Chapter 13
User Experience and Engagement in Augmented Reality Systems for the Cultural Heritage Domain

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Abstract This chapter reviews the different models of user experience (UX) and user engagement (UE) proposed for Augmented Reality (AR) systems and discusses their applicability to the Cultural Heritage (CH). Traditional models of UX and UE are not totally adaptable to the current trends in the AR continuum for the CH domain. Thus, an important HCI research area that requires investigation is the evaluation of UX and UE factors for AR systems in the CH field. This chapter proposes a conceptual framework model for assessing UX and UE in AR systems. Initially, the UX categories (such as instrumental, cognitive, emotional, sensory, social and motivational) are investigated thoroughly to have a deep understanding of all the related components. Further, the UE factors (such as aesthetics, interest, goal, novelty, interactivity, gamification and learning) are identified and categorised. Twenty AR systems in the CH domain (AR-CH) have been selected based on pre-defined criteria and evaluated against a list of derived AR characteristics. The gaps in current literature have been considered to formulate a comprehensive framework for the assessment of UX and UE factors in AR-CH systems. Metrics and methods are investigated and identified for the measurement of the UX and UE factors. This chapter lays a solid foundation for the assessment of UX and UE factors in AR-CH systems, which has the potential to help AR system developers with identifying and improving the most UX and UE influential factors in their systems.

13.1 Introduction

Cultural Heritage (CH) represents the ways of living developed by a community and passed on from generation, including customs, practices, places, objects, artistic expressions and values (Thompson 2016). CH can be expressed as Tangible or Intangible. Tangible CH is a physical property that can advocate the country's history and

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culture, whereas Intangible CH refers to those aspects that cannot be touched or seen (Vecco 2010). Mauritius has known a vivid history in the past endorsing the CH sites as a reference to visualise the timelines of the different historical aspects. Those historical aspects have mapped all the events beginning with the discovery of Mauritius to its independence and denoting its importance in the development of Mauritius.

In most of the cases, Cultural Heritage sites do not have useful information, or they lack user guides which affect the visiting experience. Although CH sites have employed traditional mediums (such as dashboards, booklets and maps) for sharing of information, visitors find it uninteresting and not motivating enough (Pendit et al. 2014). In this context, CH sites can adopt the high-tech technologies to bring more liveliness to their static environment and also taking full advantage to showcase all the detailed heritage aspects to visitors. The World UNESCO centre has cited two CH sites in Mauritius as a World Heritage site in their records namely: Aapravasi Ghat and Le Morne Cultural Landscape (UNESCO 2020). Both sites are rich in cultures and they provide an automatic sense of unity to allow us to better understand previous generations and the history of where we came from.

Undoubtedly, the effervescence in new technologies has contributed various breakthrough in the worldly activities. In the same line, the apprehend-ability of artefacts can be enhanced using 3D modelling techniques through digital technologies. Augmented Reality (AR) has been a key focus lately in the CH industry, with more and more CH institutions implementing AR to give a competitive marketing edge to the heritage assets. Some examples include the Museum of London, the Netherlands Architecture and the Powerhouse Museum in Sydney (Lee et al. 2015). Augmented Reality is an emerging technology that is widely integrating into cross-dimensional activities across the globe through various forms (Chatzopoulos et al. 2017). The development of Augmented Reality is booming, and the adoption is fierce in several sectors including education, marketing, entertainment, tourism, retail and AECO (Architecture, Engineering, Construction and Owner) (Chatzopoulos et al. 2017; Chen et al. 2017). The concept of AR stems from virtual reality, except the information is mediated with more realness and naturalness (Azuma et al. 2001). The layer of information is contextualised and supplemented with readily available data (e.g. images, locations and sounds) that changes the perspective of the user perceptions (Van Kleef et al. 2010).

The wide-appealing of this technology is supported by the increasing demands of ubiquitous gadgets (smartphones, head-worn devices and projection displays) available in the market (Chatzopoulos et al. 2017). The maturity of AR is gradually outreaching the general public, therefore taking it to new heights of high-end products (Garzón et al. 2019). As a consequence, these systems have a certain attractiveness and they can activate emotional reactions. The emotional reactions may differ from user to user. This relation is sometimes complex to understand and very few works have investigated on Human–Computer Interaction (HCI). HCI is a predominant subject that still requires investigation to understand the user experience/engagement, its prerequisites and the situational/personal mediation. Lately,

the sustainable progression of AR systems is taken for granted by designers and developers, as they often lacked focus on the HCI field (Datcu et al. 2015).

The HCI field, i.e. UX and UE is still an unexplored area in the AR-CH domain. More and more Cultural Heritage (CH) institutions are adopting AR to create the missing sparks from their static environment thus making it more energetic. Yet, the different mechanisms of visual information, interactions, interfaces and displays employed in AR application make this task even more challenging. Authors have used preliminary UX and UE frameworks to determine the enhancement aspects that could be used in the AR context. Nevertheless, the novelty of interactions with AR information has changed during the course and new types of AR, i.e. mobile AR (MAR) are surfacing and stimulating a unique experience (Chatzopoulos et al. 2017). In this lens, the previous UX and UE models are not adapted with the current trends that are ongoing in the AR-CH continuum. Though various AR applications have been available in the marketplace, very few researches have been carried out in this field of study. In addition, the user expectations are motivated by the prior experiences they had with the technology. A temporal model of the user expectations has been illustrated by Anu Kankainen that described the correlations between previous experience, present experience and more experiences (Kankainen 2003). Currently, there is a large interest in understanding the narrative aspects of AR-CH applications, but the focus on UX and UE is limited.

This chapter focussed on the application of the UX and UE enhancement models in the AR-CH field. A research methodology is employed to construct the chapter. At the initial stage, the generic UX and UE frameworks are enumerated, described and analysed to have an understanding on the technological aspects. Next, the frameworks are analysed in the AR-CH area and a classification of the influential factors affecting UX and UE is derived. The related metrics and methods to assess the UX and UE factors in AR-CH systems are identified.

13.2 Research Methodology

In this research, the objective is focussed on deriving the influential UX and UE factors in the AR-CH domain. This objective is derived based on the principles of UX and UE frameworks that were applied in the technology domain. In this vein, the general UX and UE frameworks in the technology perspectives are explored at the initial stage. The generic frameworks are filtered out based on the relevance to the field, citations, popularity and application area. The works have been categorised under the UX and UE frameworks. At the second fold, the UX and UE frameworks conceived for AR-CH systems are reviewed methodically. The next stage consists of a synthesis of the AR-CH design characteristics with the derived UX and UE factors. In this endeavour, a total of twenty works have been identified and reviewed methodically with the following conditions as described in subsections below. The methodology is depicted in Fig. 13.1.

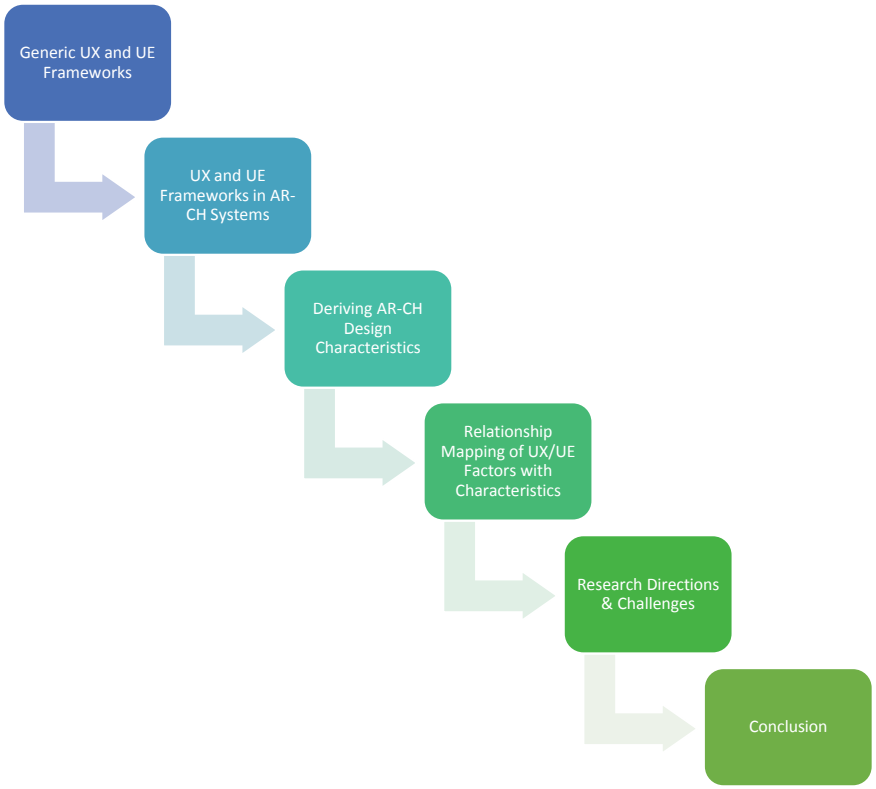

Fig. 13.1 Research methodology

13.2.1 Search Terms

The frameworks are selected by determining the most appropriate search strategy, the search items used were "Augmented Reality", "Mobile Augmented Reality", "Cultural Heritage", "Museum", "User Experience", "User Engagement", "Frameworks", "Models", "Metrics" and combination of them. The search was limited to the last 5 years from 2015 to 2020. The last update was on 10 August 2020.

13.2.2 Data Sources

With the recent technological advances in mobile systems, new positioning techniques have been developed. As such, there are some articles available on this subject. Initially, a general exploration is carried out on reputed scientific journals and conference proceedings to shortlist the relevant scientific databases. The highest relevance

of indexed papers was found in IEEE Xplore, ACM Digital Library, Springer, Science Direct, Elsevier and ERIC.

13.3 UX Frameworks

Many UX frameworks have been conceived in the AR context, but they have been mostly conceptualised with the generic UX frameworks. The understanding of these universal frameworks is vital in this study, as they comprise of various components that have been plugged in on the UX-AR frameworks. To have a broader perspective of the different UX frameworks, this section describes, analyses and evaluates these generic frameworks, theories and methods. The generic frameworks are selected based on their popularity, relevance and application area. Given the wider spectrum of UX, the study focusses on UX-AR frameworks at a later stage in this study.

Hassenzahl (2004) presented a UX model based on two features of product quality: pragmatic and hedonic. Pragmatic quality is the product's ability to promote attainment of behavioural goals (product's usefulness, usability or appropriateness) whereas hedonic quality is widely associated with the social and emotional behaviours that are perceived based on the user's experience (or post-experience). Hedonic quality can be further broken into three subgroups: stimulation, identification and evocation. Stimulation enables personal growth, identification is related to express and build one's identity through the product and evocation is the memory and emotion revolved around the product. These outcomes can vary from user to user since the users construct their personal opinions based on the product features and characteristics. Figure 13.2 provides the graphical layout of the UX model proposed by Hassenzahl (2004).

Buccini and Padovani (2007) have reworked earlier UX models and proposed a consolidated model of product experience with six categories: (1) experiences related to the senses, (2) experiences related to feelings, (3) social experiences, (4) cognitive experiences, (5) use experiences and (6) motivational experiences. The "senses" experiential corresponds to the experience related to sensory factors through vision,

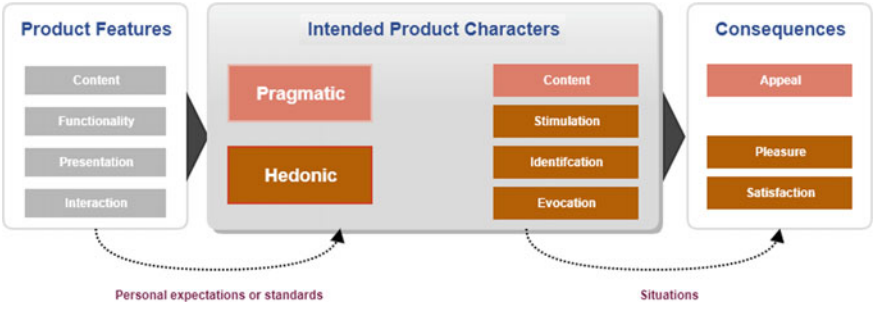

Fig. 13.2 UX model (Adapted from Hassenzahl [2004])

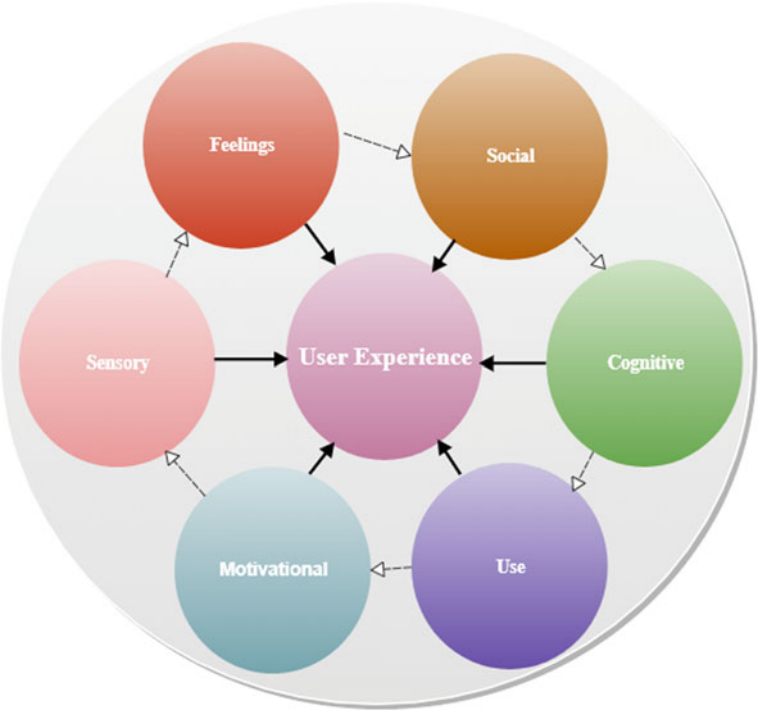

Fig. 13.3 Six categories of product experience (Adapted from Buccini and Padovani [2007])

hearing, touch, taste or smell. "Feeling" deals with emotional reactions originated from the use of the product. Social experience involves the behaviour patterns that lead to interaction and collaboration between individuals. Cognitive is related to the thought and interpretation by the user. Use experience is mainly associated with usability and functionality of the product. Motivational experience is related to the changes in human behaviour during or post usage of the product. Figure 13.3 depicts the different correlation between the six categories from the UX model proposed by Buccini and Padovani (2007).

Wright et al. (2008) proposed a UX framework based on Dewey's pragmatics and the relationship of user's interaction with the technology described by McCarthy and Wright (2004). The authors have come up with a holistic approach of experience with four main threads that are connected and common to all experiences: sensual, emotional, spatio-temporal and compositional. The sensual thread is involved with sensory, bodily engagement with a situation, i.e. the look and feel of a product. The emotional thread refers to "judgments that ascribe to other people or things of importance with respect to our needs and desire", i.e. frustration, desire, anger, joy or satisfaction is directed to another person or thing. The spatio-temporal thread underlines that experiences evolve to a particular situation ("place") at a particular time. Finally, the compositional thread is concerned with the narrative structure of

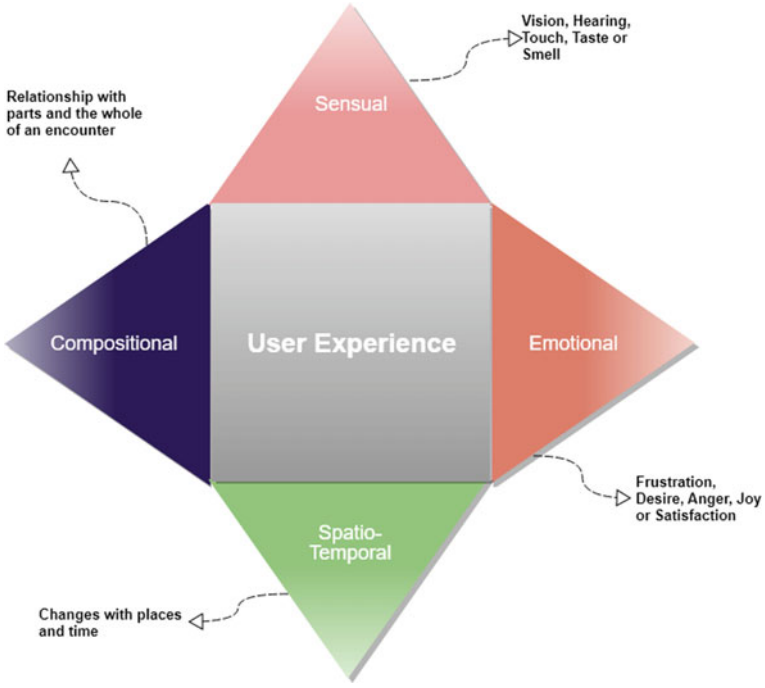

Fig. 13.4 The four connected threads of experience (Adapted from Wright et al. [2008])

an experience, how to make sense of the relationship between parts and the whole of an encounter. Figure 13.4 summarises the UX model presented by Wright et al. (2008).

13.4 UE Frameworks

The terminology "User Engagement" has been a buzzword in a variety of domain and application areas. This term as it is can be conflicting with "User Experience" as they both reveal certain aspects of a product that are deemed to provide comfort, immersion and motivation. Yet, UE has various differentiating factors with UX. As introduced earlier, UE is "a quality of interactive UX" thus highlighting a more qualitative dimension of a product. In some literature, it is often differentiated as a "non-passive consumer of information" that has a direct influence on engaging factors such as emotions, immersion, re-enactment, sharing, collaboration, endorsement, promotion, etc. (O'Brien 2016). In a more contrasting perspective, UE can be considered as the catalyst of the prior experiences that subsequently lead to a re-enactment of the same experience. For instance, the measurements of UE for a museum can be as follows: number of visits, number of activities, time spent per visit/activity, number

of endorsements or promotions, etc. As discussed previously, the term "UE" has been interrelated with "UX" and it has not been deciphered properly in earlier studies. In this section, the granularities of UE are explained using related frameworks.

Pine and Gilmore (1998) introduced the Experience Economy to illustrate the four realms of consumer experience as follows: Entertainment, Educational, Escapist and Esthetic. The model is based on two dimensions: involvement, ranging from passive participation to active participation and the desire, ranging from absorption to immersion. For instance, the passive-active participation can be related to "those following a soccer game on TV versus those attending to the soccer game" whereas absorption-immersion connection can be explained by "those in a ground stand of a sports event versus those in the field". Figure 13.5 provides the classification of the four realms of experience classified by a spectrum of connection (immersion and absorption) along the vertical, and a spectrum of participation (active and passive) along the horizontal line of the model.

Positive Engagement Evaluation Model (PEEM) (Rutledge and Neal 2012) is a model that has been designed to incorporate holistic, qualitative experience in interactive and mobile applications. The model is based on several concepts from positive psychology, narrative transportation theory, psychological flow theory, cognitive psychology and perception theory. PEEM comprises of nine elements: goal, attention, concentration, interaction, content, identity, collaboration, enjoyment and satisfaction. The goal element addresses whether the goal of the applications is clear and aligned accordingly to the user needs and tasks. The attention investigates the

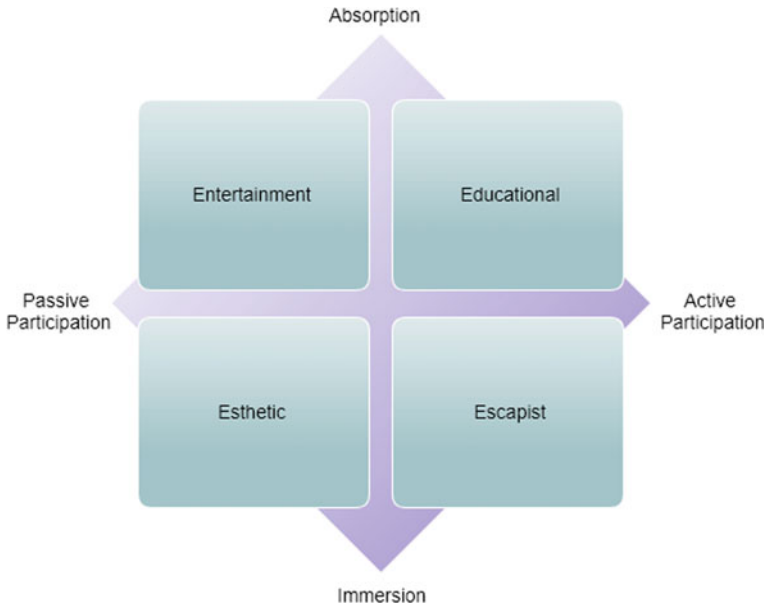

Fig. 13.5 The four realms of experience (Adapted from Pine and Gilmore [1998])

application tasks and their sequence. Concentration is accountable to keep the user attention on the application. The interaction investigates whether the application provides a clear progression from task to task. The content element addresses the media used in the application and whether the media used is seamless to execution. Identity focusses on the tasks of the application that should integrate the user into the experience. The collaboration encourages social aspects of the application. Finally, enjoyment and satisfaction is a mode of motivation or encouragement that users repeat their use of the application as well as sharing their experiences in the forms of ratings and comments. Figure 13.6 provides a graphical layout of the PEEM model.

O'Brien and Toms (2008) deconstruct the term engagement to reflect the people's experiences with technology. The authors carried out critical incident interviews with users of different types of technologies to model the process of UE. The results have indicated that engagement is a process comprised of four distinct stages: point of engagement, the period of sustained engagement, disengagement and re-engagement. The point of engagement may occur at any point during the interaction when the users delve beyond the mechanistic or routine level and invest themselves in the interaction. The period of sustained engagement is where users feel part of the interaction through an awareness of what the system is doing (feedback) and feeling connected to the technology. Disengagement is associated with positive emotions (user's needs and motivations are satisfied and they feel successful) or with negative feelings of frustration, uncertainty, being overwhelmed by challenges or information or loss of interest. Users may cycle through the stages of engagement several times during a single session, thus re-engagement is intrinsic to the model.

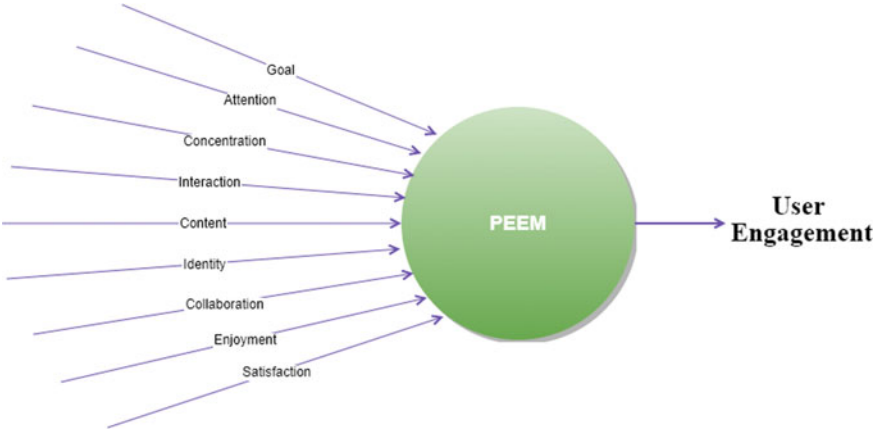

Fig. 13.6 The PEEM model (Adapted from Rutledge and Neal [2012])

13.5 UX and UE Frameworks for AR-CH Systems

The generic UX and UE frameworks have been elaborated and analysed in the previous sections. The terminologies have been described and differentiated to reach a common perspective on the nature of this study. The questions *(1) What UX and UE terminologies are? (2) What are the differences between the two terminologies? (3) What are the related frameworks? (4) How the related frameworks have improved tech-driven systems?* have been addressed in the previous sections. Yet, these questions have been answered without prior knowledge on the integration to AR-CH systems. This section concentrates solely on the UX and UE frameworks that have been modelled for AR-CH systems. The recent UX and UE frameworks in the AR-CH domain are enumerated, analysed and discussed in this section.

Han et al. (2018) presented a UX model for AR applications in urban heritage tourism through the identification of AR-related factors that influence users' satisfaction. This study extends the theoretical aspect of the UX model by Hassenzahl (2004) through the empirical confirmation of the work by Mahlke (2008). The initial stage consisted of data collection through a targeted number of groups. The data were analysed using thematic analysis to examine the alignment of the new themes and to investigate the emergent themes from the focus groups. The findings reveal that the UX is formed by the correlation of product features and the perceptions and experiences of tourists. Using the theories from Hassenzahl (2004), the formulated UX model has taken a similar shape. The UX model is depicted in Fig. 13.7. The authors have tackled each component independently to have a rationale perspective of all elements (characteristics) that are required. For instance, the attribute "content" has been associated with "personalised information", "information on local venues", etc. The product characters have been expanded with the pragmatic and hedonic attributes. Amidst all the attributes proposed in Fig. 13.7, the authors stressed that simplicity is a key driver for users next to accessibility and convenience. The hedonic aspect uncovered the emotional attachments that users can feel while using the system. The authors found that the visitors were very keen to accept the system since it supplemented their interest on the heritage aspect.

Figure 13.7 is an exploded UX map of the Hassenzahl 2004 UX theories. All the characteristics have been carefully identified in virtue of their functioning and output towards a user-centric approach. Moreover, the domain of the application is equally important in the derivation and selection of the correct characteristics. The environment on which the system should work is unequivocally central in moulding the UX model. In this way, designers and developers of such systems should be focussed on both these aspects. Though this model has been formulated with a smaller dataset, it certainly provides an initial starting point for researchers and practitioners in the field.

Tom Dieck et al. (2018a) carried out a study to examine the visitor engagement through AR at science festivals. The aim of the study is to investigate how educational, esthetics, escapist and entertainment experience using AR affect visitor satisfaction and memorable experience using the experience economy theory. At a preliminary

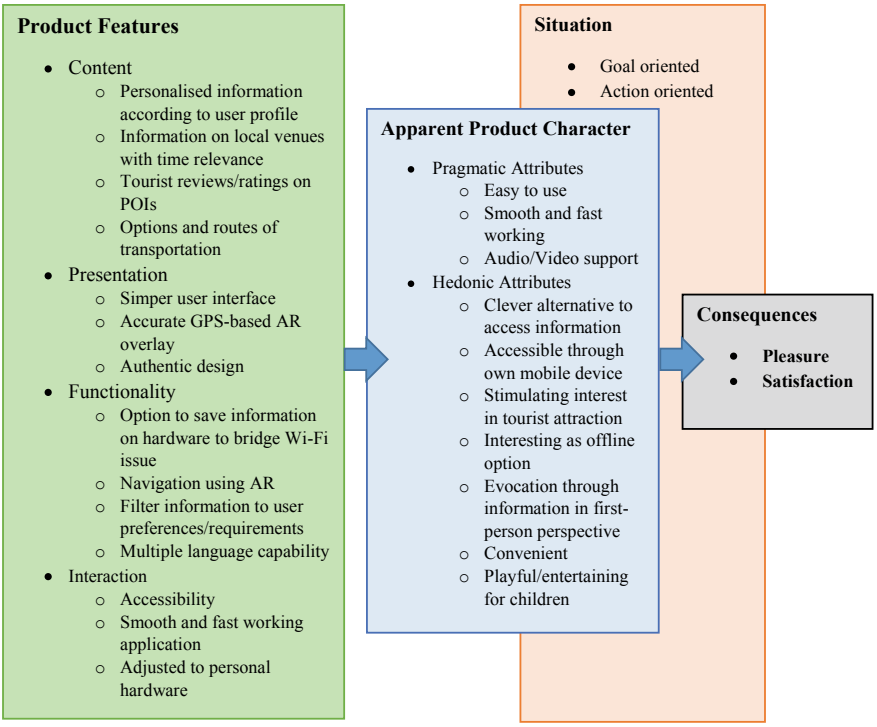

Fig. 13.7 UX Model for AR application in urban heritage tourism (Adapted from Han et al. [2018])

stage, a set of questionnaires was employed to identify and analyse the UE elements that have a greater influence on the human behaviours. From the findings, a basic theoretical framework of engagement has been conceptualised. Figure 13.8 depicts the model and relationships of the components. For instance, the authors concluded that aesthetics has a positive effect on education, entertainment and escapism. Similarly, the flow goes in the same trend (as per Fig. 13.8) until the "engagement" element is satisfied. In this study, the contributions were primarily to show a novel conceptualisation of experience economy and the links between memory and satisfaction

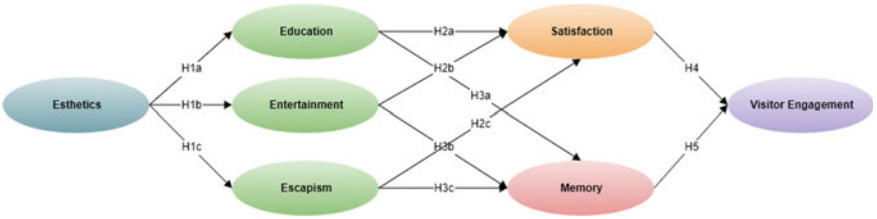

Fig. 13.8 Visitors' engagement model (Adapted from Tom Dieck et al. [2018a])

Table 13.1 The relationships between the antecedents

Hypothesis	Antecedents/experience	Positive effects on
H1a	Esthetics	Education
H1b		Entertainment
H1c		Escapism
H2a	Education	Satisfaction
H2b	Entertainment	
H2c	Escapism	
H3a	Education	Memory
H3b	Entertainment	
H3c	Escapism	
H4	Satisfaction	Visitor Engagement
H5	Memory	

leading to visitor engagement. Table 13.1 summarises the connections between the first, second and third tiers of Fig. 13.8.

The study of Tom Dieck et al. (2018a) extends the UE theories by Pine and Gilmore (1998). The engagement of visitors is theoretically conceptualised by the hypothesis in Table 13.1. However, the authors emphasised that AR experiences are originated with aesthetics rather than other elements. The authors have even evaluated the degree of positive effects on the aforementioned elements, but they have limited their study on four realms of experience (aesthetics, education, entertainment and escapism). In this context, more factors should have been identified to validate the determinants of visitor engagement.

Hammady et al. (2018) explore the UX of AR applications in museums in Leeds, UK and Cairo, Egypt. This paper delineated a clear framework of UX of AR applications in museums by emphasising on the UX theories. The authors have thus come up with an application called "MuseumEye" which encompasses a combination of multimedia content such as audio commentaries, video representations and a gallery of images. A UX design process model has been put forward in prior to develop the application. The model consists of three stages as follows: requirements, design for UX and evaluation. In the requirement phase, skills and data are required before starting to design and develop the system. The second phase "design for UX" determines the prerequisites of the application, e.g. museum context, visitors, technical information on AR. The third phase "Evaluation" assesses the UX experience of the AR application in the museum. This study contributes on synthesising a UX design model for AR application to reach the optimum levels of user interactions required that reflect ultimately on the entire museum experience.

The authors have evaluated the UX aspects based on the following parameters: immersion, useful, easy to use, interesting, intuitive and visuals. The assessments were carried out in both sites; Leeds, UK and Cairo, Egypt. The results show that the AR applications have been useful, as most of the respondents found it useful. In this study, the process of deriving the UX aspects has been supported by the three

stages (requirements, design for UX and evaluation). They have not explored a UX framework in the first place to weigh on their prototype design model. As such, the UX factors in this work are limited to have an enhanced contribution on the museum experience.

13.6 Classification of UX and UE Factors in AR–CH Systems

The sections above have provided a comprehensive narrative of the UX and UE frameworks. At the preliminary stage, the generic UX and UE frameworks are reviewed that are conceived in the technological domains. Next, the chapter is focussed on the UX and UE frameworks on AR applications in the CH domain. The aforementioned sections have provided enough information to understand the underlying components of the UX and UE frameworks and create a virtual mapping of the requirements. In this endeavour, this section synthesises the UX and UE factors from the related frameworks discussed earlier. A classification of the factors is carried out methodically. At an initial level, the UX and UE factors are identified at a broader perspective, i.e. technological level. The second phase carries out a mapping of the requirements of the AR-CH applications (including MAR) with UX/UE factors. The third phase consists of evaluating the UX/UE factors in the CH domain.

The recent developments in AR (including MAR) have made the user-centred design process even more challenging since the users of emerging technologies find it difficult to express their needs because of their lack of knowledge in the technology's potential (Olsson 2013; Lee and Hannafin 2016). The concept has changed from a technological-driven perspective to a more user-centric perspective. The tangibility, interactivity and pervasiveness of AR have brought various instances of the initial perception of the technology.

13.6.1 UX Factors in AR Systems

In consideration of the literature in this field, Table 13.2 presents the expected UX elements. A new breadth of elements is included to adapt to the recent advancements of AR technology. In the same vein, the identified UX and UE elements will take into consideration the current users' expectations and the recent evolution of AR.

Table 13.2 presents a synthesis of characteristics of the desirable UX elements relevant for futuristic AR services. Twenty elements have been identified and categorised from the model proposed by Buccini and Padovani (2007). As a starting point, the model of Buccini and Padovani has been chosen for exploration since it comprises enough experiential categories. Each category has been expanded to retrieve the UX elements deem for AR context. Moreover, the models of Hassenzahl

Table 13.2 The identified UX elements for AR

#	Expected UX characteristics	Product features
1	Usefulness	Readily available context information for augmentation
2	Efficiency	Provides different layers of information
3	Accessibility	Device and environment free
4	Ease of Use	User-centric/Simple UI
5	Mobility	Navigating freely
6	Awareness & Knowledge	Real-time and Location-based enablement
7	Intuitiveness	Augmentation at the focal point
8	Personalisation	Personalised contents
9	Delightful	Showcasing hidden aspects
10	Liveliness	Novelty in the superimposition
11	Playfulness	Gamification element
12	Appealing	Multimodal interface
13	Immersive	360 degree panorama & 3D view
14	Connectedness	Connecting with other people
15	Sharing & Collaborating	Sharing and teaming with other people
16	Stimulation	Immersing on the experience
17	Evocation	Digital reconstruction of past events
18	Creativity	Storytelling
19	Dynamic	Contents are changed at regular intervals
20	Distinctive	AR contents change at the next encounter

(2004) and Wright et al. (2008) have also facilitated the inclusion of certain UX elements to cover up possible user expectations. Above all, the list of elements has been inspired from the work by Olsson (2013). Some of the elements have been tweaked to reflect the current user expectations and the changing dynamics of AR technologies. Some of the elements have been tweaked to reflect the current user expectations and the changing dynamics of AR technologies. For example, "usefulness" has substituted both "empowerment" and "meaningfulness" as characterised by Olsson (2013). The term "usefulness" in AR can be inferred as providing valuable information, therefore empowering the users at the same time. The characteristics "delightful" have consolidated both "amazement" and "surprise" since it implies "the experience has been enjoying and at the same time it provides some facets of revelations". In regards to the recent developments of AR, the term "immersive" is more appropriate to signify that the experiences should be engaging and arouse the users' senses that they are inside the experience. In another vein, "sharing and collaboration" instils more towards a sharing and learning cultures among the users thus creating certain bonds between them.

13.6.2 UE Factors in AR Systems

In this subsection, the discussion is oriented on the UE factors for AR services. As mentioned previously, very few works have focussed on the UE elements in the AR context. Many works have conflicted UX with UE or vice versa, and they have not provided a clear direction on the significance that they have in AR systems. In the context of the literature presented in this study, the differentiation between UX and UE is unequivocal. Recapitulating, UE is a quality of UX which can be attributed by the measurements of, but limited to: amount of time, number of activities, endorsements, promotions, suggestions, challenges-faced and solved and connecting/collaboration with users. Table 13.3 lists the UE elements from a conglomerate of existing models as follows: Experience Economy (Pine and Gilmore 1998), PEEM model (O'Brien 2016), Flow theory (Romero and Calvillo-Gámez 2011), UE theories by O'Brien and Toms (2008) and engagement model by Tom Dieck et al. (2018a). Existing UE elements have been identified from these models, and in turn they have been grouped as follows: initial point of engagement, the period of engagement and continued engagement. In addition, new elements have been included based on our own perception of engagement. For instance, exploration,

Table 13.3 The identified UE elements for AR

#	Expected UE factors	Engagement level
1	Aesthetics	Point of engagement
2	Interest	
3	Goal	
4	Novelty	
5	Interactivity	Period of engagement
6	Content	
7	Attention	
8	Exploration	
9	Awareness	
10	Feedback	
11	Concentration	
12	Learning	
13	Gamification	
14	Collaboration	
15	Sharing	
16	Immersion	Maximum engagement
17	Challenges	
18	Identity	
19	Satisfaction	Re-engagement/disengagement
20	Memorable	

gamification, sharing, immersion and challenges are the novel elements put forward in this study. Deciphering the proposed model, the initial start of engagement is often triggered by the following: (1) appearance/attractiveness of the product, (2) the user's interest (or things that captured their attention), (3) the users' goal that they want to achieve and (4) the new features proposed in the product.

Table 13.3 is a comprehensive list of the UE factors derived for the AR context. The factors have been further grouped in conjunction with their engagement propensity. For example, aesthetics is an important driver for interactivity, which dictates whether users accept or reject the technology (Pallud and Straub 2014; Limerick et al. 2019). User's interest is likely to incline on the amount of information available, a sense of exploring new places and being well-informed about new developments. Kim and Chan (2003), Cruz-Benito et al. (2015) and O'Brien (2016) demonstrate that interest and goal have an impact on content, exploration and awareness. In the same propensity, the novelty can be favoured by various antecedents such as interactivity, content, exploration and awareness (Zhuang et al. 2018). Thus, aesthetics, interest, goal and novelty are the four factors that are grouped in "point of. Interactivity can be the first precursor of engagement after the user has initially started using the AR system. Lindgren et al. (2016), Barrio et al. (2015) and Cruz-Benito et al. (2015) state that interactivity and attention have a positive influence on learning and gamification. Attention can arouse the user's consciousness towards more concentration and learning. In the same category, exploration can positively influence the following factors: learning, gamification, collaboration and sharing (Barrio et al. 2015; Lee and Hannafin 2016). Lee and Hannafin (2016) infer that both collaboration and sharing have a direct connection to identity. These factors characterise the likes and dislikes of the users, thus they play an important role in the identification of users' personalities. In this connection, interactivity, content, attention, exploration, awareness, feedback, concentration, learning, gamification, collaboration and sharing are the factors that are grouped in the "period of engagement" level. The final derivative of engagement can be entitled to satisfying experience and memories (Lee and Hannafin 2016; Kim and Lee 2015). Yet, immersion, challenges and identity are the three core factors which contribute to maximum engagement, thus reaching the ultimate step of satisfaction and memorable experiences (Lindgren et al. 2016; Ali et al. 2016).

13.6.3 Classification of AR–CH Systems

At first glance, AR-CH systems can have a wide range of characteristics that could differentiate among them. For example, the functioning of the system will vary in terms of the featured services, environment, technologies or any factors that could have direct link with the workability of the system. The subsections above have shed light on the key takings of the UX and UE frameworks in AR systems. Yet is imperative to have a holistic view on the characteristics of AR-CH systems and interrelate them with the UX and UE factors. In this perspective, AR-CH systems are evaluated against a derived list of AR-CH characteristics. Eventually, this subsection

provides information on the potential UX and UE factors that can be drawn from the evaluation. Twenty works have been shortlisted based on the criteria defined in the research methodology earlier (see Fig. 13.1). Initially, an eccentric list of AR-CH characteristics is derived from the finding of Sırakaya and Sırakaya (2020), Akçayır and Akçayır (2017) and Wang et al. (2016). The reviewed works have provided additional novel types of characteristics that should be included. Table 13.4 presents a complete synthesis of the information on AR characteristics. Table 13.5 reviews the AR systems with the derived AR characteristics. Figure 13.9 formulates a relationship of the AR-CH characteristics versus the common UX and UE categories.

As shown in Table 13.5, all the related works have been reviewed thoroughly with the defined characteristics presented in Table 13.4. The assessment provides an indication of the area of focus for each system. For instance, "Real-time augmentation" is a prerequisite element for designing AR systems. The AR information should be accurate and precise to the users' field of view. In this perspective, this element should cater to all the underlying components such as data acquisition, user and device positioning, tracking and registration and superimposition. AR designers should imperatively focus on this element during the initial conception of such systems,

Table 13.4 Characteristics of AR-CH

Characteristics	Abbreviation	Description
Real-time Augmentation	RA	The perfect-inch augmentation at the right place and at right time
Fast interaction	FI	Simple UI that allows a quick interactivity between the user and system
Context-layering	CL	Augmentation of the surrounding environment
Object-layering	OL	Layered AR information is available for a particular object
Point of interest	POI	AR information is available in places of interest
Navigation	NA	Navigation map connecting the routes of the POI
Pervasive	PE	Continuously augmenting the physical world with respect to the context of the user
Storytelling	ST	3D/4D digital reconstruction of past events using AR
Gamification	GM	Inclusion of game elements to create a sense of playfulness
Sound and haptic feedback	SH	System carries out augmentation with sound and haptic mediums
Awareness and learning outcomes	AL	Increased insight into objects surrounding in a visually challenged environment

Table 13.5 Assessment of AR systems with defined characteristics

AR systems	Application area	AR characteristics										
		RA	FI	CL	OL	POI	NA	PE	ST	GM	SH	AL
LecceAR (Banterle et al. 2015)	Museum	•	•	–	•	–	–	•	–	–	–	•
AREAv2 (Geiger et al. 2013)	–	•	•	–	•	•	•	•	–	–	–	•
VisAge (Julier et al. 2016)	Town site	•	•	–	–	•	–	–	–	–	–	–
Svevo Tour (Fenu and Pittarello 2018)	Museum	•	•	–	–	–	–	•	•	–	•	•
Alleto et al. (2015)	Museum	•	•	•	•	–	–	–	•	–	–	•
Ramtohul and Khedo (2019)	Historic building	•	•	•	•	•	–	•	•	–	–	•
Han et al. (2018)	Archaeological site	–	•	•	–	–	–	–	–	–	–	–
Galatis et al. (2016)	Archaeological site	•	•	•	•	–	–	–	–	–	–	•
Gutierrez et al. (2015)	Historic building	–	–	–	–	–	–	–	–	–	–	•
New Philadelphia (Amakawa and Westin 2018)	Town site	•	•	•	•	–	–	•	•	–	–	•
Hammady et al. (2016)	Museum	•	•	•	–	–	–	•	–	•	–	–
Vecchio et al. (2015)	Town site	•	–	•	•	–	–	–	–	–	–	•
Cavallo et al. (2016)	Town site	•	•	•	•	–	–	–	•	–	–	•
Chin et al. (2017)	Historic building	–	–	–	–	–	–	–	–	–	–	•

(continued)

Table 13.5 (continued)

AR systems	Application area	AR characteristics										
		RA	FI	CL	OL	POI	NA	PE	ST	GM	SH	AL
Duguleana et al. (2016)	Historic building	•	•	•	•	–	–	–	•	–	–	–
Leach et al. (2018)	Cultural heritage	•	•	•	•	–	–	–	•	–	–	•
Tom Dieck et al. (2018b)	Art gallery	•	–	–	–	–	–	–	–	–	–	•
Pantille et al. (2018)	Museum	•	•	–	•	•	–	–	–	–	–	•
Pierdicca et al. (2015)	Archaeological site	•	•	•	•	•	–	–	•	–	–	•
Hammady et al. (2018)	Museum	•	•	•	•	•	–	–	–	–	–	•

Fig. 13.9 AR-CH design characteristics

which explains the 100%-mark percentile. The next characteristic is "Awareness and Knowledge" which shares a large proportion of interest in AR systems. The works have focussed on providing a substantial amount of information which contributes to both the spatial and cognitive aspects of the users. Such systems comprise of multi-tiered interfaces which are interconnected to provide a real-time augmentation. In this endeavour, AR systems necessitate a quick intervention from users so that the augmentation can be carried out at a reasonable time delay. This process relies on having a user-centric UI that enables a smooth interaction and easy-to-go interface. Futuristic AR systems are implementing "storytelling" and "gamification" features to provide an edge over traditional AR systems. They have gained momentum during the recent years and can be perceived as the next-gen AR systems. This section has provided an insightful indication on the area of concentration in such systems. It is imperative to expose these characteristics in relations to the associated UX and UE factors. Figure 13.9 depicts a comprehensive mapping of the characteristics and the associated UX and UE factors.

The mapping on Fig. 13.9 provides the derivations of the UX and UE factors from the characteristics of AR systems. The information is insightful for developers and

designers in the field as they can link the UX/UE factors to a specific characteristic. As mentioned above, the characteristics have been derived methodically with the recent findings carried out in this field. For instance, "Real-time Augmentation" is a prerequisite in the AR context because of the agility of the systems that make them very reactive and responsive. The speed of the augmentation should be in-line with the objects in the focus point. At the same time, such systems should provide accurate information for the particular context and should be transportable anywhere in the environment. "Awareness and Learning" have the most number of attributes associated with it. It is important because most of these systems have in focus to provide substantial information that would enhance both the spatial and cognitive aspects of the users. In the same vein, these systems can provide information that were never accessible before. The next section provides a classification of the UX and UE most influential factors in AR-CH.

13.7 Influential UX and UE Factors for Cultural Heritage AR Systems

AR technologies have been a breakthrough in the heritage industry. More and more CH institutions are adopting AR to create the missing sparks from their static environment thus making it more energetic. As this technology is maturing in the CH domains, UX and UE factors should always be in the limelight to provide an edge over the causal experiences. These factors are core aspects of the HCI that strengthens the relations among various stakeholders, e.g. visitors, products and exhibits. This section concentrates solely on the UX and UE factors of AR systems in the CH domain. Based on the identified UX and UE factors in this section, an assessment on each factor to see the most influential ones for the CH domain. Table 13.6 presents the impact assessment on the UX factors and Table 13.7 is the impact assessment on the UE factors.

The assessment from Table 13.6 provides an understanding on the importance of the different UX characteristics. The most impactful categories for the CH field are: instrumental, cognitive, emotional, sensory and motivational. The category "instrumental" revolved mostly around the practical usage of the AR system in the CH domain. For example, the composition of a museum is surrounded by several exhibits which are closely arranged to each other. Thus, the system should work effectively and flawlessly in order to present the AR information to the visitors at the right moment. Second, the interest of "learning" is certainly a priority when it comes to CH field. Visitors want to know the existence of these exhibits and the events associated with the same. In this vein, "cognitive" should be included as UX category for CH domain. The "emotional" construct is mostly related to the human behaviour while the visitors are engaging with the system. For example, an augmentation can highlight elements in a painting or artwork that are not visible to naked eyes. This can create a sense of excitement, joy or achievement, and it is important to emphasise

Table 13.6 Impact Assessment of UX factors for CH domain

Experience categories	Expected UX characteristics	Impact assessment (High—H, Medium—M, Low—L)	Rationale
Instrumental	Usefulness	H	All information should be available for a particular exhibit
	Efficiency	H	AR information should be displayed at every angle of the exhibits. Each users' action should correspond to feedback from the system
	Accessibility	H	AR should work irrespective of the device types and the environment
	Ease of Use	H	The users should be able to interact effortlessly and achieve the desired output without difficulties
	Mobility	H	System should be readily transportable anywhere on the site
Cognitive	Awareness and Knowledge	H	AR contents should be relevant to the subject and enhance the users' apprehend-ability on the exhibits
	Intuitiveness	M	The naturalness should be respected and kept within the users' context
	Personalisation	M	Personalised contents can be available at users' demand
Emotional	Delightful	H	The system should propose contents and features that make the experience enjoyable
	Liveliness	H	The AR context should be dynamic and propose new information

(continued)

Table 13.6 (continued)

Experience categories	Expected UX characteristics	Impact assessment (High—H, Medium—M, Low—L)	Rationale
	Playfulness	M	Game elements like a quiz to test the knowledge of the visitor
Sensory	Appealing	H	Interface should be attractive to capture the attention of visitors
	Immersive	H	Different layers of augmentation to captivate the users into the experience
Social	Connectedness	L	Users can connect with others at their wish
	Sharing and collaborating	L	Users can share and collaborate at their own demands
Motivational	Stimulation	M	The experiences should be exciting enough to arouse the interest of visitors
	Evocation	H	The experiences should be memorable to incite the users to come back again
	Creativity	M	The experiences should enable users to develop new skills
Spatio-Temporal	Dynamic	M	The contents should be changing at regular interval of times
	Distinctive	M	The content should be changing at the next experience

on these attributes for a working solution in a CH site. Third, the "sensory" aspect enables a flow of embodiment with the exhibits. Initially, the visitors can feel attracted by the looks and feels of the product, amplifying their sense of see, touch and taste. Furthermore, the augmentation should be carried out in such a way that visitors feel that they are inside the experience and their involvement is important. Last but not the least, "motivational" category inspires the visitors to discover new elements by themselves, develop or refine their skills and create a memorable event during their

Table 13.7 Impact assessment of UE factors for CH domain

UE factors	Impact assessment (High—H, Medium—M, Low—L)	Rationale
Aesthetics	H	The design and layout of the interfaces should be appealing
Interest	H	Users should show interest in the heritage industry before using the system
Goal	H	Users should have the aim to meet before starting the experience process
Novelty	H	The proposed contents and features should be original and innovative
Interactivity	H	The flow between users' actions should be spontaneous
Content	H	The contents on a particular exhibit should be readily available
Attention	H	The augmentation should be at the focal point
Exploration	M	The AR systems can propose users to make discovery of the exhibits by themselves
Awareness	H	Users should be aware of its surroundings and the system should push notification at regular times of interval
Feedback	H	The feedback from the system will keep the users focus on his/her user experience
Concentration	H	The system should maximise the concentration attribute to promote more learning and engagement from users
Learning	H	The augmentation should highlight elements that enhance learning on the users
Gamification	M	The system can have game elements to entertain the users in their engagement
Collaboration	M	Users can collaborate or create relationships with respect to their experience
Sharing	L	Users can share their experiences at their own demand
Immersion	H	The layers of augmentation should provide an immersive experience to the users. The users should be felt that they are inside the experience

(continued)

Table 13.7 (continued)

UE factors	Impact assessment (High—H, Medium—M, Low—L)	Rationale
Challenges	M	The AR should propose "challenges" at each level of their completed experience, making them more engaged in the completion of their activity
Identity	L	The proposed contents should have a positive influence on building oneself skills
Satisfaction	H	Globally, the experiences should be satisfying
Memorable	H	The experience should be mesmerising to engage users into more future experiences

experience. This factor influences the visitors to continue using the product for the long term.

Table 13.7 presents the impact assessment of the UE factors for the CH domain. Similarly, the assessment has been carried out taking into consideration the general requirements of an AR system and the functioning of a CH site.

From Table 13.7, it has been found that most of the factors are highly recommended for the CH domain. Fourteen attributes have been categorised as "highly influential" which represents around 70% of the total factors. Though the assessment has not been proven using statistical equations modelling, it provides some avenues on the contributing UE factors for a CH domain. For example, aesthetics and novelty are among the first factors that visitors will check before usage. During the period of engagement, factors such as interactivity, content, attention, concentration, learning and immersion play an important role. For instance, the content should be relevant to the field of view of the user, thus keeping the users attentive and concentrated on the focal objective of the exhibit. The learning interest would eventually be enhanced and users might be driven to know more on the particular object. The dimension of the experience can be augmented by immersion. Immersion can be triggered by the novelty of the features and contents proposed by the system. It can also be related to storytelling, 3D/4D, or even sound effects that render the experience more real and visitors can feel that they are inside the experience. In another perspective, gamification, collaboration and challenges have been rated as medium influencers. To the best of our knowledge, most visitors of a CH site have an objective goal when they visit a museum. The interest might be uncommon, but most of them want to enhance their cultural learning. These three attributes can provide a positive impetus on the total UE, but the features associated with these elements can be proposed at users' demand. Hence, all these attributes contribute to satisfaction and memorable factors. The re-engagement process occurs on how satisfied and memorable the previous experience was.

13.8 Research Challenges and Future Directions

This study has proposed new frameworks of UX and UE for the AR-CH systems. The frameworks have been conceived with the current literature in the field and with the consideration of the current trend happening in the AR field. First and foremost, this study has opened new research directions on the UX and UE aspects for AR-CH systems. The following existing gaps were derived from the findings of this research:

UE Literature
In the initial stage of the study, a general exploration of the UX and UE frameworks has been carried out to have a good understanding of all the stakeholders. Later, the frameworks have been narrowed down to tech-driven systems for the sake of this study. Due to very few works in this area, the frameworks have been selected based on their relevance in this field. Moreover, most of the UX frameworks covered the UE aspects in their models. In this study, UE frameworks have been declassified separately from the bias of our understanding on this topic because of the limited number of works in the area. The findings can be bias or generalised. As such, a clear delineation of UX and UE is required opening a research avenue for future works.

Conflicting UX and UE Terms
Though this study has attempted to decompose UX and UE terms individually, some factors can resonate to have the same meaning thus can be conflicting with each other. For instance, the derived UX characteristics: intuitive and liveliness can portray the same connotation at first glance. Another example of the UE factors can be attention and concentration, which have similar meanings. This conflict is mostly related to the limited number of works in deciphering the UX and UE factors. Again, this argument is widely associated with the above-mentioned point, where a critical assessment of UX and UE factors are required in the AR-CH field. In this perspective, a more granular characteristic can be derived to have a more explicit understanding of the UX and UE factors in the AR-CH domain.

Negative Experience
Most of the studies have concentrated on positive experiential elements and have not taken into consideration the negative ones. For example, “frustration” can part of the UX and it can be measured while the user is using the product. In another perspective, the disengagement factors in the UE model have not been studied. Interruptions in the systems can be one example of disengagement attributes. These negative factors can be further investigated to enhance the current models of UX and UE and eliminating the factors that are not necessary to be included. In this vein, this opens new avenues for research in this field.

13.9 Conclusion

This study has provided an extensive evaluation of the UX and UE factors that have direct influences on AR-CH systems. At the preliminary stage of the study, some general UX and UE factors are studied. The literature has been analysed thoroughly to identify the research gaps in the field of UX and UE for AR-CH systems. The study has proposed the model of UX and UE, respectively, for an AR system. The proposed UX framework has been inspired from the works of Olsson (2013). Novel elements such as accessibility, ease of use, mobility, personalisation, immersive, sharing and collaboration, dynamic and distinctive have been included in the proposed UX framework. These inclusions have taken into consideration the research gaps of existing literature. The conceptual model of UE has been put forward from the understanding of the topic and the few existing literature available on the topic. A comprehensive UE framework has been devised that demonstrates the following: a point of engagement, the period of engagement, maximum engagement and re-engagement. The model has emphasised on terms such as: aesthetics, novelty, learning, awareness, gamification and challenges which will contribute to a satisfying and memorable experience. Each UX and UE factor has been assessed qualitatively with the literature available in the field. Finally, this chapter identified the influential UX and UE factors for AR-CH systems and they are assessed qualitatively.

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