the aims, attitudes, culture and behaviour of target users.

The first type of affordance is a sort of "naturalized" way of interacting with technologies developed through the experience of use (i.e. the interpretation of specific icons, gestures for commands etc.). The latter is closer to the field of "personalization", since it pushes design towards a better user experience by taking into account specific preferences of defined target groups in specific cultural contexts (Talamo et al., 2013).

To sum up, the possibility to interact with the technology and to use it to reach an objective is not a property of the tool, but it arises in the interaction between the technology and the user within the framework of specific activities.

2.3.3 Sense of presence

The effectiveness of Virtual Reality is linked with the sense of presence that can be broadly defined as the subjective experience of being in one place or environment, even when the person is physically situated in another one (Witmer & Singer, 1998; Zahorik & Jenison, 1998).

But, this subjective perception of "being there" can occur only in the case of immersive virtual environments, while Slater et al. (2009) propose an operational definition that can be applied to pure virtual reality as well as mixed reality application.

They consider presence as the propensity of people to respond to virtually generated sensory data as if they are real, and it arises when there is a successful substitution of real sensory data with virtually generated sensory data.

User's response can occur at many levels, ranging from unconscious physiological processes (i.e. brain activation states, heart activity, skin response), unconscious automatic behaviours and reflexes, deliberate behaviour, to the highest level cognitive behaviour including the feeling of being there.

Riva and colleagues (Riva & Mantovani, 2012; Triberti & Riva, 2016) propose a model that describes the experience of presence as the outcome of the meta-cognitive process that allows us to control our actions through the comparison between intentions and perceptions. Thus, presence derives from the link between intention, perceptions and actions within the virtual environment, dealing with agency and sense of control.

«I am present in a real or virtual space if I manage to put my intentions into action (enacting them). Feeling variations in the sense of presence, one can monitor his own actions and tune his activity accordingly […] this aspects influence sense of presence also in everyday life. One can feel more or less present in a given situation depending on how much he has the impression of being able to enact his own intentions, recognizing and using environmental opportunities for action, and then monitoring the perceived action outcomes as more or less consistent with the representational content of intentions» (Triberti & Riva, 20016, p.2).

This is the perspective of the *Inner Presence* theories.

From the perspective of socio-cultural psychology, presence in a virtual environment is connected with the experience of interaction with both objects and people, and the sense of

"being there with others" is considered relevant for the co-construction of social activities in computer-mediated context (Talamo & Zucchermaglio, 2003).

The **social presence,** the perception of being in another environment interacting with others, is also investigated when the human user interacts with virtual actors and synthetic agents (Biocca, Harms & Burgoon, 2003; Nowak & Biocca, 2003).

According to the automatic social responsiveness, people automatically respond socially to entities controlled by the computer that look or behave like humans. Therefore, if an agent looks or behaves like a human (humanity illusion), people will respond in the same way as they would respond to another human (Reeves & Nass, 1996; Nowak & Biocca, 2003).

Further investigation on the sense of presence is needed in order to identify the technology's properties as well as the interaction processes that foster the sense of presence.

A common way to stimulate the presence in VR is the design of the environment with high fidelity to reality so as to become indistinguishable from reality.

But, Sanchez-Vives and Slater (2005) found that the factors contributing to high level of presence are mainly connected with the form of how data are displayed and how the users are able to interact, rather than with the realism of the environment.

Until now, it is recognized that the sense of presence is determined by the interactivity, selective attention, involvement and immersion and the illusion of non-mediation.

- **Interactivity**

Most of the studies on presence examined by Schuemie et al. (2001) consider the interactivity as a key factor. Interactivity is the extent to which the users can modify the form and the content of the virtual environment in real time.

Interactivity between the perceiver and the environment is also the core component of the definition of presence proposed by Zahorik and Jenison (1998), based on Gibson's and Heidegger ontologies.

> «Presence is tantamount to successfully supported action in the environment.
>
> The environment may be either virtual or real, as well as local or remote in relation to the operator […] When actions are made in an environment, the environment reacts, in some fashion, to the action made.
>
> When the environmental response is perceived as lawful, that is, commensurate with the response that would be made by the real-world environment in which our perceptual systems have evolved, then the action is said to successfully support our expectations. Since our knowledge of such environmental response is necessarily gained through perceptual processes, it may be seen that the coupling between perception and action is crucial in determining the extent to which actions are successfully supported» (*ivi*, p. 87).

The sense of presence derives from the extent to which the virtual environment acknowledges and properly reacts to user's actions in the environment, the correlation between users' actions and the sensory feedback provided by the system (Zahorik & Jenison, 1998; Slater et al., 2009). In this sense, interactivity is valid only when the VR system tracks users' actions (i.e. head movements) and dynamically adapt the characteristics of the environment with low latency (Slater at al., 2009).

Furthermore, to produce the sense of presence, the virtual environment's response to user's action needs to be considered as lawful, coherent with what could happen in real situations (Zahorik & Jenison, 1998). Thus, fidelity of sensory information is of paramount importance to produce the sense of presence in a virtual environment (IJsselsteijn et al., 2000).

- **Selective attention**

Witmer and Singer (1998) relate the sense of presence to the selective attention. Indeed, in VR situations user's attention shifts from the physical environment to the virtual one, but it does not require the total displacement of attention from the physical context.

Selective attention refers to the tendency to focus on selected information that is meaningful and of particular interest to the individual.

Witmer's and Singer's (1998) suggest that experiencing presence in a virtual environment requires the ability to focus on one meaningfully coherent set of stimuli provided by the VR, to the exclusion of unrelated stimuli in the physical context. To the extent that the stimuli in the physical location fit in with the VE stimuli, they may be integrated to form a meaningful whole. This argument can be also applied to the set of stimuli provided by the Augmented Reality, that specifically need to be coherent with the perception of the physical environment in order to obtain a successful augmentation.

- **Involvement and immersion**

Witmer and Singer (1998) highlight that both involvement and immersion are necessary for experiencing presence.

Involvement is defined as a psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events. Involvement depends on the degree of significance or meaning that the individual attaches to the stimuli, activities, or events. The amount of involvement will vary according to how well the activities and events attract and hold the observer's attention.

Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences. Factors that affect immersion include isolation from the physical environment, perception of self-inclusion in the VE, natural modes of interaction and control, and perception of self-movement.

Involvement in a VE depends on focusing one's attention and energy on a coherent set of VE stimuli. For many people, high levels of involvement can be obtained with media other than VE, such as movies, books, and video arcade games. Immersion depends on perceiving oneself

as a part of the VE stimulus flow. By stimulus flow we mean the dynamic stream of available sensory inputs and events that both influence the observer's activities and that are influenced by those activities.

Baños et al. (2004) found that presence does not result solely from immersion, rather it depends also on the emotional engagement, derived from the affordance of the virtual environment to elicit positive or negative emotions according to users' actions. The authors question the cognitive-based or environmental-based conceptualization of the sense of presence, suggesting the fundamental role of emotions and affective valence of the virtual situation. Thus, the experience of "being there" derived from the possibility to react to the situation both at behavioral ("do there") and emotional level ("feeling there").

- **Illusion of non-mediation**

Schuemie et al. (2001) highlight another essential aspect of the presence that is rarely investigated: the illusion of non-mediation is the extent to which a person fails to perceive or acknowledge the existence of a medium when engaged in a computer-mediated experience (Lombard & Ditton, 1997; IJsselsteijn et al., 2000). Besides people know that the experience is mediated by the technology (for example, they wear a head-mounted display), at some level and to some degree, the illusion of non-mediation can be perceived, especially when the virtual environment presents a realistic and lawful scenario (IJsselsteijn et al., 2000).

In a condition of complete sensorial immersion, the disappearance of mediation occurs and the users feel that they are part of the virtual environment (Riva, Davide & Jsselsteijn, 2003).

Otherwise, the awareness of the interfaces (i.e. the head-mounted display) that arises in case of malfunctions or external stimuli, represents a breakdown of the immersive experience and a breach of the sense of presence (Triberti & Brivio, 2017).

Indeed, to create and sustain the illusion of non-mediation, the medium should be as transparent as possible, and distractions and negative cues to presence should be avoided. For example, bad stereoscopic alignment causing eye strain, weight of a head-mounted display, process

interruptions due to malfunctions and error notices, as well as distractions that draw the user's attention from the mediated environment to the real world are likely to diminish the user's sense of presence (IJsselsteijn et al., 2000).

2.3.4 User engagement with technology

Another element that characterized a successful interaction with the technology is the engagement.

Engagement «refers to the quality of the user experience that emphasises the positive aspects of the interaction, and in particular the phenomena associated with being captivated by technology. This definition is motivated by the observation that successful technologies are not just used, but they are engaged with» (Attfield et al, 2011, p.9).

According to the literature (Attfield et al., 2011; O'Brien & Toms, 2008; Edmonds, Muller & Connell, 2006), engagement has the following properties:

- it arises from the interaction between the user and the technology;
- it involves emotional, cognitive and behavioral dimensions within the whole experience;
- it can occur in a specific and unique situation, and it can also proceed as a long-term relationship across multiple interactions;
- its intensity can change over the course of the interaction;
- it is influenced by human, technological and environmental factors;
- it determines the quality of the experience.

The cognitive dimension of the engagement is related to the focused attention (Attfield et al, 2011): being engaged in an experience involves focusing attention to the exclusion of other things, including other people (unless social interaction enhances the engagement). This phenomenon relates to distortions in the subjective perception of time during interaction. The more engaged someone is, the more likely they are to underestimate the passage of time.

Together with concentration, absorption and loss of self-consciousness, distortions in the subjective perception of time have led to parallels being drawn between engagement and the idea of flow as an optimal experience, where flow refers to a mental state in which a person is fully immersed in what they are doing.

Users are engaged when they experience emotions, essentially positive affects like astonishment, enjoyment and fun (Attfield et al, 2011).

Interactive experiences can be engaging because they present users with novel, surprising, unfamiliar or unexpected experiences. Novelty appeals to our sense of curiosity, encourages inquisitive behaviour and promotes repeated engagement. It can arise through freshness of content or innovation in information technology (Attfield et al, 2011).

The *Richness, Control and Engagement* framework (Rozendaal, Keyson & Ridder, 2009) explains levels of engagement in terms of the levels of richness and control that are shaped by the features of a product and the user's expertise. Richness captures the growth potential of an activity by assessing the variety and complexity of thoughts, actions and perceptions as evoked during the activity (e.g., variety, possibilities, enjoyment, excitement, challenge). Control captures the extent to which a person is able to achieve this growth potential by assessing the effort in the selection and attainment of goals (clarity, ease, self-confidence, freedom).

Regarding the process of engagement, Edmonds, Muller and Connell (2006) identified three attributes are important for engagement: a) Attractors, those things that encourage the audience to take note of the system in the first place; b) Sustainers, those attributes that keep the audience engaged during an initial encounter; and c) Relaters, aspects that help a continuing relationship to grow so that the audience returns to the work on future occasions.

The process of engagement has been systematically analyzed by O'Brien and Toms (2008; 2010). Although their model has been developed in relation to other kinds of applications (e-commerce, webcast, video games), it seems suitable as framework to understand the museum visitor engagement.

The process emerges with distinguishable attributes related to different stages.

- **Point of engagement** (when engagement is initiated)

The engaging experiences begins according to a specific goal or motivation, or some attractors that catch users' attention and move them forward into engagement; the point of engagement can be also triggered when something resonated with users' interest.

- **Period of engagement**

The period of sustained engagement is related to users' attention and interest being maintained in the interaction with the system. This occurs when the system provides the users with novel information - meaning elements that are new, interesting, or unusual or even as sudden and unexpected changes on the interface that evoke a reaction from the user.

Moreover, the engaging experience is sustained when the users perceived that they are in control of the interaction and appropriately challenged.

- **Disengagement**

Disengagement occurred when users decide to stop the activity, because they lose interest in the experience or when factors in the external environment caused them to cease being engaged. Users take a break from the interaction because other things come into their minds, and they turn their attention to something else. Physiological circumstances (such as eye fatigue, or needing to eat/drink or use the washroom) can also cause disengagement moments.

While at other times, disengagement is the result of external factors, such as being interrupted. The source of interruptions and distractions could be from environmental factors, such as noise, the phone ringing etc.

Disengagement can be precipitated by technological issues and usability problems.

However, disengaging from the interaction with the system is not necessarily the end of their engagement. Indeed, the activity can be temporarily dropped or stretched out during a certain period of time, and then it can be resumed. This is the case of re-engagement.

- **Non-engagement**

Poor usability produces frustration and it is a barrier for engagement, as well as Content that overwhelmed or failed to interest users.

Regarding the disengagement, Bodker (1989) introduces the notion of "activity flow" to describe the activity cycle in accomplishing a task. Automatization of effort and the resulting feeling of direct engagement can occur where a consistent, cohesive activity flow is supported by the task, artifact, and environment. Interruptions and unexpected results break the activity flow, forcing conscious attention upon the task. For many activities, this "bringing to consciousness" is disruptive of efficient performance. The problem with disrupting activity flow is that the disruption brings to conscious awareness the disrupting activity, even when this is not the main focus of attention.

2.3.4 Usability, user acceptance and domain suitability

Most of the literature about AR and VR technologies addresses the issues related to usability, limiting the unit of analysis in the interaction between the user and the device.

Adopting a socio-cultural perspective, the unit of analysis should include the activity system of social actors and tools within situated contexts (Suchman, 1987; Talamo & Zucchermaglio, 2003).

Kelly Harwood (1993) suggest to distinguish between *technical usability* – that is connected with the perceptual and physical aspects of the human computer interface – and *domain suitability* which refers to the content of information and display representation for domain tasks as well as functionality and decision-aiding algorithms. Technical usability is characterized as a bottom-up, technology driven process, while domain suitability is characterized as top-down and problem-driven.

Since a technology is used as mediating tool to reach objectives within a socio-cultural and physical context, it is possible for a tool to be usable but not suitable for domain tasks (Talamo & Zucchermaglio, 2003; Talamo, Mellini & Giorgi, 2011).

This is particularly valid for the museum domain: museum audience is heterogeneous and with different visit agendas (Hooper-Greenhill, 2006; Falk & Dierking, 2016) and each museum has a specific identity derived from its history, collection, mission and strategy (Marini Clarelli, 2005).

This mean that one solution does not fit all the museums and all the visitors. Rather, technology supporting museum experience should be designed based on a deep understanding and evaluation of both its usability and domain suitability.

Thus, as suggested by Harwood (1993), the validation of a new technology needs to consider at the same time the technical usability, the user acceptability and domain suitability.

- **Technical usability**

It is recognized that usability is the basic requirement for any kind of technology, the fundamental factor that determines the success or the failure of the technology.

Usability is defined as «the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use» (ISO 13407:1999).

What makes something usable is the absence of frustration in using it, because when a product or service is truly usable, «the user can do what he or she wants to do the way he or she expects to be able to do it, without hindrance, hesitation, or questions» (Rubin & Chisnell, 2008, p.4).

Jacob Nielsen (2012)[12] defines the quality components of usability, as briefly described in the table below.

[12] Retrieved from https://www.nngroup.com/articles/usability-101-introduction-to-usability/

Learnability	How easy is it for users to accomplish basic tasks the first time they encounter the design?
Efficiency	Once users have learned the design, how quickly can they perform tasks?
Memorability	When users return to the design after a period of not using it, how easily can they reestablish proficiency?
Errors	How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
Satisfaction	How pleasant is it to use the design?

Table 4: Usability components

From these quality components, Nielsen (1994) derived ten usability heuristics, principles and rules to design solutions with high level of usability:

- visibility of the system status
- match between the system and the real world
- user control and freedom
- consistency and standards
- recognition rather than recall
- flexibility and efficiency of use
- aesthetic and minimalist design
- error prevention
- help users recognize, diagnose, and recover from errors
- help and documentation

Such heuristics are adopted to evaluate mixed reality applications and some usability issues have been detected with it. But, mixed reality applications need specific criteria to assess their level of usability. The attempts to define heuristics for mixed reality technology are very few and application-specific, due to the diversity of solutions developed for specific context of use.

According to the literature available (Damala, 2006; Dünser et al., 2007; Kaufmann, & Dünser, 2007; Pribeanu, Balog, & Iordache, 2008; Olsson & Salo, 2012; Sutcliffe, & Gault, 2004), some specific heuristics can be added to the Nielsen's list.

Specifically, regarding the easiness, adjusting the device and the usage settings should be easy, as well as manipulating virtual objects through input device should be effortless.

Furthermore, the quality of the images and the superimposition between projection and real objects have a great impact on user satisfaction.

Another relevant factor is the comfort while using headset and handled devices: reducing the cognitive effort, avoiding avoid eye strain and fatigue (i.e. heavy helmet, uncomfortable positions) should be considered as fundamental requirements to design successful experience.

- **User acceptance**

Usability evaluation is essential to understand how the technology impacts the user experience. A further way to understand the value of the technology for potential users relies on the user acceptance (Obeidy, Arshad, & Huang, 2017).

The Technology Acceptance Model (TAM) was originally proposed by Davis (1989, 1993) to predict technology usage, and over the years it has been used in several domains of HCI field with a wide range of information technologies and user groups. TAM is considered a valuable model to investigate users' willingness to use a new technology, especially during the design process before the technology reaches maturity, or even when a technology will be implemented in an organizational context (Davis, Bagozzi & Warshaw, 1989; Davis, 1993).

Together with the usability, «user acceptance is often the pivotal factor determining the success or failure of an information system project» (Davis, 1993, p. 475).

Based on the theory of reasoned action (Ajzen, 2000), the TAM is founded upon the hypothesis that technology adoption can be explained in terms of a user's internal beliefs, attitudes and intentions.

According to this model (Davis, 1989), given the external stimulus (the technology with its specific properties and features), the actual use of a technology is predicted by the users' attitudes toward the use, which in turn is determined by:

- perceived **usefulness**, the degree to which a person believes that using a particular system would enhance his/her job performance;
- perceived **ease of use**, the degree to which a person believes that using a particular system would be free of physical and mental effort.

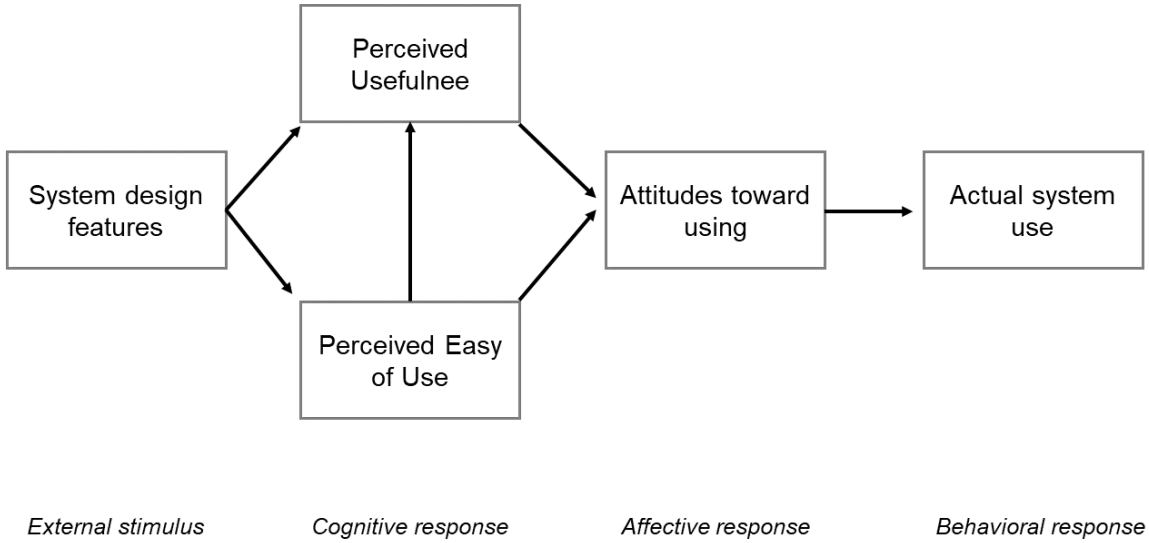


Figure 18: Technology Acceptance Model (Davis, 1989)

Dealing with intrinsic motivation to use a technology, Davis together with Bagozzi and Warshaw (1992) added another element in the TAM: the perceived **enjoyment**, the extent to which the activity to use the system is perceived to be enjoyable in its own right, apart from any performance consequences that may be anticipated.

In their studies, authors found that usefulness and enjoyment together explained 62% (Study 1 about word processing software) and 75% (Study 2 about business graphics programs) of the variance in usage intentions. Moreover, they found that usefulness and enjoyment mediate the effects on usage intentions of perceived output quality and perceived ease of use.

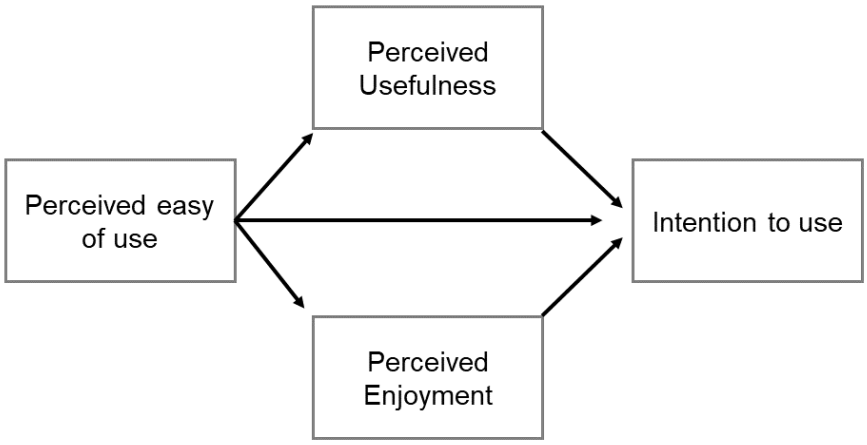


Figure 19: Technology Acceptance Model (Davis et al. 1992)

Van der Heijden (2004) noted that the original TAM scale was developed for utilitarian information systems – functional and instrumental needs – and found that the measure for perceived usefulness was problematic because of the focus on improved job performance. The author examined user acceptance of a recreational service, a Dutch website about movies and cinema, and found that perceived enjoyment and perceived ease of use were stronger predictors of intention to use such hedonic system than perceived usefulness – aesthetic, experiential and enjoyment needs.

Thus, the hedonic nature of an information system is an important boundary condition to the validity of the TAM, because perceived usefulness loses its dominant predictive value in favor of ease of use and enjoyment.

Furthermore, perceived ease of use directly contributes to future intentions to use the hedonic system because it either enhances or inhibits the user's hedonic experience.

Indeed, TAM is traditionally used in workplace domain to study the technology in organizational contexts, while few studies apply the model in the field of cultural heritage and tourism (Obeidy, Arshad, & Huang, 2017; Leue & Jung, 2014).

Haugstvedt and Krogstie (2012) applied the TAM to evaluate the acceptance of mobile AR application with historical photographs and information about a historical street.

The authors used a prototype of the application and a questionnaire that includes items related to perceived usefulness, perceived ease of use, perceived enjoyment and behavioral intention to use the application.

This study showed that both perceived usefulness and perceived enjoyment had a strong positive effect on the intention to use this type of applications, and that they both achieved dominant predictive value over perceived ease of use.

Over the years, TAM has been extended so as to include additional factors suitable for the analysis of specific solutions. For example, Bourgonjon et al. (2010) evaluated the acceptance of edutainment game for secondary students by considering gender, games experience and learning opportunity afforded by the technology.

King and He in their meta-analysis (2006) identify four major categories of modifications:

- the inclusion of external precursors such as situational involvement, prior usage experience and personal computer self-efficacy;
- the incorporation of factors suggested by other theories that are intended to increase TAM predictive power, for example subjective norm, task-technology fit and trust;
- the inclusion of contextual factors such as gender and technology characteristics that may have moderator effects;
- the inclusion of consequence measures such as attitude, perceptual usage and actual usage.

Individual differences seem to act as antecedents to TAM three core beliefs (Van der Heijden, 2004). Regarding the personal traits, **personal innovativeness** has been included in the TAM (Agarwal, & Prasad, 1998; Leue & Jung, 2014), that is related to users' willingness to be a technological pioneer by trying out new services and products.

The concept of personal innovativeness is based on Rogers' Innovation Diffusion Theory (2010) suggesting that users' personality differences can potentially influence how users form their intentions to perform behaviours.

Rogers suggests that: a) users with higher levels of personal innovativeness are more prone to have more favourable attitude towards new technologies; b) highly innovative users are more willing to embrace new technologies into their daily routine by coping with the uncertainty of innovative technologies.

Personal innovativeness is conceptualized as a trait, a relatively stable descriptor of individuals that is invariant across situational considerations (Agarwal & Prasad, 1998).

Lee, Qu and Kim (2007), in their study on online travel shopping, indicated that innovativeness influences traveller's online shopping behavior. Similarly, Parveen and Sulaiman, (2008), O'Cass and Fenech (2003) suggested that highly innovative web users are more likely to develop more positive attitude towards new technologies.

User acceptance is also connected with the process of appropriation of new technologies and their integration into daily activities. Carroll et al. (2002) investigated the appropriation of the smartphone by young people, and they proposed a model based on three processes:

- the first encounter is the moment when the user discovers the new technology, and he/she is attracted by it as long as it resonates with personal interests, actual rather than hypothetical needs and attitudes;
- the exploration is the phase when the user tries the technology's features and functions out, and evaluates whether it adds value to his/her activities and lifestyle;
- the long-term integration into everyday practices occurs when the technology fits with user's needs, and when its use is reinforced and stabilised.

Bødker and Klokmose (2012) expanded the analysis of appropriation process to consider the socio-cultural context. Specifically, they analysed how the appropriation of an artifact determines and is determined by the overall artifact ecology. Through the Activity Theory framing, they highlighted the dynamics of such complex arrangements of people and mediating technologies.

Since, the artefact ecology is in continuous development, the choice to adopt and use an artifact is situation-specific and it depends both on the material conditions of the activity and on the intended outcome.

Part II

According to the theoretical framework detailed in *Part I*, the research was designed to better understand the role of Augmented and Virtual Reality technology for the promotion of the cultural heritage.

Despite the growing interest in this topic and the amount of literature produced, there are still some open issues that I think are mainly connected with the lack of holistic perspectives.

> «Research has been done on who visits museums and to a degree why. Research has been done on what visitors do in the museum. Research has been done on what visitors learn from the museum. However, only rarely has research been done in ways that allow understanding of the whole visitor and the whole visit experience […]. The reductionist ways in which museum visitors have typically been studied, beginning with a focus on 'who' visits the museum, have long prevented us from truly understanding the museum visitor experience» (Falk, 2013, p.109).

The research agenda in the field of Museum Visitor Studies follows two different directions: the visitor-centred focus and the exhibit-centred focus. In this way, most of the research is focused on limited aspects of the visitor experience, such as motivations or learning outcomes, overlooking the interrelation between visitors' characteristics, the museum environment and the technology that all together contribute to the whole visitor experience (Falk & Dierking, 2008).

Based on the literature review, I identified some open issues that need to be addressed and I defined the following Research Questions (RQs).

RQ1: How do AR-VR technologies enhance museum mission and strategies?

In most of the literature about design projects in museum and cultural heritage domain (see *§1.4*), the technology seems to be implemented as a neutral tool within a *vacuum*, meaning

without considering – or, at least, documenting – the features of the museum context in which the technology is implemented, the specific museum identity and the overall strategy that guides the technological innovation.

As in the study of Damala and Stojanovic (2012), technological innovation should be considered in the light of the strategies the museum adopts to promote the heritage and to engage the audience of regular and potential visitors.

RQ2: What are the motivations that drive visitors to visit museums using AR-VR technologies?

Besides the relevant literature about the motivations for visiting museums (see *§1.3.1*), the motivations to use AR-VR technology are not specifically addressed, also because the research often involved participants as tester, purposely recruited to assess the technology (see for example: Loscos et al., 2004; Yoon & Wang, 2014).

Thus, there is the need to investigate the reasons why visitors decide to perform the visit using the technology.

RQ3: How does the technology mediate the museum visit experience?

To answer this question, the enabling and constraining features of AR-VR technologies should be further investigated, as well as the benefits visitors derived from the museum experience mediated by the technology.

What kinds of museum-related contents could be provided through the technology?

How is the technology embedded into the museum context?

Are the learning outcomes limited to the increase in knowledge and understanding?

These questions are intended to increase our understanding of the visitor experience according to the features and affordances of the AR-VR technologies.

RQ4: How does the social interaction occur when the technology provides individual and immersive experience?

In *§1.3.3*. I discussed some interesting researches investigating interactions and conversations among visitors, which highlight that the social interaction is a core element of the visitor experience.

There are also interesting studies about technologies that supports social interactions and collaboration among visitors, both within the museum space (Grinter et al, 2002; Hall, Ciolfi & Bannon, 2001; Fraser et al., 2004; Dini, Paternò & Santoro, 2007) and with remote users through the web (Brown et al., 2003).

Nevertheless, there is the need to further investigate the way technologies designed as individual experience provide opportunities and limitations to the social interaction (Vom Lehn & Heath, 2003, 2007).

To address these open issues, I designed and carried out two complementary studies.

The **Study 1** is a qualitative investigation performed at the *Ara Pacis Museum* in Rome (Italy), with the aim of analysing the experience of visitors who performed a tour that integrates AR and VR technologies (called *Ara as it was*).

Specifically, the study answers to the RQ1 by analysing the distinction between the "design-for-use" that reflects the designers' perspective on user practice, and the "design-in-use" that is the users' perspective on their own practice (Folcher, 2003).

Indeed, «designers can create only the preconditions for emerging user practices» (Kaptelinin & Nardi, 2006, p.113), and then the users integrate the artifacts into their activities to create new practices.

This issue is particularly relevant for the museum domain, since the technology should serve as the "meeting point" between the museum's mission and its heterogeneous audience of regular and potential visitors.

The RQ2, RQ3 and RQ4 are addressed considering the specific case of the Ara as it was tour, by analyzing how the characteristics of the visitors, the museum context and the technology features determine the whole visitor experience.

Since the Study 1 is a situated research focused on a specific context and on a specific technology, I decided to include another study with the purpose of collecting data from a wider audience, about different forms of AR and VR technologies.

The **Study n.2** is a survey on museum audience performed through an online questionnaire, in order to complement and enrich the results gained from Study 1, by specifically addressing the RQ3 and RQ4.

Together, the two studies provide some interesting insights about the museum experience that be used to better design innovative technologies for the promotion of cultural heritage.

3. Study 1: Visitor experience at the Ara Pacis Museum

The research context is the Ara Pacis Museum in Rome that was selected because it offers an innovative tour that combines AR and VR, called *Ara as it was*.

The Ara Pacis Museum is part of the museum network run by the Rome City Council[13], that includes an extremely diverse group of museums and archaeological sites.

The museum was built around the monument of the *Ara Pacis Augustae*, an altar dedicated to the Roman goddess of Peace, that was commissioned by the Roman Senate in 13 B.C. to honor the return of the Emperor Augustus to Rome after three years in Hispania and Gaul.

The monument served as mean to celebrate Roman Peace (*Pax Augusta*), a long period of peacefulness, abundance and prosperity approximately from 27 B.C. to 180 A.D.

The monument consists of a traditional open-air altar, surrounded by precinct walls with elaborately and finely sculpted entirely in Luna marble (see *Figure 20*).

The monument is embedded in an architectural structure designed by Richard Meier & Partners Architects. The structure is characterized by the contrast of light and shade: the visitors pass through the access gallery, an area in shadow, to reach the central pavilion which holds the Ara Pacis in full natural light filtered through crystal panels, the "shrine of light". This expanse creates an uninterrupted continuity with the outside world, and also helps to create the silence necessary to enjoy the monument in full.

[13] Further information about the Rome museum network are available at http://www.museiincomuneroma.it/en/musei_in_comune/il_sistema_museale (Retrieved in October 2018)

Figure 20: The Ara Pacis inside the museum central pavillion[14]

Since October 2016, the museum allows visitors to perform the tour called "Ara as it was"[15].

It is a multimedia tour that combines AR and VR, telling the story of the monument and immersing the visitor into the original context of the Ara Pacis.

The visitors wear the Samsung Gear VR headset that includes the visor combined with the Samsung Galaxy S7 smartphone and the headphones.

The tour is divided into nine Points of Interest (POIs).

The first two POIs are based on VR: the visitors, seated on the chairs, are greeted with a 360° filmed view of the Ara Pacis in the Campo Marzio (the original location of the monument) and then virtually attend the sacrificial ritual performed by actors within a virtual scenario at the time of Ancient Rome (*Figure 21* and *23*).

The following seven POIs are located around the monument, where the view of the altar's details is augmented with the colours and the related audio description (*Figures 22* and *24*).

[14] Source: Jose Antonio at Italian Wikipedia. Retrieved from https://commons.wikimedia.org/wiki/File:Ara_Pacis_Roma.JPG

[15] The project is commissioned by Roma Capitale and the Department for Cultural Development through the Capitoline Supervisory Body for the Cultural Heritage Department. It is organized by Zètema Progetto Cultura and developed by ETT SpA.

Figure 21: Visitors at the VR POI

Figure 22: Visitors at the AR POI

Figure 23: Virtual scenario[16]

[16] Screenshot from the video by ETT s.p.a. https://www.youtube.com/watch?v=Akd5-r1gZKc&t=27s

Figure 24: Frieze augmented with the colours[17]

The tour lasts about 45 minutes, it is scheduled every Friday and Saturday in the evening, and the visitors are organized in groups of 10 people, starting the tour every 10 minutes.

The tour is available only in the evening because it needs a reserved time, so to avoid the interference with the guided tours and the other people who freely visit the museum during the day.

The purpose of Study 1 is to investigate the role of the Ara as it was tour in supporting museum's strategy for the promotion of the heritage and for the audience-development (RQ1), as well as in enhancing the visitor experience (RQ2, RQ3, RQ4).

Dealing with the complexity of the subject matter, I adopted the ethnographic methods to collect data and the Service Design Thinking methodology to analyze data, in order to build a bridge between research and design and to maintain the double focus on the museum and the visitors.

[17] Screenshot from the video by ETT s.p.a. https://www.youtube.com/watch?v=Akd5-r1gZKc&t=27s

3.1 Data collection methods

The field research relies on the ethnographic investigation with the aim of describing the phenomena occurring in the situated context, highlighting the interpretations and meanings of the people involved (Grudin & Grinter, 1994; Kuniavsky, 2003).

Ethnography is a qualitative method developed in the field of anthropology, starting from Malinowski's work titled "Argonauts of the Western Pacific" (1922) to investigate customs and traditions of social groups in New Guinea.

Ethnography is a research perspective that strongly relies on the situated nature of knowledge: through the field research, knowledge is co-constructed in the interaction between the researcher and the participants within a dialectic process.

Through the participant observation that requires the active involvement of the researcher to the context and practices under investigation, and through the reflexivity that makes the researcher's experience matter (Draper, 2005; Dourish, 2006; Hammersley & Atkinson, 2007), the ethnography provides "thick description" (Geertz, 1973) of phenomena as they occur in situated context.

Ethnography in the domain of Museum Visitor Studies is widely used, in line with the constructivist and socio-cultural turn of the new museology (see *§ 1.2.2*).

Similarly, the adoption of ethnography in the field of HCI derives from the need for a holistic perspective and methods to deeply investigate work activities as well as everyday practices, in line with the second wave (see *§ 2.2*).

> «One of the first conditions of acceptable Ethnographic work certainly is that it should deal with the totality of all social, cultural and psychological aspects of the community, for they are so interwoven that not one can be understood without taking into consideration all the others» (Malinovski, 1922, p. xvi)

> «An Ethnographer who sets out to study only religion, or only technology, or only social organisation cuts out an artificial field for inquiry» (ivi, p.11)

Ethnography can benefit design project at different levels (Hughes et al., 1994; Crabtree & Rodden, 2002; Talamo, Mellini & Giorgi, 2011):

- during the exploration phase, within an iterative process in which the research provides insights for the design that in turn arises questions for further investigation;
- to evaluate the designed solutions within specific context and make proper adjustments before the final release;
- as follow-up research to analyze possible modifications of tools and practices derived from the introduction of new technologies.

The research performed at the Ara Pacis Museum represents an example of ethnographic investigation to evaluate a technology already implemented in the museum context.

Data were collected through a mixed method in order to focus the attention on the personal, environmental and technological components of the experience, both as observed by the researcher and reported by the participants.

As Hein (2002) points out, each single method to collect data has advantages and limitations and it provides information only about limited aspects of the experience. For this reason, I decided to jointly use different methods in order to improve the richness of the data and provide a comprehensive dataset to analyze the complexity of the user experience (Preece, Rogers & Sharp, 2002; Zucchermaglio et al., 2013; Stickdorn et al., 2018), as well as possible gaps between the intention of the designer and the intention of the user (Folcher, 2003; Kaptelinin & Nardi, 2006).

Figure 25 shows a scheme of the research activities, from the preparation phase until the data collection.

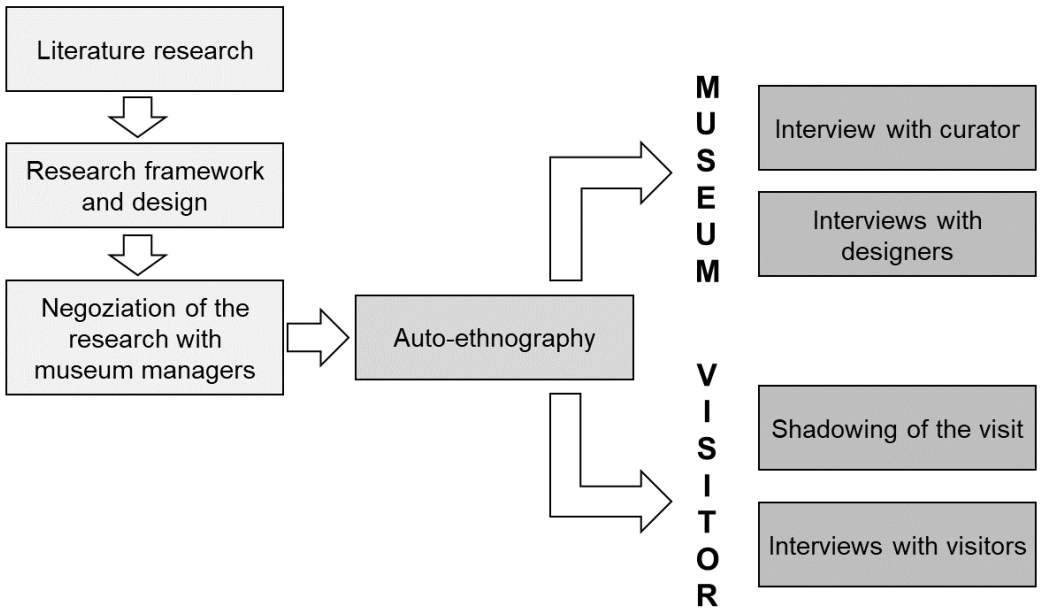


Figure 25: Research activities

During the preparation phase, an extensive literature research was performed to define both the theoretical framework described in *Part I* and the research design. Since it is a situated research, the research design was defined at the beginning and it was further detailed throughout the data collection (Zucchermaglio et al., 2003).

Furthermore, the research was designed and carried out by a team of three people from the IDEaCT Lab[18]. We collaborated to define together the objectives, the plan and the methods of the research; we organized the meetings to discuss about the research as a joint enterprise, adjusting the methods and developing a shared repertoire of concepts and tools. With this in mind, I can say that we formed a community of practice (Wenger, 1999).

Once the research has been negotiated with the museum Curators and Director, the data collection phase started with the auto-ethnography that represents a middle step that laid the groundwork for the analysis of both the museum and the visitor experience.

[18] "Interaction DEsign And Communication Technologies" Joint Lab of the University of Rome Sapienza http://dip38.psi.uniroma1.it/en/node/5832

3.1.1 Auto-ethnography

The auto-ethnography (also called self-ethnography or reflexive ethnography) is defined by Maréchal (2010) as a «method of research that involves self observation and reflexive investigation in the context of ethnographic fieldwork and writing» (p.43).

Auto-ethnography is used by anthropologists and social scientists in the case of *insider ethnography* – to study communities and social groups they belong to as representative members – and in the case of *outsider ethnography* – to investigate researcher's personal experience when participating in activities of other groups (Hayano, 1979; Maréchal, 2010).

In both the cases, this method strongly relies on the reflective practice, by acknowledging that researcher not only interprets the results according to the specific theoretical framework, but construct them through the lens of the personal background, culture, beliefs and attitudes (Draper, 2005; Dourish, 2006; Hammersley & Atkinson, 2007).

I decided to perform auto-ethnography at the Ara Pacis Museum in order to explore the research context by visiting the museum and using the technology, while writing field notes. In this way, the museum identity and the properties of the tour were investigated and the research design was further defined.

Instead of searching for objectivity and reducing the source of "bias" that is the researcher's experience and influence, my attempt was to use my personal experience as a source of information about both the topics under investigations and the way they are investigated (Maréchal, 2010).

Thus, the field notes collected during the auto-ethnography represent the "space" to reflect about my experience as a visitor, by reporting the expectations, emotions, mode of interaction with the device and features of the museum environment.

Furthermore, the field notes were used to identify in the case study the most relevant topics to be investigated, along with the methods to investigate them (specifically, the questions of the interviews and the observation grid).

Two sessions of auto-ethnography were carried out with different focuses: the first one was carried out during the preparation phase, as preliminary exploration of the research context, when the research was organized and negotiated with the Curators and the Director of the Ara Pacis Museum; the second one was performed just before the collection of data about visitors, so as to further validate the research design.

3.1.2 Semi-structure interviews

Semi-structure interviews were selected as main method to collect data. The questions asked were mainly open-ended so to foster the respondents to describe their experience and point of view, without forcing them to select from pre-defined answers. Although the interview framework has been defined to cover a list of pre-defined questions, it was flexible enough to be adapted to the narration of the interviewed, so to expand and enrich the answers (Silverman, 2015).

Interviews were performed with the museum curator, with the project manager and designer of E.T.T. and with the visitors.

Interviews with curator, project manager and designer aim at investigating what is called the design-for-use (Folcher, 2003) or technology-as-designed (Carroll et al., 2002). Specifically, they were asked to describe the objectives and expected benefits that motivated the introduction of the Ara as it was tour, as well as the design process and the decisions made about the technology and the organization of the tour.

Interviews with visitors were performed at the end of the tour, in order to collect data about the design-in-use (Folcher, 2003), meaning how they experience the tour using the technology.

The following table reports the topics discussed during the interviews with the different participants.

Interviewees	Topics
Ara Pacis Museum Curator	- museum mission and strategies - objectives of the Ara as it was project - expected benefits in terms of audience development - target visitors - stakeholders involved
E.T.T. Project Manager and Designer	- characteristics of the tour and features of the technology - design process and resources needed - evaluation of the solution and visitors' feedback
Visitors	- motivations that drive them to visit the museum and to use the technology; - previous experiences using AR/VR applications; - emotions; - opinions about the contents and the organization of the tour - benefits from the visit - problems and limitations of the tour

Table 5: Topics of the interviews with curator, project manager and designer

3.1.3 Shadowing of the visit

The shadowing is a form of observation that is often used in workplace studies to observe participants as they move inside different contexts (McDonald, 2005; Hammersley & Atkinson, 2007), and also to observe how the artifacts move between people and contexts, as a source of articulation work (Mellini, 2013; Talamo et al., 2015).

Shadowing differs from the stationary observation that is commonly used in Visitor Studies, when the researcher stays in one room/area of the museum and observes the interaction of the visitors with the exhibits (Hein, 1998). Stationary observation is a useful method to evaluate the exhibits (i.e. attracting power, reading of the panels), but it provides only snapshots of the visitor experience.

On the contrary, shadowing allowed me to observe the whole experience within the museum context for the entire duration of the tour, and to perform the interview at the end of the tour to asks for visitors' opinions.

During the shadowing, the following elements were observed and written down:

- path and movements inside the museum space;
- superficial/deep observation of the monument and artifacts;
- use of other tools (i.e. panels)
- interaction with the devise;
- comments and dialog with others (staff and visitors).

Movements and stops are tracked using a simplified map of the museum space (*Figure 26*), integrated into the field notes, that represents the artifacts ecology of the museum.

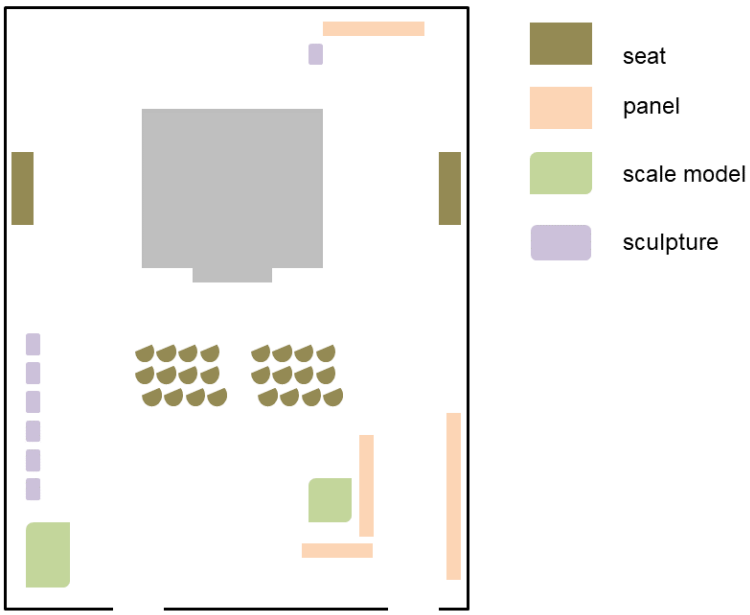


Figure 26: museum map used during the shadowing

As sketched in the map, the collection of the Ara Pacis Museum is composed of the monument, some busts and sculptures, and the ecology of artifacts includes also interpretative tools in the form of scale models of the monument, informative panels and a video screen.

3.1.4 Visitors participating in the research

All the visitors waiting to start the tour were approached and asked to participate in the research. The Director provided the authorization to perform the research at the museum, and visitors were asked to give their consent with, approximately, this description.

"The research aims for analysing the visitor experience using the Ara as it was. I am interested in identify both the benefits and the problems of such kind of technology. If you agree to participate, I will follow you during the visit observing your interaction with the technology, and at the end of the tour we will perform an interview asking for your opinions".

21 visitors were interviewed, all Italian language speaking.

Table 6 reports the information about participants.

Sex	Male	16
	Female	5
Age	18 – 34 years old	9
	35 – 54 years old	7
	+ 55 years old	5
Components	Couple	13
	Small group	8

Table 6: Information about participants

Most of the interviewed visitors (16 up to 21) live in Rome. Most of them (12 up to 21) have already visited the Ara Pacis Museum and they decided to come back to experience the Ara as it was tour. These are two relevant information that will be further discuss along with the results.

3.2 Data analysis methods

Regarding the interviews with the curator, project manager and designer, **content analysis** was performed in order to categorize the transcripts according to the key themes that reflect the

design-for-use (Folcher, 2003), the objectives and the expected benefits of the Ara as it was project.

The methodology used to analyze data about the visitor experience is the **Service Design Thinking** (SDT). It is a holistic approach that helps to create new services or improve existing ones, to make them more useful, usable, desirable for users as well as efficient and effective for providers (Moritz, 2005; UK Design Council, 2010;).

SDT is at the same time a mindset, a process and a toolset to design innovative services and to develop new value propositions for existing services (Stickdorn & Schneider, 2012; Stickdorn et al., 2018).

In the last years, the shift from "product" design to "service" design – from owning to using, from things to experience – changed the worldwide economy that now is focused on service dominant logic, with different advantages both for organizations and for customers (Pine & Gilmore, 1998).

> «Service design is the activity of planning and organizing people, infrastructure, communication and material components of a service in order to improve its quality and the interaction between service provider and customers. The purpose of service design methodologies is to design according to the needs of customers or participants, so that the service is user-friendly, competitive and relevant to the customers» (Service Design Network, 2008)

Designing a service is more than just designing a single product, and it requires to consider the whole experience of people using the service, that becomes tangible and usable through its touchpoints, within a sequence of actions (Moritz, 2005).

Taking in account the whole experience requires to design the user journey, starting from the pre-service period when the user gets in touch with the service and considering all the steps to go on, as a coherent process (Stickdorn & Schneider, 2012).

In such perspective, the museum is an institution providing the visitors with different services (i.e. guided tours, cafeteria, temporary exhibitions etc.) which act as "meeting points" between the museum mission and the visitor needs and goals.

Note that I used the SDT approach not to design a new service, but with the purpose of evaluating an existing one, specifically to investigate the impact of the "Ara as it was" on the visitor experience and the way it supports the museum mission and strategy.

The Service Design Thinking is a valuable approach to elaborate the research data and produce models of the visitor experience, to gain suggestions and insights for design purposes.

Indeed, raw data in the form of interview transcripts and field notes are not inherently useful, because they need to be "translated" into relevant information to drive the design process towards user-centred solutions (Pruitt & Adlin, 2010; Cooper, Reimann & Cronin, 2007).

The process of data analysis in Service Design Thinking is called "sensemaking" because it requires the interpretation of the data and the elaboration of models of the experience (Stickdorn et al., 2018).

> «Models are used extensively in design, development, and the sciences. They are powerful tools for representing complex structures and relationships for the purpose of better understanding, discussing, or visualizing them. Without models, we are left to make sense of unstructured, raw data, without the benefit of any organizing principle. Good models emphasize the salient features of the structures and relationships they represent and de-emphasize the less significant details» (Cooper, Reimann & Cronin, 2007, p.76).

With this purpose in mind, designers take advantage from a wide set of tools and techniques developed to model the user experience.

Among the different tools available (Stickdorn & Schneider, 2012; Stickdorn et al., 2018), I selected three tools that allowed me to integrate data from different sources (auto-ethnography, shadowing and interviews), to map the visitor experience and to gain relevant insights.

The tools described hereafter need to be considered in combination. Indeed, all together they provide a deep understanding of the different personal, environmental and technological dimensions of the visitor experience.

3.2.1 Empathy Map

Empathy Map (EM) was created by Scott Matthews at XPLANE, and then the technique was published by Gray, Brown and Macanufo (2010) as part of a human-centred design toolkit called *Gamestorming*.

The Empathy Map helps in designing business models according to customers' perspectives, by developing a deep understanding of customers' needs, behaviors and preferences.

«An empathy map is a collaborative visualization used to articulate what we know about a particular type of user. It externalizes knowledge about users in order to create a shared understanding of user needs, and aid in decision making» (Gibbons, 2018).

Basically, this technique is used in two stages of the design process, with specific purposes:

- during the ideation phase, to develop innovative design concepts and identify requirements (see for example: Roussou et al., 2013)
- during the evaluation phase, to elaborate data from usability assessment (see for example: Gibbons, 2018).

In order to be a valid technique, the Empathy Map should be created based on empirical data, using data from interviews and observations of the user interaction with the technology (Bratsberg, 2012; Ferreira, Barbosa & Conte, 2016).

Furthermore, an aggregated EM represents a user segment rather than one particular user. It is created by combining multiple individual maps from users who have similar characteristics and can be grouped into one segment.

The original structure of the map (Gray, Brown & Macanufo, 2010) includes six areas: what the users hear and see, say, feel and do. With the diffusion of this tool, other versions were proposed, according to the designers' goals (i.e. ideas generation or usability evaluation).

The following figures show the visual structure of the original map (*Figure 27*) and another version of the map (*Figure 28*).

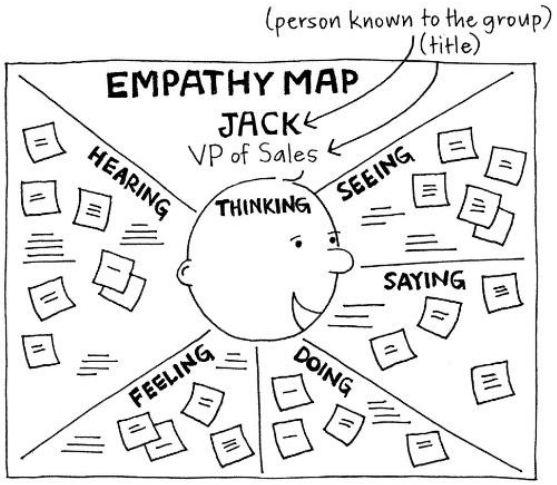


Figure 27: Original structure of the Empathy Map (Gray, Brown & Macanufo, 2010)

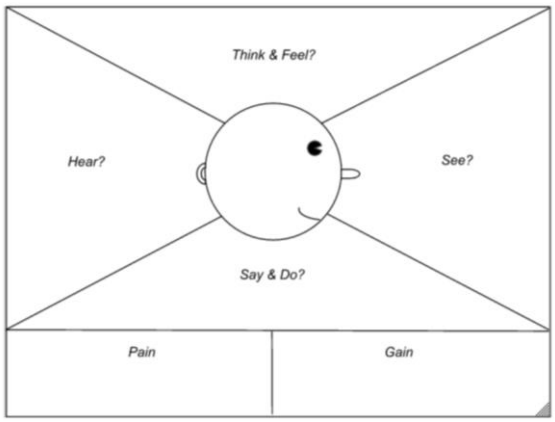


Figure 28: Structure of the Empathy Map used by Bland (2016)

A brief discussion of the visual structure of the above maps is needed. I point out that sketching only the head of the user conveys a vision of the experience as resulting from the "mental" states and cognitive processes. On the contrary, the experience of places and artifacts is a more complex phenomenon that involves all the body, the emotions and the social-cultural aspects of our being in the world.

For this reason, the structure of the EM I use "surround" the person (*Figure 29*) and includes distinctive areas, each of them with specific topics.

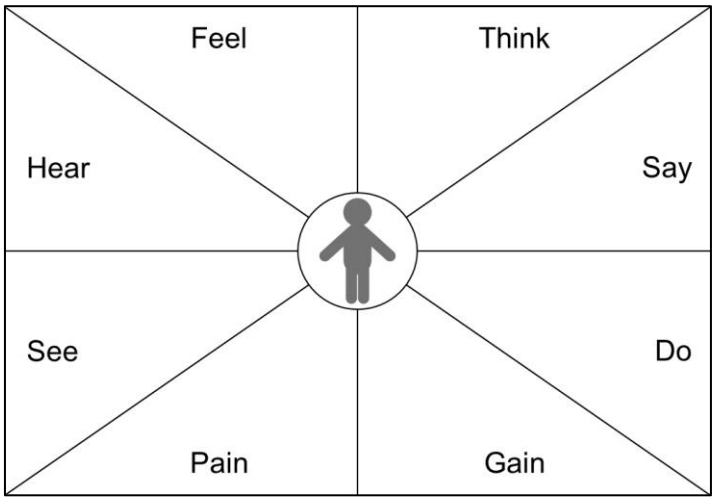


Figure 29: Template of the Empathy Map

Starting from the areas of the map, I decided to tailor them so to reflect the relevant dimension of the visitor experience in the museum mediated by AR and VR technology (*Table 7*).

DO	– routines and habits – previous experiences – what the user does during the interaction
SAY	– Excerpts and relevant use of the words – how the user describes his/herself – suggestions to other people
GAIN	– needs and wishes – ideas to improve the experience
PAIN	– pain points – struggles and barriers
HEAR	– suggestions and opinions heard from others – opinions about the audio description of the tour
SEE	– what the user notices in the surrounding environment – opinions about the visual contents of the tour
FEEL	– feelings and emotions
THINK	– meanings, opinions and visions of the world – reflections arose during the tour

Table 7: Categories of the Empathy Map

To create the EM, I selected the contents from the interview transcripts and included them in the corresponding categories of the map.

I decided to create two different maps to distinguish between two segments: the first-time visitors and repeated visitors (Black, 2005). This allows me to compare the experience of the two groups and identify possible distinctive features.

3.2.2 Personas

Personas are a wide-spread technique originally proposed by Cooper (1999). They are a valuable tool for the user-centred design, because they encourage empathy and facilitate thinking from the user's perspective (Constantine, 2006; Cooper, Reimann & Cronin, 2007).

They are fictional characters representing attributes of real users: from their social and demographic characteristics, to their own needs, desires, motivations and habits (Constantine, 2006; Cooper et al., 2014).

During the design process, Personas support coherent and appropriate decisions while avoiding incorrect generalizations, and convey knowledge about users both within the design team and to various stakeholders (Ferreira, Barbosa & Conte, 2016).

Personas can be used as main reference throughout the design process, from the ideation to the evaluation phase (Cooper, Reimann & Cronin, 2007).

I used Personas both to identify the target users and to analyse how the museum experience changes according to visitors' characteristics.

I created Personas starting from the Empathy Map (Ferreira et al., 2015). But, instead of differentiating Personas based on behavioral patterns as proposed by Cooper (1999), I decided to apply three criteria to create the distinct profiles: a) distinction between first-time visitors and repeat visitors; b) level of familiarity and knowledge about the museum-related contents; c) motivations and outcomes.

The first criterion is a pre-defined distinction made at the beginning to distinguish visitors' segments, while the other two criteria emerged as relevant from the EM.

The structure I used to create Personas includes the following elements:

- fictional name;
- portrait image;
- an excerpt from the interview that summarizes, at a glance and in one sentence, the main characterization of the visitor;
- age, level of education, work domain;
- with whom he/she visits the museum;
- a general description of the profile;
- motivations for visiting the museum;
- benefits gained from the visit experience;
- problems faced and suggestions to improve the tour.

3.2.3 Activity diagram

Applying the Service Design Thinking, it is important to visualize the user experience occurring over time throughout all the steps and the touchpoints, in order to find the gaps between users' needs and available solutions (Stickdorn et al., 2018). With this purpose in mind, I decided to use the Activity Diagram as technique to further elaborate the data.

The Activity Diagram derived from Indi Young's (2008) Mental Model that is an affinity diagram of user's activities and goals, matched with existing tools, services and products. It helps to identify opportunities for designing innovative solutions based on the lack of the existing tools.

A brief discussion about the name of this tool is needed, since the term "Mental Model" seems quite ambiguous. Indi Young (2008) explains the name in this way:

> «Because the Mental Models […] are collections of the root reasons why a person is doing something, they belong to the set of mental representations that are built over a long period of experience and are thus resilient. These Mental Models represent what a person is trying to accomplish in a larger context, no matter which tools are used» (p.11)

In psychology, the term "mental model" is used to define the mental representations of the world that people create, manipulate and use for reasoning and decision making (Johnson-Laird, 1980).

Indi Young refers to the mental model in its broad sense, to define users' representation of a specific activity domain, with the relative objectives, needs and actions.

My adaptation of the original Mental Model is called Activity Diagram because it maps users' activity system related to the museum visit, through the lens of the cultural-historical Activity Theory.

It maps the hierarchical levels of the activities and the mediating tools that are of paramount importance because they enable the visitors to reach their objectives.

In this way, it allows me to evaluate whether the museum's services – not only the Ara as it was tour, but the whole museum offering – meet users' needs and goals.

As shown in *Figure 30*, the structure of the diagram includes an upper part with users' activities grouped based on their goals, and a bottom part with the existing resources that support the related goals.

Figure 30: structure of the Activity Diagram

Using both the field notes from auto-ethnography and shadowing as well as the interview transcripts, the diagram was built through the following steps:

1) identification of the excerpts from interview transcripts and field notes that are related to visitors' activities and goals;
2) rephrasing and summarizing the excerpts in the form of a task (infinite verb and object);
3) grouping the tasks by affinity in vertical columns, on the basis of their similarities;
4) the same process of aggregation is repeated for towers with the same goals, organizing them into goals.
5) organization of the goals in chronologic order;
6) identification of the existing resources that support the activities.

This latter step is essential to analyse the activities as purposeful mediated interactions between the visitors and the museum context, and the artefact ecology that characterized the museum setting as an ecosystem of tools and services.

3.3 Results and discussion

The results discussed hereafter highlight the way the design-for-use that reflects museum managers' and designers' perspectives, fits the design-in-use that reflects the visitor experience (Folcher, 2003).

First of all, I discuss how the Ara as it was tour is intended to enhance museum mission and strategy, by reporting excepts from the interviews with museum curator, project manager and designer (RQ1).

After that, I present the models of the visitor experience and discuss the most relevant results derived from them, in order to address the RQs 2, 3 and 4.

3.3.1 Technology to support museum mission and strategy

The "Ara as it was" project derives from a research carried by the museum to examine the monument and identify traces of the original colours. That study arose the need for disseminating the results among the museum audience. So, since 2014 the event called "The Colours of the Ara Pacis" was organized in special dates, during which a system of light projections showed the altar with the colours[19].

Due to the success of this event, the museum Director and Curators started to think about a way to make this experience more immersive and to better convey the monument-related information.

This is how the "Ara as it was" project was born.

The project objectives are mainly connected with the communication of heritage-related information and with the strategy for audience development.

- **Valorisation of the tangible and intangible heritage**

The monument-related information are connected with both the architecture and decoration of the Ara and the function it served in ancient times.

[19] Sources: http://www.arapacis.it/en/mostre_ed_eventi/eventi/i_colori_dell_ara (retrieved in October 2018).

In *Excerpt 1*, the museum curator explains the need for conveying information about the "tangible" aspects of the monument (its structure and decorations) and the intangible heritage that is related to the context and history of the monument.

> «*We came up with the idea to communicate contents, not only about the colours, but more widely about the monument […] the idea to transform the study, that is a specialized study of the monument, of its contexts, its history, into a narration based on augmented and virtual reality*»
>
> [Excerpt 1 – interview with the museum curator]

The intention of the museum managers was to exploit the results from the specialized study of the monument, to transform the knowledge into a narration based on AR and VR.

AR and VR were considered suitable to provide a reconstruction that is at the same time imaginary and based on a scientific investigation of the colours and the original environment, together with information about the Roman culture (i.e. traditions and rituals, organization of the society, role of the Emperor Augustus etc.).

Considering the curator's intention reported in *Excerpts 2* and *3*, the technology serves as communication medium to better convey such information, compared to text-based interpretative supports.

> «[We expected to convey] a *set of contents, what they* [the ancient Romans] *wore, their attitudes, how a sacrifice was performed and all the things that you learn with difficulty just by reading. In this way* [using the technology] *you immediately absorb them because if you wear the glasses and look around, you will see a series of older people, young people, ministers, magistrates, all of them dressed in a certain way*»
>
> [Excerpt 2 – interview with the museum curator]

«[the goal was] *to relive the Ara Pacis with the sacredness it has […] to revitalize this monument and convey a range of contents related to what it represents, because it is in the middle of the change from the Republic to the Empire, it is the manifesto of the first Emperor who changed the management of the Roman government*»

[Excerpt 3 – interview with the museum curator]

The above excerpts highlight the need for conveying information about the intangible heritage that constitutes the activity context of the monument. In this sense, the technology is intended to show the "invisible" by revealing the original colours, the monument as a culturally developed product and a mediating tool of activities (Kaptelinin, 2011).

- **Affordances of AR and VR**

The connection between tangible and intangible heritage lead to the choice of using both AR and VR, as described by the project manager in *Excerpt 4*. The AR part of the tour aims at providing the visitors with audio and visual contents superimposed on the perception of the monument, while the VR part provides a virtual representation of the monument's activity context.

«*the augmented reality allows to add information to the reality* […] *without the need for a physical intervention on the monument* […] *the virtual reality allows the visitors to be immersed in a reconstructed world, to live the experience of being in front of the Ara Pacis as it was in that time, of being in Rome as it was at that time*»

[Excerpt 4 – interview with the project manager]

Excerpt 4 points out that the features of AR and VR technologies – in another word, the Tool-Object affordances (Kaptelinin & Nardi, 2006) – suggested new possibilities for communicating information and engaging the visitors.

Specifically, the VR technology allows the re-contextualization of the monument into the (virtual) original context. Indeed, the musealization of artifacts always requires a process of de-contextualization from the original context and function, and contextualization into the museum environment for preservation and exhibition purposes (Marini Clarelli, 2005).

Given the technology affordances, the challenge was to implement the technology into the Ara Pacis Museum context. In *Excerpt 5*, the designer specifically mentions the challenge to develop the storytelling that links the different POIs around the monument.

> «[the challenge was to] *identify a series of stories to be mixed so to become the narration of the monument* […] *the words are like an accompaniment to the painting through which the Ara turns in colours, exactly following the narration*»
>
> [Excerpt 5 – interview with the designer]

Unlike the traditional audio-guides based only on audio contents, the Ara as it was integrates the audio description with the virtual scenario and the visual augmentation of the monument. This made the design process more complex and it required a close collaboration between museum curators and design team, to reach the connection between audio and visual contents.

In *Excerpt 6*, the designer reports some observations made during the evaluation phase: she appreciates that some visitors spend time between the POIs looking at the Ara's walls and talking about the reliefs, or continue the visit after they gave back the headset.

> «*the best thing happens when they* [the visitors] *stop and lower the headset to see the reliefs* […] *and they start talking about it* […] *they give back the headset and they come back to see, and this is great*»
>
> [Excerpt 6– interview with the designer]

From designer's perspective, the function of the technology is to enable the observation of the monument and stimulate the discussion among the visitors.

Indeed, one of the main issues when designing ICT for the museum visit is the trade-off between the so called "eyes-up" and "eyes-down" (Spallazzo, Ceconello & Lenz, 2011): museum digital guides should not stimulate the visitors to stare at the mobile screen, preventing them to observe and enjoy the artifacts exhibited.

> «Handheld technology users have been accused of being antisocial, of clogging up a gallery, of only being interested in exhibits covered by the guide, and of only engaging passively with artworks. Screen-based multimedia tours are further accused of distracting the visitor from looking at the exhibit; but do visitors look at exhibits while reading labels? Such criticism personifies handheld technologies as a master rather than a tool» (Tallon & Walker, 2008, p. xxi).

This is a matter especially related to mobile applications with videos and textual contents, when the screen of the device becomes the focal point of visitor attention and the graphic representation acts as a substitute of the original artefact (Vom Lehn & Heath, 2003).

Nevertheless, the same issue can occur when using the headset with virtual and/or augmented contents.

In the case of the Ara as it was, the organization of the tour into POIs and the possibility to low the headset enable the trade-off between the vision of the contents and the authentic observation of the monument.

- **Target visitors and audience development strategy**

Regarding the target visitors, the tour purposely addresses the non-expert audience providing a first approach to the monument, in the attempt to stimulate visitors' curiosity to deepen the knowledge and get further information.

Moreover, the project represents a strategy of audience development with the aim of engaging people interested in new technologies, as mentioned by the curator in the following excerpt.

> «*A technology, when it is created, creates its own public and so we took the opportunity to engage them*»
>
> [Excerpt 7 – interview with the museum curator]

Excerpt 7 highlights the intention to use the technology as an engagement factor, by providing potential and repeat visitors with new forms of interaction with the museum collection (Black, 2005; Tallon & Walker, 2008).

In such perspective, the technology serves both as an attractor and a sustainer (Edmonds et al., 2006): it can attract the audience who recognize the potential value of the technology in the first place, and then it can sustain their interest during the visit (Ciolfi & Bannon, 2002; Sandifer, 2003; Heath & Vom Lehn, 2008).

3.3.2 Empathy Maps of the museum visit experience

The Empathy Map integrates all the dimensions of the visitor experience as reported by participants during the interviews. As mentioned before, I created two Empathy Maps to distinguish between first-time visitors and repeated visitors (Black, 2005).

Several insights can be derived from the Empathy Maps, regarding the benefits as well as the weakness of the Ara as it was tour.

First time visitors

FEEL

- I like it (the exhibition), I was impressed by it [G06]
- I was curious to see the exhibition in this way [C02]
- I was curious to see how the exhibition is organized [C11]
- I was curious to see this (exhibition) since I have already seen the (exhibition at) Fori Imperiali [C12]
- We were attracted by this kind of presentation [C08]
- We liked the idea of understanding the artistic composition, architecture (of the Ara) and especially the figures (represented on the marbles) [C09]
- The voice of the actor is moving [C12]
- I felt an emotion I have never experienced before [C02]
- The narrations are well done, the quality of the audio is high and the voices are known, I recognized the voice actor who dubs Russell Crow [C11]
- It was a particular sensation when I felt immersed in that reality, like there were people around us [C08]
- (during the VR) I felt like I was on the helicopter and I was surprised because I didn't expect it [C12]
- For me, it is fascinating to see what has been left by characters of the history [C11]
- I got excited when I felt close to such ancient things [C02]

HEAR

- Narrations are well done since they are not too long and concise [C02]
- Narrations are suitable for this kind of visit [G03]
- Someone told me that (the exhibition at) the Fori Imperiali is more pervasive [C02]
- In my opinion, the narrations provide the right balance between information and show [C12]
- Narrations are very clear [C08, C09, C13]

THINK

- When you visit ancient Greek and Roman sites, you often overlook that they were coloured, so I think it is important to convey the right vision of the monument [C06]
- I expected to better understand the context, compared with what I can understand by myself, with my imagination [C02]
- I was surprised to see that expanse (of green fields) that is now full of buildings [C02]
- (when I learnt about the exhibition) I understood it is particular and interactive [C02]
- Since portions of the marbles are missing and we still don't know what they represent, it was nice to imagine what they could conceal [C11]
- We Romans have no idea how Rome was in ancient times, so I think that if you like Rome and you like antiques, you should try this experience [C11]
- If there is the guide, I will not be so impressed because of the different visual effect [G06]
- It allows you to go back in time [C06]
- I am culturally enriched [C06]
- (During the VR) It seems I was there with them [C02]
- Augustus is a great historical figure, and thinking that he tried to bring peace can be useful to the people who nowadays have to make decisions [C11]
- I am quite disappointed [G03]
- I am interested in technologies applied to cultural heritage [C06]
- This system is effective, fun and pleasant [C02]
- It is a satisfying and interesting experience [C06]
- Everything was positive [C12]
- I think the tour does not provide too much information because they (museum curators) do not want to overload the visitor [C06]
- It was a pleasant surprise [C11]

SAY

- I define this exhibition as cold and pedantic [G03]
- I am not interested in this kind of events [G03]
- It is not often that I am here in Rome, there was such possibility (to visit the museum) and I said "let's see how it was" [C11] I suggest to find the time to
- I am not so prone to museums, I prefer live performance like theatre [C08]
- It is something completely different from the other museums you usually visit [G06]
- I am not familiar with technology [C02]
- I recommend it to those who have never done it [G06]
- There was such possibility (to visit the museum) and I said "let's see how it was" [C11]
- I suggest to find the time to come and try it [C11]
- It is for sure an experience to repeat, maybe in other domains or for other monuments [C11]

SEE

- (I like to) see the colours, the Romans, the live presence of people, the clothes of that time, the reconstruction of the surrounding landscape [C08]
- The virtual reality part (of the tour) is more engaging due to the different visual effect, because you have a 360° view [G03]
- It gives you an authentic vision of the monument like it appears when it was built [C06]
- We would like to bring our son, but it is not possible because he is under thirteen years old [C11]
- I liked to see the pieces of monument turning colour so I can distinguish the figures [C13]
- The duration (of the tour) is appropriate because the position is not comfortable [C12]
- When you live in Rome, there are lots of interesting things to see, and this is one of them [G06]
- We did not understand where to go (after the VR part) [G06]
- 3D devices make me uncomfortable, I feel a sensation like loss of balance [G03]
- It allows you to see how Rome was [G06, C11
- I had troubles ttying to activate the contents [C13]
- (The application) got stuck [C02]
- I had troubles trying to sharpen (the images), then I said "well, that's ok" [C11]
- Since I am not informed, sometimes I have troubles linking the narrations I listen with what I see [G03]
- The headset made me uncomfortable, it made me dizzy [C02]
- Images were quite blurry [C02, C12, C09, C13]

PAIN

Do

- We used virtual and augmented reality during the Expo and at the Padro Museum [C08]
- I have already used innovative technologies at the Augustus court [C12]
- I had to change the device [C02]
- You can understand what you did not know before [G06]
- We used this technology at Fori Imperiali [C09, G03]
- We decided to visit the museum when we passed in front of it [C13]
- It makes you absorbed, it allows you to join the atmosphere of ancient times, it helps to better understand what you read on books [C02]
- I used the augmented reality in Paris [C06]
- I felt immersed into the monument [C13]
- You visit the monument in a more active, fun and exciting way [C08]
- The videos allow me to reflect about what I see and looking for it on the walls (of the Ara) [C11]
- With a traditional visit, you can see only the sculpture and you cannot distinguish the different figures [C13]
- I acquired information and I enjoyed it more because the video showed me the details I would not recognized if I visited the museum by myself [C12]
- Now we want to see the (exhibition at) Fori Imperiali that is similar [C02]
- We appreciate the quality of the contents and the structure (of the tour) because it is not too long [C11]
- Now I have a clear understanding of the monument as it was [C06, C09]
- I would like an increased virtual immersion to intensify the fascination [C02]
- It allows you to understand the difference between what we see today and how it was in that time, that is totally different from the current context [C08]
- I would like to walk within (virtual) scenarios [C02]
- I would like to use this system in other museums and situations like this [C02]
- Of course, virtual reality helps our imagination more than anything else [C11]

GAIN

Repeated visitors

FEEL

- I am very glad I came here [G07]
- Reconstructing something that is impossible to see to naked eye, is very interesting and exciting [C01]
- Now I am curious to see the Mausoleum (of Augustus) [C10]
- I felt fascination, astonishment, surprise [C01]
- It is always a great emotion when I visit the Ara Pacis [G07]
- I loved the sensorial immersion, the subjective participation to the ceremony [C07]
- I am always moved when I pass in front of, for example, Terme di Caracalla and I think there were Romans with the toga [G07]
- I was curious to see the 3D with the colours [G01, G05]
- I was curious to see augmented and virtual reality applied to the architecture (of the monument) [C07]
- We were curious because it is something new [G04]
- Of course, seeing things with colours, as they were, make me feel a sort of emotion [C04]
- It was surprising [G04]

THINK

- Unfortunately, today Campo Marzio is full of buildings [C04]
- I think this is the future of the cultural heritage fruition [C01]
- I have never looked at the issue of the colour [C10]
- The contents are simple because they need to be understood by everyone, since this is a place open to the public with different cultural background [C05]
- Ancient world is very similar to the current world, the difference is only the technology [C05]
- If I bring my students to the museum, they will be moved by this technology, while usually at the museum I need to explain and they get bored [C10B]
- I understood that Roman society at that time had a complex structure [C03]
- The technology enhances the visit that, otherwise, could result in a boring experience [C10]
- I think this technology is not mature, it is still under development [G08]

SAY

- It was a pleasant experience, I recommend it [C03]
- I am open to (experience) new technologies [C01]
- The Ara Pacis is one of the best monuments in Rome [C05]
- We already knew the monument and its history [C05]
- I can describe it (the visit) as a journey into the past we belong to [C04]
- We are interested in the architecture of the Ara Pacis and the history it represents [C07]
- I am very demanding [C07]
- It was worth it [G07]
- It was interesting, exaustive, pleasant and engaging [G04]
- I am interested in the history of Rome [G07]
- It is extraordinary [C10A]
- We are interested in Arts in general [G02]
- An adjective that can summarize the visit is phantasmagorical [C05]
- We love history [C07]
- It is an interesting and informative experience [C01]
- It is interesting and fascinating [G01]
- It was very interesting [C10B]
- To deepen (the knowledge) there are thousand ways, meanwhile you have to start from something to approach, then you can follow up [G02]
- It is a very fantastic resource [C10B]
- I can describe the visit as interesting, innovative and curious [C07]

HEAR

- One of my friends said that it is a new and unique way to see the Ara Pacis [C03]
- The contents are narrated by the dubber I recognized [G01]
- My friend invited me (to visit the museum) [G01]
- In my opinion, the narrations are too concise [C10A, C10B]
- The contents are too superficial [C01, G02]
- The narrations are well done [C04, G01]
- The narrations are clear and exhaustive [G04]
- The narrations are clear and interesting [C03, G07, G08]
- One of my friends told me about this exhibition [C01]
- The narrations are too quick, they do not allow you to focus on what you listen [G04]
- The contents are well done because they are comprehensible by everyone and meticulous regarding the use of words [C05]

SEE

- We are used to see the Colosseum, we imagine it without colours, but it was coloured [C03]
- Who is not used to see ancient Rome with colours, here it is [C05]
- It is, for sure, very different from what you usually see [G01]
- These technologies help you to better visualize how something was [G08]
- Our attention was attracted by the advertisements who are disseminated in Rome [G04]
- I turned my head and I saw the landscape and the Romans [C01]
- It is interesting to see the context and the ceremony [C07]
- I saw Augustus who invited me to the ceremony [C07]
- I felt the best emotion when I saw the relief with the acantus leafs, the flowers and the animals [C04]
- It is interesting to see how the missing parts (of the marbles) are completed [G04]
- It is open only during the weekend [C03]
- The images were blurry [C04, C03, C07, G01]
- Seeing the colours of such kind of monuments helps you to understand how they really looked like [C10A]
- Holding the headset makes you tired [C04, C10A, G05]
- Without the (virtual) reconstruction, you cannot perceive the chromatism and the ornaments [C03]
- I experienced nausea, like on the boat [G07]
- Through the glasses I can see how the Ara Pacis really was [G01]
- I am an animal-rights activist and I didn't like the animal sacrifice (shown in the video) [C04]
- The headset is not comfortable [C04]
- It produces eye strain [C01, G01]
- I saw the reality in the time of ancient Rome [C01]
- The contents are too simple, but they are suitable for people who are in a rush [C01]
- The tour is too short [C05]
- The quality and resolution of the images could be improved [C10]
- Since the exhibition is open during the evening, I cannot bring my students to the see it [G07]

PAIN

Do

- It is our habit to visit exhibitions, guided tours around Rome, we do it a lot with some associations we are member of [G02]
- I have the (virtual reality) headset at home to play [C10A]
- Two years ago, I used this technology in Valencia [C04]
- Some years ago, I visited an exhibition with the coloured statues at the Vatican Museums [C05]
- I used innovative technologies at the Domus Aurea [C10A]
- I decided to come to accompany my mother [C10A]
- I visited the Ara Pacis more than once [G01]
- I think this is the fourth time I come to the Ara Pacis [G07]
- We read the information described on the panels [G02]
- I already visited the museum [C10A]
- I was quite informed because I searched for information and I saw several videos on the web [G07]
- It made us culturally enriched [G04]
- I learnt new things [C03]
- It gave us a new way to approach the arts [G04]
- It is interesting for two reasons, because it uses an innovative technology that is not Pokemon-go or other similar fooleries, and because it shows (the colours) without the need for painting the Ara [C05]
- I reinforced my knowledge about history [G07, G08]
- It is interesting but only if you already visited the museum and you are informed [G05]
- I was impressed by the work carried out to reconstruct the missing parts (of the marbles) [C10A]
- It engages also the lazy people who might not pay attention to many things [G04]
- It allowed me to deepen the knowledge about the history, arts and tradition of ancient Rome [C01]
- It makes people in contact with the culture, even those who are not interested [C10A]
- You have to do it if you are not an historian or an archaeologist, you are culturally enriched [G02]
- It allows you to understand that it (the monument) is not a white boring and incomprehensible thing [C10A]
- Now I understand much more about the Ara Pacis and the reasons why it was built [G01]
- It allows to appreciate the Greek-Roman culture even if you have not a certain cultural background [C05]
- I would like to see the internal part (of the Ara) in the same way [C05]
- This solution should be applied to all the monuments of Rome, to make the history more understandable even for those who are not familiar with it [C01]
- It could use Augustus to accompany you during the visit and he can explain next to you [C07]
- The narrations could be improved and enriched [C10A]
- I think it needs to be further advertised [C03]

GAIN

- **Motivations towards the Ara as it was tour (RQ2)**

First of all, the EM provides information about the motivations for visiting the museum and attending the Ara as it was tour.

The intention of the museum curator was to exploit the technology as an attractor for the audience. Indeed, as reported in *Excerpt 8-9-10*, curiosity towards the technology represents the engagement factor that drives visitors to the museum, especially those who already visited it.

> «*I was curious to see the exhibition in this way*»
>
> [Excerpt n.8 - visitor interview C02]
>
> «*We were attracted by this kind of presentation*»
>
> [Excerpt n.9 - visitor interview C08]
>
> «*We were curious because it is something new*»
>
> [Excerpt n.10 - visitor interview G04]

Visitors decided to visit the museum because they were curious to experience the tour with AR and VR technologies, expecting to enjoy something new and interesting.

Since most of the participants (16 up to 21) are repeated visitors, this means that technology can be used as a source for sustained engagement, defined as a relationship establishes with a particular museum that is maintained with varying levels of connection through different life stages (Everett & Barrett, 2009).

By providing a new way to visit the museum, the technology is exploited to develop museum audiences as long term, regular users rather than one-off visitors (Black, 2012).

- **Mediation of the technology (RQ3)**

The value of the Ara as it was relies on the possibility it offers to both improve the visual perception of the monument and to immerse the visitors into its original context. These two functions can be described using the metaphor of the time machine.

> «The idea of a time machine has triggered people's imagination for many years, with different fantasies about how such a thing would look and work, and especially what experiences of ancient and future times it would give us. Virtual reality environments that present the past might be thought of as contemporary time machines» (Mosaker, 2001, p.1).

The VR part of the tour provides the experience of immersion and the illusion of being there, in the ancient Campo Marzio attending the ceremony with ancient Roman people. In the following excerpts, visitors describe the way they experience the immersion into the virtual scenario.

> «*I saw the reality in the time of ancient Rome*»
>
> [Excerpt n.11 - visitor interview C01]
>
> «*It allows you to go back in time*»
>
> [Excerpt n.12 - visitor interview C06]
>
> «*I turned my head and I saw the landscape and the Romans*»
>
> [Excerpt n.13 - visitor interview C01]
>
> «*I got excited when I felt close to such ancient things*»
>
> [Excerpt n.14 - visitor interview C02]
>
> «*I saw Augustus inviting me to the ceremony*»
>
> [Excerpt n.15 - visitor interview C07]
>
> « [I like to] *see the colours, the Romans, the live presence of people, the clothes of that time, the reconstruction of the surrounding landscape*»
>
> [Excerpt n.16 - visitor interview C08]
>
> «*I love the sensorial immersion, the subjective participation to the ceremony*»
>
> [Excerpt n.17 - visitor interview C07]

Specifically, *Excerpts 15, 16* and *17* can be referred to the social presence that is the perception of "being there with others" (Biocca, Harms & Burgoon, 2003; Nowak, & Biocca, 2003; Talamo & Zucchermaglio, 2003), besides the others are actors in a virtual representation. Visitors experienced the illusion of going back in time, of being in the scenario surrounded by people.

Note that in this case, because the visitors do not interact with the actors represented in the video, social presence is not *copresence* that occurs when people actively perceive others and feel that others are actively perceiving them (Nowak & Biocca, 2003).

Considering the relationship between the two technologies integrated into the tour, they enable two different perceptions: the VR is an effective tool to represent the original context and function of the monument, while the AR provides the fascinating visualization of the original colours.

In particular, the augmentation with the colours enables the visitors to see the monument as it was in its former glory. In this way, the technology provides the right vision of the monument, as mentioned in the following excerpts.

> «*When you visit ancient Greek and Roman sites, you often overlook that they were coloured, so I think it is important to convey the right vision of the monument*»
>
> [Excerpt n.18 - visitor interview C06]
>
> «*Seeing the colours of such kind of monuments helps you to understand how they really looked like*»
>
> [Excerpt n.19 - visitor interview C10A]

Excerpt 18 and *19* are related to the aesthetics of the monument, but the function of the tour does not rely only on the visual augmentation.

Indeed, *Excerpt 20* and *21* highlight that the visual augmentation linked with the audio description allows the visitors to focus the attention on the details and identify the different elements of the reliefs.

> «*I liked to see the pieces of the monument turning colours so I can distinguish the figures*»
>
> [Excerpt n.20 - visitor interview C13]
>
> «*the video showed me the details I would not recognize if I visited the museum by myself*»
>
> [Excerpt n.21 - visitor interview C12]

The technology supports the visitors in focusing the attention and interpreting what they observe on the monument, by proposing some key-concepts related to the socio-cultural context of the monument.

By representing its original appearance and function, the technology acts as a bridge between the visitors' activity contexts and activity context of the monument (Kaptelinin, 2011).

- **Outcomes of the visit experience (RQ3)**

The mediation of the technology determines the benefits the visitors gain from the visit experience.

The outcomes are not only related to the acquisition of specific knowledge about the monument (i.e. its function, architecture and decoration), rather they include a general cultural enrichment, pleasure and enjoyment, and the will to live similar experiences in other museums and heritage sites (Hooper-Greenhill, 2006).

The following excerpts point out the increase in knowledge and understanding as reported by the visitors.

«*It allowed me to deepen the knowledge about the history, arts and tradition of ancient Rome*»

[Excerpt n.22 - visitor interview C01]

«*I reinforced my knowledge about history*»

[Excerpt n.23 - visitor interviews G07, G08]

«*Now I have a clear understanding of the monument as it was*»

[Excerpt n.24 - visitor interviews C06, C09]

«*It gave us a new way to approach the arts*»

[Excerpt n.25 - visitor interview G04]

As suggested by Hooper-Greenhill (2004), knowledge and understanding can be subject-specific as well as they can result in making connections between different domains.

Indeed, the tour provides the visitors with stimulus for reflecting about other times and for making comparison with the current situations (Sheng & Cheng, 2012).

The following excerpts highlight some forms of critical thinking and questioning stimulated by the tour (Black, 2012), and the meaning making in terms of connections (Hein, 2006).

«*Augustus is a great historical figure, and thinking that he tried to bring peace can be useful to the people who nowadays have to make decisions*»

[Excerpt n.26 - visitor interview C11]

«*Unfortunately, today Campo Marzio is full of buildings*»

[Excerpt n.27 - visitor interviews C04]

«*Ancient world is similar to the current world, the difference is only the technology*»

[Excerpt n.28 - visitor interview C05]

«*I understood that Roman society at that time had a complex structure*»

[Excerpt n.29 - visitor interview C03]

Another relevant outcome reported by the visitors is the desire to live similar experiences in other museums. The positive experience lived at the Ara Pacis museum improves the interest and constitutes the prior knowledge that reinforces the motivation, benefiting other museums and heritage sites (Rennie & Johnston, 2007; Falk & Dierking, 2016).

> «*Now we want to see the* [exhibition at] *Fori Imperiali that is similar*»
>
> [Excerpt n.30 - visitor interview C02]
>
> «*I was curious to see this* [exhibition] *since I have already seen the* [exhibition at] *Fori Imperiali*»
>
> [Excerpt n.31 - visitor interview C12]

Such results about the benefits gained from the visit experience support the need for considering all the possible and unexpected outcomes which range from understanding, value, reflection, meaning making and the desire to learn more (Hooper-Greenhill, 2006; Black, 2012).

- **Problems and limitations of the device (RQ3)**

Besides the positive aspects of the experience, some problems are reported by participants, mainly in relation to usability and ergonomics. Indeed, some visitors pointed out the low resolution that provides blurry images, and the uncomfortable device that needs to be hold for all the duration of the content.

It is well recognized that in case of mixed reality technology, poor quality of the images, eye strain, heavy headset and the need to maintain uncomfortable positions negatively affect the user experience (see for example: Dünser, & Billinghurst, 2011; Dünser et al., 2007; Gabbard & Hix, 2001; Kaufmann, & Dünser, 2007; Ko, Chang, & Ji, 2013; Olsson, 2013; Pribeanu, Balog, & Iordache, 2008; Sutcliffe, & Gault, 2004).

Furthermore, some visitors described symptoms like nausea, dizziness, loss of balance and a general discomfort, which are related to cybersickness that is the side effect of the virtual reality (LaViola Jr, 2000; Burdea & Coiffet, 2003).

3.3.3 Visitor profiles as Personas

Starting from the Empathy Maps, four Personas were created according to the differences in visitors' profiles, motivations and benefits gained from the experience: *Lorenzo* and *Nicola* are the first-time visitors, while *Teresa* and *Rebecca* represent the group of repeated visitors.

Through the Personas, I can analyse how differences in visitors' characteristics that Falk and Dierking (2016) define as personal context, determine different visit experience.

Lorenzo is an art enthusiastic and he already used mixed reality technologies in other museums; besides the problems occurred during the tour, he appreciates the experience of educational leisure.

Lorenzo «*It allows you to join the atmosphere of ancient times*»

 [20]

Age: 45 years old
Education: Master degree
Work domain: Insurance
First touchpoint: advertising posters
Resident in Rome
First visit, with his wife

Profile

He loves Rome and he likes visiting museums and heritage sites during the free time, with his family.
He already used immersive technologies in other museums, both in Rome and abroad, and he appreciated their value for the museum visit experience.

Benefits

He values the possibility offered by the technology to see the monument in its

Motivations

He wanted to have a pleasant evening with his wife, doing something interesting.
He saw advertisement about the Ara as it was on posters disseminated around the city.
He was curious to visit the museum using an innovative application, expecting to see the original context of the monument, in interactive way.

[20] Source: https://pxhere.com/en/photo/1040941

former glory, by augmenting the marble with the colours and reconstructing the missing parts of the reliefs. Furthermore, the tour allowed him to focus the attention of the details, and better understand the artistic composition and the figures represented. He reflected about the Campo Marzio, comparing its ancient landscape (an expanse of green fields) to the current context that is full of buildings. Having pleasant experienced this technology, he would like to visit other museums in the same way.	Since there are a lot of interesting things to see in Rome, he was engaged by the technology. **Pain Points** - Lorenzo and his wife would like to bring their son with them, but it is not allowed because he is under 13 years old. - During the tour, he had to change the device because it crashed. - He tried to sharpen the images that seem quite blurry, with no effect. - He thinks the duration of the tour is appropriate because using the device is not comfortable for a long time. - He prefers more detailed contents, but he acknowledges that the simple and concise information are designed so to not overload the visitor.

Lorenzo is a frequent visitor who often visits museums and heritage sites to spend the free time with his family. He is familiar with AR-VR technologies used in other museums and he was curious to experience the Ara as it was tour.

Besides he faced the malfunction of the device and the blurry images, he appreciates the mediation of the technology that augments the vision of the monument and focus the attention on monument's details.

Unlike *Lorenzo*, **Nicola** is an occasional visitor not so interested in museums, because he prefers other cultural leisure activities such as attending to theatre performance. He came to the Ara Pacis Museum because his friends organized the visit. What he appreciates is the fascination and surprise effect, the show experience created by the tour.

Nicola *«I am not so prone to visiting museums, I prefer live performance like show at the theatre»*

 [21]

Age: 40 years old
Education: PhD
Work domain: news media
First touchpoint: friends
Tourist from Palermo
First visit, with a group of friends

Profile

Nicola is not interested in museums and history, because he prefers to attend live performance at the theatre.
He is in Rome for vacation, and he walk around the city with his friends who live in Rome. They organized the visit to the Ara Pacis museum.
He is not familiar with technology and he have never used augmented/virtual reality applications.

Benefits

He considers the experience as a pleasant surprise that culturally enriched him.
He enjoyed the immersion into the original context of the monument, when he felt like he was very close, like there were people around him.
When he visits ancient Roman and Greek sites, he overlooks they were coloured. So, he thinks it is important to convey the right vision of the monument.
He enjoyed the tour because it provides the right balance between information and show, through an engaging and fascinating experience.

Motivations

The decision to visit the museum was made by his friends, and he was suggested to join.
He expected to experience something different compared to other museums and traditional visit modality.

Pain Points

- He found not so easy to activate the AR contents by finding the right position in front of the monument's walls.
- He experienced dizziness and a general discomfort using the headset.
- He would like an increase of virtual immersion to intensify the fascination, for example by walking within virtual scenarios.

[21] Source: https://www.pexels.com/photo/man-in-white-dress-shirt-sitting-on-black-rolling-chair-while-facing-black-computer-set-and-smiling-840996/

He appreciates the clear narrations and the voice of a famous dubber that is moving.	

Comparing the profiles of *Lorenzo* and *Nicola*, the connection between personal context and outcomes is evident since Lorenzo is a content-oriented visitor while Nicola is a show-oriented visitor.

Lorenzo is passionate about arts and his main motivation is learning and discovery, therefore the benefits he gains from the visit are related to the acquisition of knowledge about the monument.

Nicola is not interested in visiting museums and what he appreciates of the Ara as it was tour is the fascination and the enjoyment of visiting the museum in a very different way compared to the traditional visit modality. This visitor profile is similar to the "experience seeker" proposed by Falk and colleagues (Falk, Moussouri & Coulson, 1998; Falk, Heimlich & Bronnenkant, 2008; Falk, 2009; Falk, 2013).

Both the learning-oriented and the enjoyment-oriented visitors appreciate the Ara as it was, since it improves the traditional interpretative tool that is the audio-guide with a virtual scenario and the visual augmentation of the monument.

The other two Personas, *Teresa* and *Rebecca*, represent the repeated visitors (Black, 2005).

Teresa is a teacher and she was curious to visit again the Ara Pacis Museum using the technology. She notices some limitations in the organization of the tour, but she values the project because it provides a useful tool suitable for non-expert visitors.

Teresa *«The visit is a journey into the past we belong to»*

[22]

Age: 55 years old
Education: Master degree
Work domain: Education
First touchpoint: newspaper
Resident in Rome
Repeat visitor, with his son

Profile

She teaches in a high school, and she loves arts and history.
She often visits heritage sites organized by the association she is member of.
Sometimes, she organizes school trip to museums, but the students usually get bored.

Motivations

She has already visited the Ara Pacis Museums more than once, and she decided to visit it again because of the Ara as it was tour she read about on the newspaper.
She considers the Ara Pacis one of the best monuments in Rome, and she wanted to try this visit modality expecting to experience something new.

Benefits

She considers the Ara as it was an interesting and valuable project, and such solution should be applied to all the monuments of Rome, in order to better understand and appreciate the heritage, even if you are not a historian neither an archaeologist, with a certain cultural background.
She got excited when she was immersed in that reality, joining the ceremony and feeling astonishment, fascination and surprise.
The tour allowed her to deepen the knowledge about the history and the culture of ancient Rome. She reflected about the complex organization of the society at that time. She also appreciates the augmentation of the monument and the reconstruction of what is not visible to naked eyes.

Pain points

- Cradling the headset made her tired and produced eye strain.
- Since the tour is available only in the evening, she cannot organize a school trip to bring the students to the museum.
- She would like to use the application to see the internal part of the monument.
- She considers the contents as too simple and sometimes superficial, according to her interest and need.

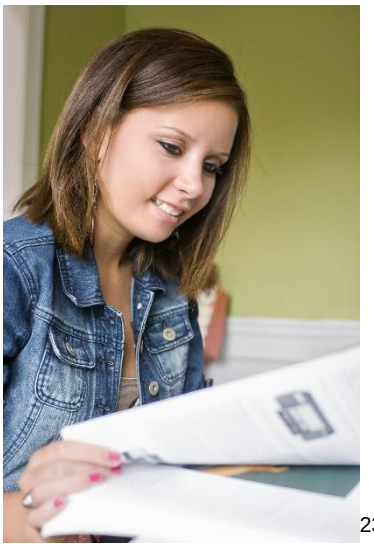
[22] Source: https://meridianplanners.com/teacher-2/

She considers the narration well done because they are comprehensible by everyone and meticulous regarding the use of the words.

Teresa is a frequent visitor with a passion for arts and history. The museum visit represents both an activity to spend the free time, and a teaching practice.

Rebecca is an expert visitor who works in the domain of cultural heritage and she is particularly interested in the application of innovative technology to museums. She is quite disappointed by the quality of the tour but she recognizes the relevance of the research performed by the museum – to identify traces of the original colours and to interpret the reliefs from iconography perspective.

Rebecca *«I am expert and I am very demanding»*



Age: 30 years old
Education: PhD
Work domain: Cultural heritage
First touchpoint: word-of-mouth
Resident in Rome
Repeat visitor, with a group of relatives and friends

[23] Source: http://www.freestockphotos.biz/stockphoto/15997

Profile	Motivations
She studied Art History and she works in the domain of cultural heritage. She loves the history of Rome, and she interested in the application of innovative technologies to the cultural heritage. She used such kind of technologies in other museums and archaeological sites, both in Rome and abroad. She usually searches for information before the visit, so to be informed and better enjoy the visit.	One of her friends told her about the exhibition. Since she has visited the Ara Pacis museum several times, and she already used mixed reality technologies in other museums, she was very curious to see how AR and VR technologies are applied to this kind of monument. She thinks this is the future of the museum experience.
Benefits	**Pain Points**
She was impressed when she saw the Ara with colours, especially the relief with the acantus leafs. She really appreciates the work carried out by the museum, to recreate the original context and to reconstruct the missing parts of the reliefs, without the need for an intervention on the monument. She likes the project because it makes people in contact with the culture, even if they are not experts or not so interested in ancient Roman Arts. The technology is valuable because it allows you to perceive the chromatism and the ornaments of the monuments.	- She thinks this technology is not mature, it is still under development and it needs further improvements. - She considers the narration as too concise and the tour as too short, they should be improved and enriched. - Since she is an animal-rights activist, she was impressed by the sacrifice shown by the video.

Both *Teresa* and *Rebecca* are repeated visitors with prior knowledge about the museum-related content. For this reason, they consider the tour too simple and they would like to have rich and detailed contents.

The key concept to understand such profiles is the professional vision (Goodwin, 1994): «professional vision consists in socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group» (ivi, p.606). Professional vision emerged from three main practices: a) *coding*, to transform the observed

phenomenon into an object of knowledge; b) *highlighting*, to focus the attention on the salient features of the phenomenon; c) producing and articulating material representations.

It is well known that prior knowledge about the museum-related content impacts the visitor experience (Black, 2005; Caru & Cova, 2005; Taheri, Jafari & O'Gorman, 2014; Falk & Dierking, 2016), but I suggest that professional vision is a more useful concept to describe how the personal background and expertise determine both the expectations and the evaluation of the visit experience.

Rebecca uses the visit as an activity to develop her knowledge/skills and practice her professional vision. Given the expertise, she recognizes the need for improving the organization of the tour and providing detailed contents, as well as she acknowledges the complex study that lead to the tour design.

The professional vision is relevant also in the case of *Teresa*, who is a teacher. Besides she needs more detailed information to deepen the knowledge about the monument, she considers the narrations as valuable because they are designed to be clear for a wide audience with different cultural backgrounds.

The design of contents for a wide audience, of course, requires the balance between simplicity, with the risk however of saying too little and being superficial, and complexity that tends to redundancy, potentially boring the visitors with content that is too elaborate or specialised (Cultraro, Gabellone & Scardozzi, 2009).

This is more important in the case of repeat visitors, who may be already informed about the museum-related content and they want to learn more.

The solution to this fundamental issue could be the design of different contents the visitors can select according to their prior knowledge and visit agenda (Falk & Dierking, 2016), interests and learning style (Black, 2012).

3.3.4 Activities and tools of the museum visit experience (RQ3 – RQ4)

The Activity Diagram is particularly suitable to depict the visitor journey along with the digital and physical touchpoints, throughout the whole visit experience.

Figure 31 shows the diagram in its totality, while *Figure 32* is the legend to identify the sources of data and the solutions of the content map.

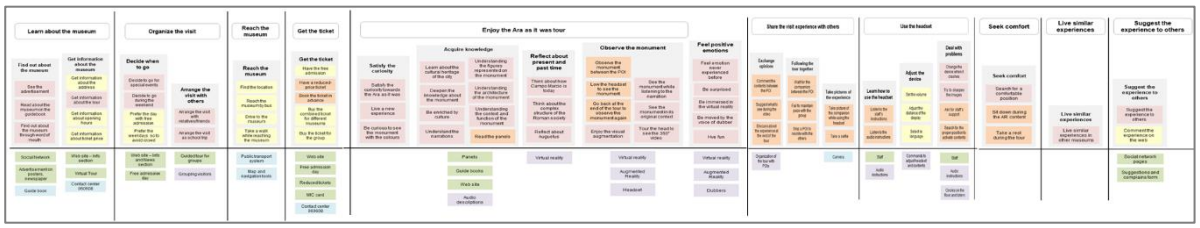


Figure 31: Image of the Activity Diagram

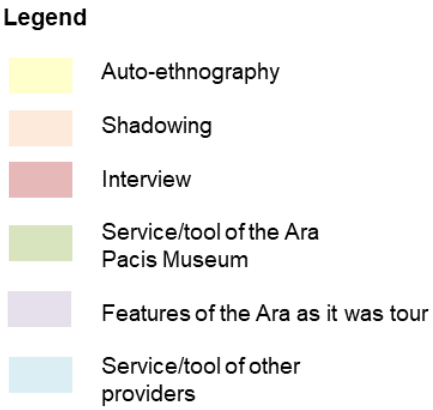
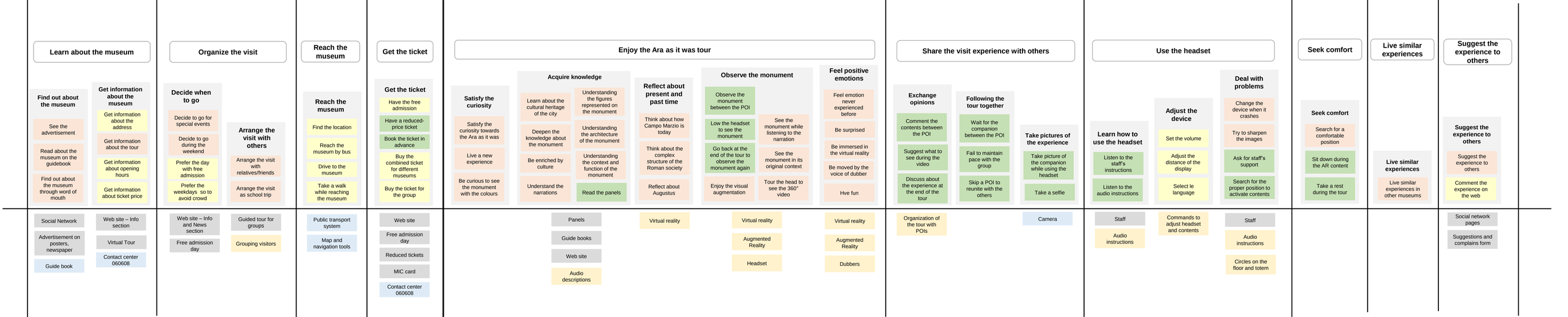


Figure 32: Legend of the Activity Diagram


Learn about the museum
Find out about the museum
See the advertisement
Read about the museum on the guidebook
Find out about the museum through word of mouth
Get information about the museum
Get information about the address
Get information about the tour
Get information about opening hours
Get information about ticket price
Social Network
Advertisement on posters, newspaper
Guide book
Web site – Info section
Virtual Tour
Contact center 060608
Organize the visit
Decide when to go
Decide to go for special events
Decide to go during the weekend
Prefer the day with free admission
Prefer the weekdays so to avoid crowd
Arrange the visit with others
Arrange the visit with relatives/friends
Arrange the visit as school trip
Web site – Info and News section
Free admission day
Guided tour for groups
Grouping visitors
Reach the museum
Reach the museum
Find the location
Reach the museum by bus
Drive to the museum
Take a walk while reaching the museum
Public transport system
Map and navigation tools
Get the ticket
Get the ticket
Have the free admission
Have a reduced-price ticket
Book the ticket in advance
Buy the combined ticket for different museums
Buy the ticket for the group
Web site
Free admission day
Reduced tickets
MIC card
Contact center 060608
Enjoy the Ara as it was tour
Satisfy the curiosity
Satisfy the curiosity towards the Ara as it was
Live a new experience
Be curious to see the monument with the colours
Acquire knowledge
Learn about the cultural heritage of the city
Deepen the knowledge about the monument
Be enriched by culture
Understand the narrations
Understanding the figures represented on the monument
Understanding the architecture of the monument
Understanding the context and function of the monument
Read the panels
Panels
Guide books
Web site
Audio descriptions
Reflect about present and past time
Think about how Campo Marzio is today
Think about the complex structure of the Roman society
Reflect about Augustus
Virtual reality
Observe the monument
Observe the monument between the POI
Low the headset to see the monument
Go back at the end of the tour to observe the monument again
Enjoy the visual augmentation
See the monument while listening to the narration
See the monument in its original context
Tour the head to see the 360° video
Virtual reality
Augmented Reality
Headset
Feel positive emotions
Feel emotion never experienced before
Be surprised
Be immersed in the virtual reality
Be moved by the voice of dubber
Hve fun
Virtual reality
Augmented Reality
Dubbers
Share the visit experience with others
Exchange opinions
Comment the contents between the POI
Suggest what to see during the video
Discuss about the experience at the end of the tour
Following the tour together
Wait for the companion between the POI
Fail to maintain pace with the group
Skip a POI to reunite with the others
Take pictures of the experience
Take picture of the companion while using the headset
Take a selfie
Organization of the tour with POIs
Camera
Use the headset
Learn how to use the headset
Listen to the staff's instructions
Listen to the audio instructions
Adjust the device
Set the volume
Adjust the distance of the display
Select le language
Deal with problems
Change the device when it crashes
Try to sharpen the images
Ask for staff's support
Search for the proper position to activate contents
Staff
Audio instructions
Commands to adjust headset and contents
Staff
Audio instructions
Circles on the floor and totem
Seek comfort
Seek comfort
Search for a comfortable position
Sit down during the AR content
Take a rest during the tour
Live similar experiences
Live similar experiences
Live similar experiences in other museums
Suggest the experience to others
Suggest the experience to others
Suggest the experience to others
Comment the experience on the web
Social network pages
Suggestions and complains form

The Activity Diagram of the museum visit starts with the **first touchpoints** where the visitor journey begins.

Interviewed visitors learnt about the Ara Pacis Museum and the Ara as it was tour through the advertisement on posters and newspaper, on social network (mainly Facebook) and on the guide book for tourists. Another source of information is the word-of-mouth by friends or relatives who have previously visited the museum and recommend the visit as an interesting experience (Falk & Dierking, 2016).

The first touchpoint has a great importance since it is the first contact between the visitor and the museum, as a source of information and expectation about the museum and the service it offers (Stickdorn et al., 2018).

One of the most relevant result is related to the transformation of the visit practice derived from the introduction of a new mediating artefact (Kaptelinin & Nardi, 2006).

Indeed, a relevant portion of the diagram shown in *Figure 33* is related to the **use of the device**: learning how to use the headset, adjusting the device and dealing with problems and malfunctions differentiate the Ara as it was experience from the traditional visit.

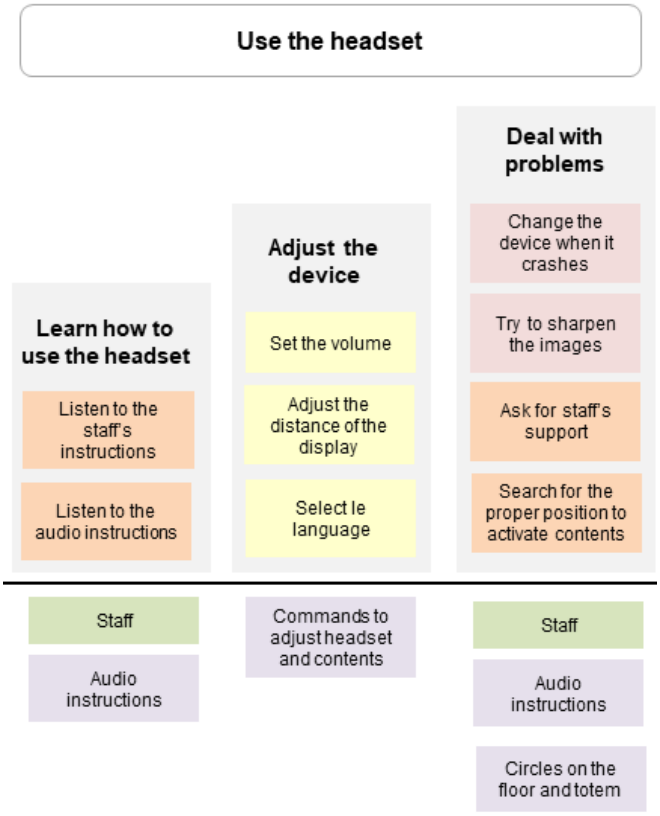


Figure 33 – Portion of the Activity Diagram

As pointed out by Norman (1991) about cognitive artefacts and by Bødker and Klokmose (2012) about artifacts ecology, the introduction of a new tool changes the activity of the users who need to perform additional tasks.

To this end, in the Ara Pacis Museum a system of instruction and support was designed in order to facilitate the visitors in learning how to and properly use the device.

First of all, at the beginning of the tour, a museum assistant is in charge of explaining the organization of the tour and providing instructions to adjust the device (language, volume, activation of the contents).

In addition, two physical artefacts are designed and placed inside the monument as supporting tools: each POI around the monument is highlighted with its number and the picture of the relief, and yellow circles on the floor are intended to show where the visitors have to stop to activate the contents (*Figure 34*).

Figure 34: Image of the POI

Thanks to the shadowing, I found that such physical artefacts are not always effective since some visitors failed to recognize their function. In that case, the help of the museum staff is essential to help the visitors.

The following excerpt from the field notes reports a case in which the visitor does not identify a POI and he asks for the support of the museum assistant.

> «*He asks to the assistant because he cannot find the POI6. After POI6, the assistant indicates where the other POIs are located, without any request from the visitors, anticipating their need for orientation*»
>
> [Excerpt 32 - Field notes of shadowing C05]

This is an example of affordance failure, since the intention of the designer who planned and implemented the supporting tools are not always understood by the users. Such gap is filled by the museum assistants who has the experience and the ability to recognize visitors needs and support them in overcoming possible troubles.

In the **artifacts ecology** (Jung et al., 2008; Bødker & Klokmose, 2012; Bødker, 2015), the head-mounted display is the core device of the tour. It is integrated with the physical tools described above, and with a set of other artefacts which form the artefact ecology of the museum as a stratification.

Indeed, the introduction of a new technology occurs as an increase of existing tools and practices, and over the years the technological stratification evolves since only rarely a new technology totally replace an existing tool (Zucchermaglio & Alby, 2005; Alby, 2007; Bruni & Gherardi, 2007).

This is particularly evident in the case of the Ara Pacis Museum, in which the new practice of the Ara as it was tour is embedded in the museum physical contexts with traditional tools like the panels.

The panels represent the traditional text-based interpretative tool that you can find in every museum (Falk & Dierking, 2016), and some visitors read them at the end of the tour in order to get further information about the monument and the museum (*Figure 35*).

Figure 35: Two visitors reading the panel at the end of the tour

The AR-VR technology cannot replace the traditional interpretative tools. Specifically, the technology does not replace the scale model of the monument with the 360° virtual reconstruction, neither the informative panels with the audio description, since the traditional interpretative tools are used as complementary supports as much as they respond to visitors' needs and interests (Falk & Dierking, 2016).

Figure 36: Image of the museum including scale models and panels[24]

Indeed, the personal context determines not only the attracting power of the exhibits but also the use of interpretative tools: research has demonstrated that surprisingly high numbers of visitors attend to text and graphic panels that are well designed and on a topic of interest to them (Falk & Dierking, 2016).

Thus, the technology represents an additional mediating artifact that should be properly integrated into the museum context, according to the pre-existing practices and tools (Alby, 2007).

[24] Source: http://www.arapacis.it/it/percorsi/galleria_fotografica

Furthermore, the Activity Diagram show how the "Ara as it was" is included in a wider ecosystem of services and tools (Stickdorn et al., 2018) provided by the Rome City Council and by other providers.

The bottom part of the Activity Diagram can help the museum to identify possible target in order to establish joint strategies and partnership.

Indeed, the ability to forge partnership with other organizations and local communities is a fundamental strategy for the 21th century museum, to remain relevant for the society, reach new audience and develop innovative projects (Black, 2012).

I can derive from the Activity Diagram other two relevant insights about the visitor experience that are connected each other: the social interaction between visitors and the trade-off between eyes-up and eyes-down. These two aspects are connected because they are enabled by the organization of the tour into POIs around the monument.

I have already mentioned the issue of **eyes-up/down** when discussing about museum digital guides that should not stimulate the visitors to stare at the mobile screen, preventing them to observe and enjoy the exhibits (Vom Lehn & Heath, 2003; Spallazzo, Ceconello & Lenz, 2011).

The AR part of the tour is organized into 7 POIs around the monument, and the transition between one POI and the following one enables the visitors to observe the monument to naked eyes, after they have listened to the audio-description.

The transition between POIs also enables the visitors to comment and exchange opinions, delimiting the moments for the **social interaction** (**RQ4**).

Indeed, when the mixed reality applications are not purposely designed for a shared and collaborative usage, they structure the social dimension of the experience by posing opportunities and limitations.

Regarding the content of the dialogues between visitors listened during the shadowing, I can refer to the categorization proposed by Allen (2003). I took notes of three kinds of conversations:

- *perceptual talks*, when one visitor draw other visitor's attention to note the details of the relief;
- *affective talks* as expressions of feelings elicited by the AR-VR contents, especially surprise but also disgust when the VR video shows the ritual sacrifice;
- *strategic talks* in the form of instructions about the use of the device and the position to activate the contents.

Furthermore, the field notes report perceptual talks initiated by the museum assistants who get close to the visitors and draw their attention on particular details of the monument.

Given the importance of social interaction for museum learning and enjoyment (Falk & Dierking, 2016), designers should consider both the possibilities and the limitations that the technology pose to the social interaction among visitors.

Indeed, Vom Lehn and Heath (2003) found that people, even when they use a device designed for an individual user, enjoy talking to others and sharing their experience of the exhibition with them. Thus, the experience of exhibitions can be enhanced when interpretation devices provide them with opportunities to communicate with each other.

4. Study 2: Survey on museum audience

Since the Study n.1 performed at the Ara Pacis Museum is project-specific, providing a description of a particular case and involving a limited number of visitors, I designed the Study 2 so to complement the qualitative investigation and analyse other elements of the visitor experience, related to other museums and technologies.

The Study n.2 is a survey about museum audience and it was carried out through an online questionnaire.

This study cannot directly address the **RQ1** by investigating museum's intention to use the technology as a strategy to pursuit the mission. Nevertheless, the questionnaire collects data about visitors' motivations as well as the barriers that prevent them from visiting museums. These two aspects need to be considered to better design technologies within a wider audience development strategy.

RQ2 is addressed by analysing the factors that predict visitors' intention to use technology as interpretative tools during the museum visit.

Moreover, **RQ3** that is related to the mediation of the technology and **RQ4** about the social interaction are addressed with specific questions.

The questionnaire was created using SurveyMonkey[25] and it was disseminated from June to July 2018. The sample of respondents was collected both from a panel managed by Demetra opinioni.net s.r.l.[26] (350 respondents) and through snowball sampling (79 respondents).

422 is the total number of respondents who completed the questionnaire.

4.1 Design of the questionnaire

The questionnaire was designed based on the RQs, the research framework and the issues identified in Study 1, from which I selected the most relevant topics to be investigated.

[25] SurveyMonkey https://it.surveymonkey.com/
[26] Demetra opinioni.net s.r.l. https://demetra.com/

The structure of the questionnaire was divided into three main sections, covering specific topics and following a specific question order:

1) visitors' profiles;
2) user acceptance of traditional and innovative technologies in museums;
3) evaluation of the museum experience using AR or VR technologies.

For each section, I listed a number of multiple-choice questions and items with Likert scales.

Before the dissemination of the questionnaire, I performed a piloting in order to better design it. Specifically, I proposed the questionnaire to five people, with different ages and level of expertise in the questionnaire domain, asking them to complete the questionnaire and reporting possible issues. This test allowed me to avoid ambiguity of the questions (i.e. due to complicated wording in a question that make it incomprehensible), identify alternatives for answers I have not foreseen, test the screening questions and the sequencing.

As mentioned before, the questionnaire is structured in three sections.

The **first section** aims at identifying the respondent's profile based on the distinction proposed by Hood (2004) between frequent visitors, occasional visitors or non-visitors.

The section includes questions about demographic information, preferences for museums and cultural leisure activities (*Annex*, Questions 1- 8).

Respondents identified as occasional and non-visitors are asked to report the barriers that prevent them from visiting museums (*Annex*, Question 9). The options cover both practical constraints and negative motivations (Davies & Prentice, 1995; Prentice Davies & Beeho, 1997; Prentice, 2004; Hood, 2004; Kay, Wong & Polonsky, 2009).

Respondents identified as frequent visitors are asked to report the motivations for visiting museum (*Annex*, Question 10). The items were defined according to the literature review described in *§ 1.3.1*.

The section includes also the scale of the Personal innovativeness that identifies the respondent according to his/her willingness to be a technological pioneer by trying out new solutions and products (Agarwal & Prasad, 1998; Leue & Jung, 2014).

The **second section** of the questionnaire is intended to evaluate the user acceptance of technologies implemented in museums, and it is based on the Technology Acceptance Model (Davis, 1989; Davis et al., 1992; Haugstvedt & Krogstie, 2012).

I selected four kinds of technology: the traditional audio-guide, the Augmented Reality based on mobile device and wearable device, the Virtual Reality with head-mounted display. The technologies are presented through an image and a brief description of the main characteristics, as shown in the following table.

Audio guide

[27]

It allows you to listen audio contents related to the exhibited artifacts, by selecting the corresponding number

[27]https://commons.wikimedia.org/w/index.php?search=audioguide&title=Special:Search&go=Go&searchToken=b4qppxw685b9uudwvd8tfho2j#/media/File:Audiogid_pushkin.jpg

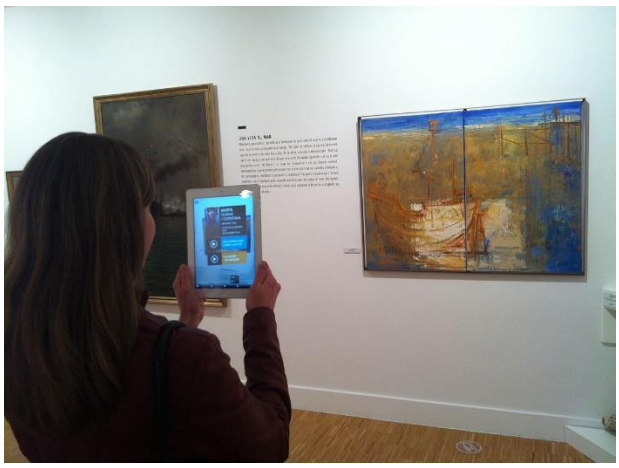
Augmented Reality (1)

 [28]

It augments the perception of monuments or objects together with the audio description,

by wearing a headset

Augmented Reality (2)

 [29]

It superimposes images, texts or videos to the exhibited artifact,

by using a smartphone or a tablet

[28] https://www.youtube.com/watch?v=Akd5-r1gZKc

[29]https://commons.wikimedia.org/wiki/File:Augmented_reality_at_Museu_de_Matar%C3%B3_linking_to_Catalan_Wikipedia_(47).JPG

Virtual Reality



[30]

It allows you to explore a virtual environment and move inside the space, by using a headset

Table 8: Names, images and descriptions of the technologies

After the presentation of the technology, the respondent is invited to answer to rate on a 7-points Likert scale the degree of usefulness, ease of use, enjoyment, and the intention to use the technology in a future visit to a museum.

The **last section** of the questionnaire aims for evaluating the experience with AR/VR technologies.

Since the visitor experience is a complex phenomenon that includes personal, technological and environmental factors, I selected the topics which are more relevant according to the research objectives and the results gained from Study 1.

- The mediating function of the technology (see *Annex,* Question 19) is investigated considering its ability to orient the visitors inside the museum, to focus visitors' attention and to reveal the activity system of the exhibited artifacts (Kaptelinin, 2011; Yoon and Wang, 2014).

[30] Sources: https://commons.wikimedia.org/w/index.php?curid=37879192
https://www.flickr.com/photos/30478819@N08/36436456890

- The level of usability (see *Annex*, Question 20-21) is determined by the ease of use, the need for instructions, the quality of the contents and images, the interaction with the device and the malfunctions (Damala, 2006; Dünser et al., 2007; Kaufmann, & Dünser, 2007; Pribeanu, Balog, & Iordache, 2008; Olsson & Salo, 2012; Sutcliffe, & Gault, 2004).
- Immersion (see *Annex*, Question 22) is conceptualized in terms of visitors focusing attention on the set of stimuli provided by AR/VR, and experiencing involvement into the situation (Witmer & Singer, 1998).
- Emotions (see *Annex*, Question 23) includes Ekman's (1999) categorization of the six fundamental emotions – happiness, anger, fear, sadness, disgust, and surprise – together with other positive affects which are most relevant in the museum domain (Falk, & Gillespie, 2009; Alelis, Bobrowicz, & Ang, 2013; Del Chiappa, Andreu, & Gallarza, 2014).
- The artifacts ecology (see *Annex*, Question 24) is investigated by considering the joint use of different interpretative tools (Bødker & Klokmose, 2012).
- The social interaction (see *Annex*, Question 25) is investigated in terms of synchronicity of the tour and moments in which conversations occur during the visit.
- The outcomes of the visit (see *Annex*, Question 26) are conceptualized as a set of learning and leisure benefits the visitors gain from the museum experience (Packer & Ballantyne, 2002; Hooper-Greenhill, 2004, 2006; Rennie & Johnston, 2007; Pekarik & Schreiber, 2012).

The questionnaire ends with the last question that aims at evaluating the level of satisfaction related to the whole visit experience, on a 5-points Likert scale.

4.2 Data analysis and results

Data were analysed using IBM SPSS.

The sample of the questionnaire is composed of 422 respondents and the following table reports their demographic information.

Sex	Female	N = 208	49,3 %
	Male	N = 214	50,7 %
Expert	Yes	N = 64	15,2 %
	No	N = 358	84,8 %
Age	18 – 30 years old	N = 87	20,6 %
	31 – 50 years old	N = 166	39,3 %
	51 – 70 years old	N = 144	34,1 %
	71 – 80 years old	N = 25	5,9 %
Education	Secondary school	N = 37	8,7 %
	High school	N = 217	51,4 %
	Bachelor/Master	N = 136	32,2 %
	Post-graduate	N = 32	7,5 %

Table 9: Demographic information about the sample

Referring to the distinction proposed by Hood (2004), 63% of the respondents are frequent visitors, 24% are occasional visitors and 13% are non-visitors.

The frequent and occasional visitors (N=368) report that they often visit museum during travels (M=3,14; SD=1,027), a little bit more than in their city of residence (M=3,97; SD=0,888). The difference is not so relevant and this suggests that visiting museum is an activity not only related to the travel experience.

Indeed, as investigated in *Study 1*, the local residents visit museums as a cultural leisure activity during the free time, to know the heritage of their city. As pointed out by Black (2012), the

museum of 21st century needs to engage the local visitors so to act as a memory store for the local community as well as a meeting place of the community.

Regarding the preferences for museums and heritage sites reported in *Table 10*, there are little differences among the typologies of museums.

N = 422; min.1, max 5		
Typology of museum	**M**	**SD**
Wildlife parks and botanical gardens	3,88	0,976
Monuments	3,86	0,944
Science and technology	3,85	0,902
History	3,71	0,970
Ancient art and archaeology	3,69	0,953
Home museums	3,55	1,030
Aquarius and zoos	3,50	1,173
Modern art	3,32	1,044
Contemporary art	3,23	1,061
Ethno-anthropology and paleontology	3,13	1,125
Musical instruments	3,03	1,093

Table 10: Mean and Standard Deviation for typology of museums

It is interesting that wildlife parks and botanical gardens are the most preferred heritage site (M=3,88; SD=0,976). They are a particular form of heritage site that since 1946 the ICOM recognize as museum[31].

According to Cornell and Meyer (2004), the motivations that drive visitors to botanical gardens include the appreciation of the aesthetic and rare qualities of plants, interest in garden design and landscaping techniques used in different periods of history, admiration of gardens' scenery and 'ambience', and pleasure in being outdoors.

Botanic gardens attract a wide range of domestic and international tourists, as well as regular visitors from their local areas. As both conservation and education are among the objectives of

[31] ICOM Constitution, 1946 available at http://archives.icom.museum/hist_def_eng.html

botanic gardens, they are potentially well-placed to offer community education about conservation, to engender pro-conservation attitudes, and to encourage the public to support conservation efforts (Ballantyne, Packer & Hughes, 2008).

4.2.2 Barriers and motivations toward museums

Motivations are the key factors to understand museum audience and better respond to visitors' needs, as well as the barriers need to be considered to better engage the audience (Falk & Dierking, 2016).

Regarding the **barriers**, 54 respondents out of 422 (13%) are classified as non-visitors and they provided a list of barriers and constraints that prevent them from visiting museums, as reported in *Table 11*.

The absence of museums in the city of residence or the difficulty in reaching the museum location is the most selected barrier; it follows the expensive ticket price, the lack of information and free time, and preferences for other leisure activities.

Barriers	**N**
There are no museums located in my city / museum location is difficult to reach	27
Ticket price is expensive	11
I am not informed about museums and cultural events	10
Lack of free time	10
I prefer to spend the free time in other places (i.e. cinema, theatre)	9
Museums are only for experts	5
I am not interested in museums	4
Visiting museum is not a pleasant pastime	4
Museums are not for enjoyment and relax	4
Lack of companion to go with	4
Museums are only for tourists	1

Table 11: Number of selections for barriers

Referring to the distinction proposed by Davies and Prentice (1995), practical constraints are most frequently selected as barriers, compared to the negative motivations.

In addition to the practical barriers, respondents report some negative motivations that prevent them from visiting museum: negative attributes of the museum experience (not pleasant, not enjoyable neither relaxing), perceived target audience of tourists and experts (Davies & Prentice, 1995; Prentice Davies & Beeho, 1997; Falk & Dierking, 2016).

To deal with such negative motivations, Black (2012) suggests to change the images and perceptions that many individuals and communities have of museums, by changing the museum brand. Note that developing museum into a brand is not marketization, rather it requires the shaping of messages about museum collection and experience (Caldwell, 2000).

«To the museums profession, it is a *values brand* based on authenticity, trust, cultural provision and learning opportunities» (Black, 2012, p.46).

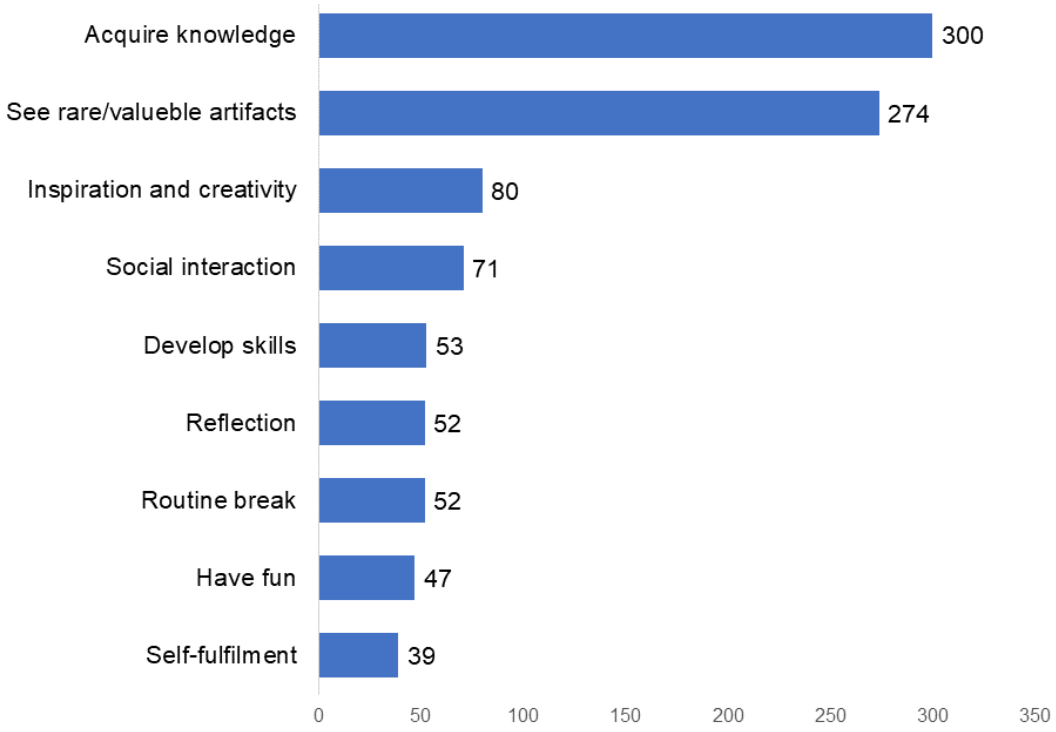
In the communication with the potential audience, Scott (2000) suggests to include in the museum branding not only the attributes that it meaningfully owns, but also the attributes associated with an ideal leisure experience.

> «Rather than presenting an image of museums (and other forms of heritage sites) as educationally 'worthy', we need to present an image as quality leisure destinations, but then build on this by emphasising that museums 'add value' to an outing through the very positive attributes noted above – a unique, authentic engagement with the 'real thing' that differentiates us from all other forms of leisure outing» (Black, 2012, p.48).

Developing the museum brand and fostering the audience engagement require a deep understanding of the added value visitors find in the museum (Black, 2012).

Regarding the **motivations** for visiting museums, acquiring knowledge and seeing rare/valuable artifacts are the most selected motivations by respectively 71,1% and 64,9% of the respondents, in line with the results discussed by Pekarik and Schreiber (2012).

The graph below outlines the different motivations as selected by the respondents.



Graph 1: motivations for visiting museums

This result supports the traditional representation of the museum as a place for informational and the visual/aesthetic experiences connected with the history and culture of human kind.

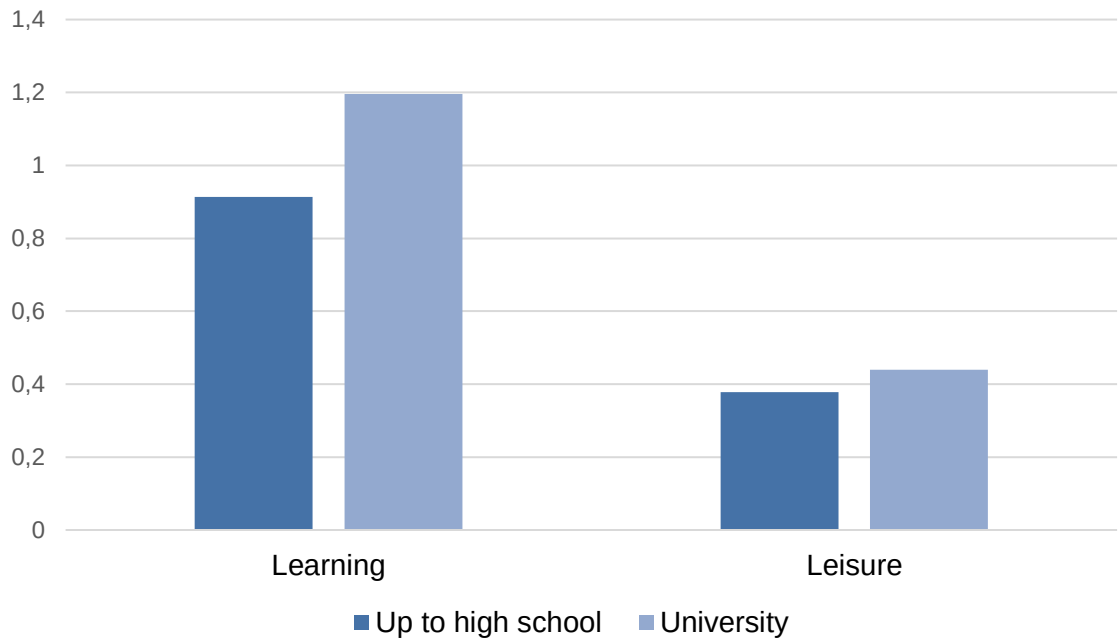
Pekarik and Schreiber (2012) found that learning and aesthetic experience are relatively unlikely to be selected together, because they represent two distinct schemas of the visitor motivations.

On the contrary, 54% of the respondents selected together these two motivations.

Moreover, in order to compare the different motivations, I create two variables by clustering the motivations into Learning and Leisure: within *Learning* variable, I included acquire knowledge, develop skills, inspiration and creativity; while in *Leisure* variable, I included social interaction, break the routine and have fun.

The ANOVA repeated measures shows a difference between the two variables ($F = 162.330$; $p < .01$; $\eta 2 = .278$): Learning motivations resulted higher ($M = 1.026$; $DS = 0.704$) than Leisure motivations ($M = 0.402$; $DS = 0.599$).

Another interesting result comes from the ANOVA performed between motivations and educational level ($F = 4.915$; $p < .05$; $\eta^2 = .012$): Learning motivations resulted higher for high education ($M = 1.196$; $DS = 0.685$; $N = 168$) than for low education ($M = 0.913$; $DS = 0.694$; $N = 254$), while Leisure motivations are quite the same (see graph below).



Graph 2: ANOVA between motivations and educational level

In line with the museum's mission of education and enjoyment established by the ICOM (2007), visitors perceive the museum as a place for educational leisure, where they can experience learning in an enjoyable way (Packer, 2006).

Furthermore, considering the relevance of learning motivation, museums represent the informal setting for the life-long learning since they provide the opportunity to develop knowledge and understanding though the interaction with the cultural heritage.

4.2.3 Intention to use technologies in museums

In order to investigate visitors' intention to use technologies in museum, I combined the TAM model (Davis, Bagozzi & Warshaw, 1992) with the personal innovativeness (Yussof et al, 2011; Leue & Jung, 2014).

Table 12 shows the regression model: the dependent variable is the intention to use the technologies (audio guide, headset-based AR, tablet-based AR and headset-based VR), while the independent variables are the usefulness, easiness, enjoyment and personal innovativeness. According to the regression model, both usefulness, enjoyment, easiness and personal innovativeness predicts the intention to use the audio guide as well as the more advanced technologies based on AR and VR.

DV: Intention to use the **audio guide** F = 181,789; $p < 0.1$; $R^2 = 0.636$; N = 422	SE	β	*t*	Sig.
Usefulness	0.49	0.412	0.480	.000
Easiness	0.046	- 0.032	-0.828	0.408
Enjoyment	0.42	0.461	11,130	.000
Personal innovativeness	0.008	0.092	3.058	.002
DV: Intention to use the **AR Visor** F = 217,727; $p < 0.1$; $R^2 = 0.676$; N = 422	SE	β	*t*	Sig.
Usefulness	0.48	0.442	10.433	.000
Easiness	0.46	-0.095	-2.516	.012
Enjoyment	0.52	0.462	10.069	.000
Personal innovativeness	0.09	0.103	3.483	.001
DV: Intention to use the **AR Tablet** F = 290,303; $p < 0.1$; $R^2 = 0.736$; N = 422	SE	β	*t*	Sig.
Usefulness	0.46	0.414	10.769	.000
Easiness	0.45	0.004	0.117	0.907

Enjoyment	0.49	0.438	9.875	.000
Personal innovativeness	0.08	0.137	5.069	.000
DV: Intention to use the **VR** F = 355,517; $p < 0.1$; $R^2 = 0.773$; N = 422	SE	β	*t*	Sig.
Usefulness	0.45	0.412	10.538	.000
Easiness	0.44	-0.022	-0.605	0.546
Enjoyment	0.47	0.509	11.744	.000
Personal innovativeness	0.08	0.067	2.707	0.007

Table 12: Regression model of TAM

This result supports the need for considering the usability at different levels: usefulness is the potential value of the technology to support visitors' motivations and drive to meaningful outcomes; enjoyment is related to aesthetic, experiential and pleasure needs, in connection with positive emotions derived from the use of the technology; easiness is required in order to facilitate the visitors in learning how to and properly use the device.

Van der Heijden (2004) find that the intention to use hedonic services is predicted by perceived enjoyment and perceived ease of use, more than usefulness.

On the contrary, the regression model shows the significance of easiness as a predictor of the intention to use the technology.

This can be explained by considering that museum experience is not a purely hedonic experience – based on aesthetic, experiential and enjoyment needs – because visitors look for specific outcomes connected with different forms of learning (Hooper-Greenhill, 2002, 2004) and with different visit agendas (Falk, Moussouri & Coulson, 1998).

Moreover, the relevance of personal innovativeness supports the idea that innovation relies on the encounter between the technological artifacts and the pioneers, who are able to recognize the potential value of the technology (Gaudin, 1978).

4.2.4 Museum artifacts ecology and technology functions

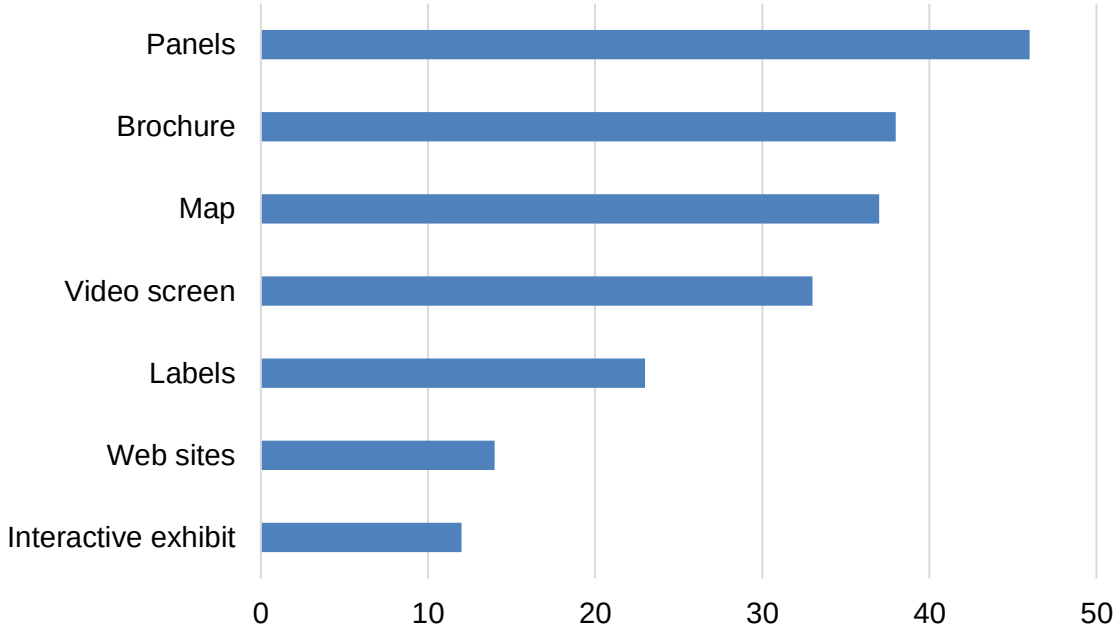
Regarding the kind of AR and VR technologies, 42% of the respondents used more than one tool during the visit. As reported in *Table 13*, the most frequently used technology is the AR based on projection on the walls, followed by the AR based on smartphone/tablet, the headset-based VR, eyeglass-based AR and finally the hologram.

Technologies	**N**
Projection of 3D scenario on the walls	33
Augmented Reality based on smartphone/tablet	32
Virtual Reality based on headset	29
Augmented Reality based on smart glasses	24
Hologram	16

Table 13: Number of AR-VR technologies selected by respondents

Within the artifacts ecology of the museum (Jung et al., 2008; Bødker & Klokmose, 2012; Bødker, 2015), 83% of the respondents jointly used other informative tools during the visit in addition to the AR/VR technologies.

As shown in the graph below, the most frequently used tools are the traditional informative support like panels, museum map, brochure and video screen.



Graph 3: Number of visitors who used informative tools

As pointed out in Study n.1, the museum environment is characterized by a multitude of tools, a stratification of tools implemented over time with different purposes, that form the artifacts ecology. They are jointly used by the visitors according to their needs and the agenda of the visit (Falk & Dierking, 2008; 2016).

Within the artifacts ecology, some of these tools can have specific functions or overlapping capabilities (Bødker & Klokmose, 2012).

For example, the museum map is usually intended to support the need for orientation inside the museum space; labels and captions are used to identify the exhibited artefact and provide concise and specific information about the place of origin, the author, the material/technique etc.; while brochure, panels and video screen are communication tools to provide information about the museum and the collection.

AR-VR technologies do not replace the other interpretative tools as long as the latter continue to successfully mediate the museum experience according to visitors' needs and objectives.

Furthermore, compared with the traditional audio guides, the advantage of using AR-VR technologies is related to the affordances that go beyond the communication of information, to include other form of mediation.

Regarding the function of the technology as mediator, the Mean ranging from 5,17 to 5,96 supports the value of the technology to provide the structures to focus visitor attention on relevant information and to enable the visitors to see what is invisible through virtual reconstructions and multisensorial augmentation (Yoon et al., 2012; Yoon & Wang, 2014).

N = 83; min.1, max 7		
Functions	**M**	**SD**
To enhance the multisensorial perception	5,96	1,292
To imagine other contexts and situations of past times	5,89	1,250
To focus the attention on artifacts' details	5,83	1,208
To understand the meaning of the artifacts exhibited	5,66	1,346
To identify the most important artifacts of the collection	5,46	1,492
To be oriented in the museum space	5,17	1,731

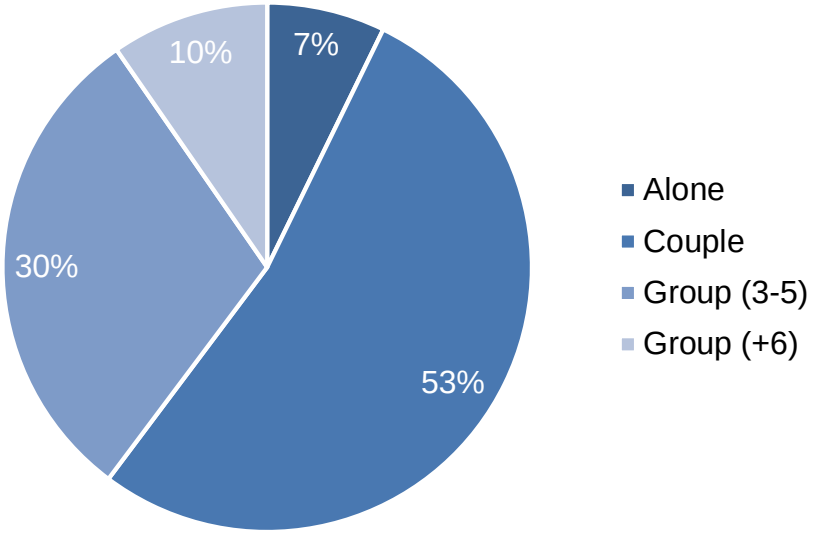
Table 14: Mean and Standard Deviation of technology functions

These mediating functions of the technology are enabled by the affordances of the technology, by allowing the visitors to perceive the exhibited collection with additional information related to both the tangible aspects and the intangible dimensions that reveal the artifacts as culturally developed products (Kaptelinin, 2011).

4.2.5 Social interaction during the AR-VR experience

Given the social nature of the museum visit (Falk & Dierking, 2016), the questionnaire investigates the moments in which social interactions occur during the visit.

Only 6 respondents out of 83 visited the museum alone, while the others shared the experience with a companion or with a group of people (*Graph 4*).



Graph 4: Percentages of alone visitors, couples and groups

Among the 77 respondents who visited the museum with a companion or a group of people, the issue of synchronicity is investigated: 40 respondents followed the tour together; 22 respondents stopped waiting for the companion/group and/or they skipped some points of interest, in order to maintain the synchronicity; while 15 out of 77 met again the companion/group only at the end of the tour.

Regarding the dialogues among visitors, 55 respondents (66%) report that they had conversations both during the vision of the contents, between POIs and at the end of the tour. The other 28 respondents report that they engage in conversations as shown in the table below.

Moments for conversations	**N**
Only during the vision of the contents	3
Only between POIs	3
Only at the end of the tour	6
During the vision of the contents and between POIs	5
During the vision of the contents and at the end of the tour	7
Between the POIs and at the end of the tour	4

Table 15: Moments for social interactions

It is notable that most of the visitors who used only headset-based VR or eyeglass-based AR, which provide immersive and individual experiences, report that they had conversations during the vision of the contents. This aspect raises two fundamental questions.

Is it a breakdown of the immersive experience?

According to Triberti e Brivio (2016), a breakdown occurs when the mediated action is not finalized and the flow of interaction is interrupted, due to malfunctions of the system, errors of the user or external stimuli. In such situation, the cognitive processes such as memory and problem solving are activated to identify the source of errors and to plan what Suchman (1987) calls situated actions.

Is it a moment of disengagement?

O'Brien and Toms (2010) define disengagement as the moments when the users stop the activity due to external factors or because they lose interest in the experience.

I cannot consider the social interaction occurring within the flow of interaction as a breakdown or a point of disengagement, since it is a core element of the experience – that occurs even if the experience is mediated by a technology designed for individual use – and also because the respondents report high level of immersion and involvement (*Table 16*).

N = 83; min.1, max 5		
Immersion and involvement	**M**	**SD**
I felt myself immersed in another time/place	4,11	1,024
I was totally involved in the situation	4,12	0,916
My attention was completely focused on what I was seeing	4,03	0,777

Table 16: Mean and Standard Deviation of immersion and involvement

Visitors report that they experienced immersion and focused their attention on the situation (Witmer & Singer, 1998).

Furthermore, regarding the emotions, positive states elicited during the visit experience prevail and they are indicators of engagement, especially curiosity, interest and enthusiasm as reported in *Table 17* (Attfield et al., 2011).

In addition to Paul Ekman's (1999) categorization of the six fundamental emotions – happiness, anger, fear, sadness, disgust, and surprise – and I consider other positive affects which are most relevant in the museum domain (Falk, & Gillespie, 2009; Alelis, Bobrowicz, & Ang, 2013; Del Chiappa, Andreu, & Gallarza, 2014).

N = 83; min.1, max 7		
Emotions	**M**	**SD**
Curiosity	6,17	1,069
Interest	5,93	1,166
Surprise	5,83	1,248
Fun	5,80	1,429
Enthusiasm	5,64	1,535
Happiness	5,20	1,504
Confusion	2,12	1,714
Hanger	2,07	1,866
Disgust	1,93	1,779
Sadness	1,86	1,609
Boredom	1,84	1,565
Fear	0,40	1,140

Table 17: Mean and Standard Deviation of emotions

In particular, positive emotions can act as "sustainers" to keep the visitors engaged during the experience (Edmonds et al., 2006), and they are indicators of the visitor satisfaction (Del Chiappa, Andreu, & Gallarza, 2014).

In the attempt to enhance visitor engagement, managers should consider the museum as an emotionally driven experience consumption site, where hedonic and functional motivations are mixed together and should be jointly supported (Del Chiappa, Andreu & G. Gallarza, 2014).

«The combination of intellectual, emotional, and physical involvement is the essence of an interactive (and enjoyable) museum» (Falk & Dierking, 2016, p.114).

This means that both the museum physical context and the technologies used as interpretative tools should foster enjoyable experience while avoiding negative affects like confusion and boredom.

4.2.6 Outcomes of the visit experience

As discussed in *§ 1.2.1*, museums are informal learning settings in which learning occurs not only as an increase in knowledge and understanding, by acquiring specific museum-related contents, but it may cover changes in attitudes and values, reflection and meaning making, as well as creative thinking and enjoyment (Hooper-Greenhill, 2004, 2006).

The table below reports the different outcomes gained from the visit experience.

N = 83; min.1, max 7		
Outcomes	**M**	**SD**
I spend time in enjoyable way	6,10	1,275
I had fun	6.01	1,339
I deepen my knowledge	5,99	1,153
I learnt new things	5,98	1,297
I reflected about the meaning of the artifacts	5,96	1,234
I live a new and unusual experience	5,94	1,282
I admired rare and valuable artifacts	5,94	1,365
I exchanged impressions and opinions with others	5,84	1,494
I reflected about other times and places	5,84	1,320
I shared a pleasant experience with others	5,83	1,421
I got relax	5,70	1,323
I stimulate the creativity	5,51	1,611
I got inspired	5,20	1,591
I develop my skills	5,17	1,738
I reflected about my personal experiences	5,02	1,660
I changed my opinions, judgements, values	4,64	1,923

Table 18: Mean and Standard Deviation of outcomes

The highly rated outcomes are related to both the leisure experience (spending time in enjoyable way, having fun) and the learning experience (deepening the knowledge and learning new things), and this supports the vision of museum as context for educational leisure.

As pointed out by Hooper-Greenhill (2004, 2006), learning in museums happens when the visitors acquire new knowledge or use prior knowledge in new ways, making connections between different domains and reflecting about personal experiences. Indeed, since the museums conserve and exhibit the tangible and intangible heritage connected with the culture and history of human kind, they support the historical reminiscence in terms of getting historic content, reflecting about other times and context and recalling personal memories (Sheng & Cheng, 2012).

The learning component of the experience is combined with the leisure outcomes related to fun and pleasure during the museum visit, especially when the experience is shared with relatives and friends.

The relevance of the outcomes is also related to the level of satisfaction reported by the visitors. Visitor satisfaction is usually investigated in terms of affective response elicited by the museum environment, collection, services and interpretative tools (see for example: De Rojas & Camarero, 2008; Del Chiappa, Andreu & Gallarza, 2014; Cancellieri et al., 2018).

In Study 1, I found that the usability problems and malfunction of the device negatively impact the experience, but interviewed visitors tolerate these issues because they highly value other aspects of the experience, especially the outcomes related to learning and enjoyment.

Thus, I performed the regression to evaluate the level of satisfaction (dependent variable) as predicted by usability, learning and leisure outcomes (independent variable).

The table below shows the regression model.

DV: Level of satisfaction F = 48,271; $p < 0.1$; $R^2 = 0.647$; N = 83	SE	β	*t*	Sig.
Usability	0.71	0.161	2.070	.027
Outcomes leisure	0.64	0.529	5.698	.000
Outcomes learning	0.63	0.257	3.283	.010

Table 19: Regression Model

According to the regression model, the level of satisfaction is predicted by learning and leisure outcomes, as well as by the level of usability.

Museum visiting takes place during the free time, as a leisure activity with the expectation of a pleasurable experience. As discussed by Stephen (2001), the perspective of the museum as a context for recreation and amusement do not conflict with the museum's functions of collecting and educating, rather it enhances the museum mission towards a greater public benefit that is the contributing to a good quality of life.

Conclusions

This thesis aims at investigating the role of Augmented and Virtual Reality technologies implemented in the museum domain. This interest derives from the need to better understand how technologies support museum's mission and enhance the visitor experience.

It requires a holistic perspective to consider the way the museum experience is shaped by visitors' characteristics and agenda, technology features and the peculiarities of the museum environment.

To this end, I conceptualize the visitor experience mediated by AR-VR technologies by referring to the Contextual Model of Learning elaborated by Falk & Dierking (1992, 2000, 2016) in the domain of Museum Visitor Studies, with the cultural-historical Activity Theory elaborated by Leontiev (1974, 1978), Engeström (1987, 2000) and further developed by Kaptelinin e Nardi (2007) in the domain of Human-Computer Interaction.

The integration of these two frameworks contributes to the advancement of the knowledge about museum visitor experience, since the Activity Theory improves the Contextual Model of Learning by specifically addressing the role of AR-VR technologies in mediating visitors' activities.

According to such theoretical framework, I designed and carried out two studies.

Study 1 is a qualitative investigation performed at the Ara Pacis Museum in Rome, and it is focused on the distinction between design-for-use and design-in-use (Folcher, 2003): design-for-use represents the intentions, objectives and expectation of the museum managers and designers related to the implementation of a new technology; the design-in-use reflects visitors' practices, needs and objectives derived from the use of the technology.

Thanks to the joint use of auto-ethnography, shadowing and interviews to collect data, and by taking advantage from the Service Design Thinking techniques to analyse data, this study provides a deep understanding of the visitor experience mediated by the AR-VR technology, in light of the museum's mission and strategies.

The findings of this study provide a rich description of the visitor experience, while pointing out some relevant issues that need to be further investigated.

For this reason, **Study 2** was designed to complement and further investigate the issues arose in Study 1, by collecting data from the wide audience of frequent, occasional and non-visitors (Hood, 2004).

Given the complexity of the visitor experience and the limitations of the questionnaire as research technique, Study 2 was designed to investigate specific elements of the visitor profiles (motivations and barriers), their intention to use innovative technologies as interpretative support, and specific elements of the experience derived from the use of such technologies.

The Study 2 is also intended to evaluate whether the issues investigated in the Ara Pacis Museum are relevant in other museums and with other forms of AR-VR technologies.

Hereafter, I discuss the main findings that derived from the integration of the two studies and some insights that can be used to better design innovative technologies supporting the museum visitor experience.

First of all, technology can be exploited as an engagement factor to attract potential and repeated visitors (Black, 2005) who are curious and interested in new forms of museum experience enabled by the use of innovative technologies.

In particular, 57% of visitors in Studio 1 and 43% of respondents in Studio 2 have already visited the museum and they came back for an additional visit with the mediation of the technology.

By providing a new way to visit the museum, the technology can be exploited to develop the museum audiences as long term, regular users rather than one-off visitors (Black, 2012).

The technology can act as an attractor (Edmonds, Muller & Connell, 2006) especially for the pioneers, those who are curious and have positive attitudes towards innovative tools. Indeed, according to the results of Study 2, the intention to use technologies in museum is predicted by

the personal innovativeness that is related to users' willingness to be a technological pioneer by trying out new services and products (Agarwal, & Prasad, 1998; Yussof et al, 2011; Leue & Jung, 2014). Visitors with higher levels of personal innovativeness have more favourable attitude towards new technologies, they are more willing to use the technology during the museum visit, as long as the technology is considered useful, easy to use and enjoyable.

Within the museum environment, the AR-VR technologies are embedded into the stratification of tools that characterized the artifacts ecology of museums.

The artifacts ecology, the stratification of tools and the process of adoption of new artifacts by the users are often investigated in workplace studies, especially in high-technological contexts and collaborative activities (see for example: Star & Ruhleder, 1994; Star, 1999; Bruni & Gherardi, 2007).

The museum context provides relevant opportunities to investigate a particular form of ecology composed by artifacts of the exhibited collection and artifacts designed as interpretative tools.

In such ecology of different tools with specific, complementary or even overlapping functions (Jung et al., 2008; Bødker & Klokmose, 2012), the AR-VR technology does not replace the more traditional interpretative tools (i.e. the panels), because the latter are used as complementary supports as much as they respond to visitors' needs and interests (Falk & Dierking, 2016).

Thus, the benefits of introducing AR-VR technology in the museums relies on its function of mediation, enabled by the affordances at different levels: a) the technology enables the visitors to see what is invisible to the naked eyes, through multisensorial perception; b) it focuses visitors' attention on artifacts' details; c) it supports the imagination and immerse the visitors in other times and context; d) it facilitates the understanding of tangible and intangible aspects of the heritage.

As pointed out by Kaptelinin (2011), in these ways the technology reveals the activity system of the artifacts as culturally developed products, and builds a bridge between the museum collection and the visitors' motivations and goals.

Such technology mediation supports the visitors in reaching the desired outcomes that are related to both learning and leisure. The benefits that the visitors derive from the experience concern not only the acquisition of specific information, but they include a general cultural enrichment, pleasure and enjoyment, and the will to live similar experiences in other museums and heritage sites (Hooper-Greenhill, 1995).

But, when introducing another tool to mediate the museum experience, we need to consider that the new tool changes the activity of the visitors who need to perform additional tasks (Norman, 1991; Bødker & Klokmose, 2012),

In the Ara Pacis Museum (Study 1), even if the visitors are familiar with AR-VR technologies used in museums or in other situations, additional tasks are requested to understand how to perform the tour, adjust and properly use the headset, and deal with struggles and malfunctions. Thus, high level of usability is necessary, considering the specific properties of AR-VR technologies (Dünser et al., 2007; Dünser, & Billinghurst, 2011; Olsson, 2013), as well as the design of a system of instructions in order to facilitate the visitors in learning how and properly use the technology.

While addressing the research questions defined according to the literature review, this thesis highlights other open issues that need to be further investigated.

First of all, the mediation of the technology should be analysed in the context of different museum typologies (i.e. science centers, art galleries, monuments etc.). Indeed, each museum has a specific identity and collection and visitors have different motivations and expectations towards the museums. So, we need to better understand how the technology acts as a bridge between the different museum collections and the visitors' motivations and desired outcomes.

Moreover, the integration of innovative technologies within the artifacts ecology should be further investigated in order to design complementary tools and provide the visitors with a range of resources to support the free-choice learning.

It is also interesting to analyse the technology as an engagement factor for the non-visitors, to deal with the negative motivations that prevent them from visiting museums (Davies & Prentice, 1995; Prentice Davies & Beeho, 1997; Prentice, 2004; Hood, 2004; Black, 2012). For example, technological innovation can be exploited as a strategy to contrast with the vision of museum experience as boring, not enjoyable, too intellectual and not interesting, by providing the non-visitors with a tool to support both the learning and the enjoyment outcomes of a cultural leisure experience (Stephen, 2001). In this way, a successful museum experience mediated by the technology can change visitors' attitudes and value towards role of museums in the society.

Hereafter, I would like to highlight two main issues that need to be considered when designing innovative technology for the promotion of the cultural heritage.

- **Designing personalized experience**

Due to budget restrictions and the resources needed to design and implement mixed reality tours, museums usually design one solution to be offered to all visitors. But, thinking of museum audience as an undifferentiated mass is in contrast with the audience-centred perspective (Hooper-Greenhill, 2004).

Several authors (Vlahakis et al., 2001, 2002; Weil, 2002; Falk, Dierking & Foutz, 2007; Tallon & Walker, 2008; Ardissono, Kufik, & Petrelli, 2012) suggest to design personalized experiences, contents and organization of the tour according to visitors' motivations, backgrounds and visit agendas.

Indeed, nowadays the trend in goods and services provisioning relies on personalization and customized experience, and it is relevant also for the museum domain (Ardissono, Kufik, &

Petrelli, 2012), since museums are informal learning context where the visitors choose which activities to participate in, the path to follow, and the information to seek (Leister at al. 2016). Based on the level of expertise, the familiarity with and interests in the museum-related content (Falk, Moussouri & Coulson, 1998; Hooper-Greenhill, 2000; Taheri, Jafari & O'Gorman, 2014; Falk & Dierking, 2016) as well as the professional vision (Goodwin, 1994), visitors have different needs and expectations towards the museum visit, in terms of exhibits to attend and information to gain. Thus, the design of personalized experience can benefit the museum in meeting the needs of heterogeneous audience.

- **Enabling social interactions among visitors**

Several studies investigate the social interaction among visitors as a core aspect of the museum experience (Hein, 1996; Hooper-Greenhill, 1999; Falk and Dierking 2000; Allen, 2007; Ellenbogen, Luke & Dierking, 2007Falk, Dierking & Foutz, 2007).

Nevertheless, an individualistic conception of the visitors seems to underlie the design of ICT (Vom Lehn & Heath, 2003). Even if the technology is designed as individual experience, for individual usage, it should enable the social interaction by offering moments when the visitors can engage conversations to exchange ideas and reflections.

This issue is particularly relevant for the museum to act as a facilitator, by enabling the visitors to construct the meaning from the exhibit through the social interaction, as in the perspective of the constructivist museum (Hein, 1999, 2002; Hooper-Greenhill, 2006, Black, 2012).

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Annex: Questionnaire

Questions/item	Options/scale
1) Age	
2) Sex	○ M ○ F
3) City of residence	
4) Do you study/work in the domain of cultural heritage?	○ Yes ○ No
5) How many museums did you visit in your life?	○ None ○ 1-3 ○ 3-9 ○ More than 9
6) How often do you visit museums: – in your city? – during travels?	1. Never 2. Rarely 3. Not rarely nor occasionally 4. Occasionally 5. Often
7) How interested are you in the following typologies of museum? – Ancient art and archaeology – Modern art – Contemporary art – Science and technology – History – Musical instruments – Ethno-anthropology and paleontology – Monuments – Home museums – Wildlife parks and botanical gardens – Aquarius and zoos	1. Not at all 2. 3. 4. 5. Very much
8) How often do you attend to the following cultural leisure activities? – Watch cultural programs on tv – Watch movies at the cinema – Attend to show at the theatre – Listen music – Play musical instrument – Read books/journals – Write poems/stories – Artistic creations	1. Never 2. Rarely 3. Not rarely nor occasionally 4. Occasionally 5. Often

Question	Options
9) Which are the barriers and constraints that prevent you from visiting museums?	☐ Ticket price is expensive ☐ There are no museums located in my city / museum location is difficult to reach ☐ I am not informed about museums and cultural events ☐ Lack of free time ☐ I prefer to spend the free time in other places (i.e. cinema, theatre) ☐ I am not interested in museums ☐ Visiting museum is not a pleasant pastime

	☐ Museums are not for enjoyment and relax ☐ Museums are only for tourists ☐ Museums are only for experts ☐ Lack of companion to go with

Question	Options
10) Select the three most important motivations that drive you to visit museums	☐ Learn new things and enhance the knowledge ☐ Develop my skills ☐ Be inspired and stimulate the creativity ☐ Admire rare and valuable artifacts ☐ Reflect about personal experiences ☐ Spend time with relatives and friends ☐ Break the routine ☐ Have fun ☐ Self-fulfilment ☐ other (please, specify)

Questions/item	Options/scale
11) How do you agree with the following statements regarding your attitudes towards innovative technologies? – If I heard about a new technology, I would look for ways to experiment with it – Among my peers, I am usually the first to try out new information technologies – I like to experiment with new technologies – In general, I am hesitant to try out new information technologies.	1. Totally disagree 2. 3. 4. 5. 6. 7. Totally agree

Questions/item	Options/scale
Image and description of: Audio guide, AR based on tablet, AR based on headset, VR based on heaset	
12) Have you ever used this technology in a museum?	o Yes o No
13) How much do you think it is: – Useful – Easy to use – Enjoyable	1. Not at all 2. 3. 4. 5. 6. 7. Very much
14) Would you like to use this technology in a future museum visit?	1. Not at all 2. 3. 4. 5. 6. 7. Very much

Questions/items	Options/scale
15) What is the museum where you used the technology?	
16) Have you visited the museum before and then you came back to visit it again using the technology?	o Yes o No
17) With whom did you visit the museum?	o Alone

	○ In couple ○ With a group of 3-5 people ○ With a group of 6 or more people
18) What kind of technology did you use?	○ Mobile Augmented Reality (i.e. you used a smartphone/tablet to visualize additional contents ○ Eyeglass AR (es. you wear the glasses to superimpose images/text on the perception of the reality) ○ Virtual Reality (es. you wore a headset to explore immersive virtual scenario) ○ Projection of 3D scenario on the walls ○ Holograms

Questions/item	**Options/scale**
19) How did the technology support you during the visit? – To be oriented in the museum space – To identify the most important artifacts of the collection – To focus the attention on artifacts' details – To understand the meaning of the artifacts exhibited – To imagine other contexts and situations of past times – To enhance the multisensorial perception	1. Not at all 2. 3. 4. 5. 6. 7. Very much

Questions/item	**Options/scale**
20) How do you agree with the following statements about the usability of the technology? – It is easy to use – I need detailed instructions to understand how to use it – It is easy to adjust the device – Contents are clear and comprehensive – The quality of the images is high – Handling the device is not comfortable – It requires to maintain an uncomfortable position	1. Totally disagree 2. 3. 4. 5. 6. 7. Totally agree
21) Did you face malfunctions of the technology (i.e. the device crashed)?	○ Yes ○ No

Questions/item	**Options/scale**
22) How did you live the experience of immersion? – I felt myself immersed in another time/place – My attention was completely focused on what I was seeing – I was totally involved in the situation	1. Not at all 2. 3. 4. 5. Very much

Questions/item	**Options/scale**
23) What emotions did you felt? – Happiness – Surprise – Hanger – Disgust – Fear – Sadness	1. Not at all 2. 3. 4. 5. 6. 7. Very much

– Enthusiasm – Interest – Fun – Curiosity – Boredom – Confusion	

Questions/item	**Options/scale**
24) During the visit, did you use other tools?	☐ None ☐ Labels and captions ☐ Panels ☐ Map of the museum space ☐ Brochure ☐ Screen showing videos ☐ Games/interactive exhibits ☐ Web sites with information about the museum/collection ☐ Other (specify)

Questions/item	**Options/scale**
25) How did you interact with the person/s with whom you visited the museum? – We were always in sync and we follow the tour together – During the tour, I had some breaks to meet again the other person/s – I fell behind and I skipped some points of interest – We met again only at the end of the tour – We commented during the vision of the contents – We commented between one point of interest and the other one – We commented at the end of the tour	o Yes o No

Questions/item	**Options/scale**
26) What are the outcomes you gained thanks for the museum visit? – I learnt new things – I deepen my knowledge – I develop my skills – I stimulate the creativity – I got inspired – I changed my opinions, judgements, values – I live a new and unusual experience – I admired rare and valuable artifacts – I reflected about the meaning of the artifacts – I reflected about other times and places – I reflected about my personal experiences – I shared a pleasant experience with others – I exchanged impressions and opinions with others – I spend time in enjoyable way – I had fun – I got relax – Self-fulfilment	1. Not at all 2. 3. 4. 5. 6. 7. Very much

27) How much did the technology allow you to gain the above outcomes?	1. Not at all 2. 3. 4. 5. Very much

Questions/item	**Options/scale**
28) How satisfied are you in the visit experience?	1. Not at all 2. 3. 4. 5. Very much