


User eXperience in educational eXtended Reality applications in the Cultural Heritage domain

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Abstract

With the increasing prevalence of educational eXtended Reality (XR) Cultural Heritage (CH) experiences, it becomes increasingly important to understand the user, and learner, experience of such installations and develop bespoke methodologies to capture and evaluate these experiences. Our work aims to expand the existing knowledge of User Experience (UX) in CH incorporating XR, especially for educational aspects inside, by displaying and analysing UX understanding and evaluation methods. Through investigation and research on UX work of applications described from various sources, this paper summarises the current trends, limitations, and challenges of UX evaluation in this field and represents the direction of future work.

CCS Concepts

• **Human-centered computing** → HCI theory, concepts and models;

1. Introduction

UX is generally understood as inherently dynamic, given a person's ever-changing internal and emotional state and differences in the circumstances during and after an interaction with a product [KC20]. Developing educational CH applications requires considering learning experiences. Whether for formal or informal learning, interactions shape how learners perceive the usefulness and usability of technology for achieving learning goals [KN18], with emotional components influencing a range of learning outcomes, including engagement and higher-order thinking [TGGLH22]. According to Fast et al. [FBGL18], XR refers to all real-and-virtual combined environments and human-machine interactions. CH applications have used XR to improve learning experience and engagement [HGLS22, LCC23]. However, challenging interactive technologies can create negative emotions, which hinders meaningful learning [TGGLH22]. Overall, the factors that affect UX in CH applications with educational significance are complicated.

2. Methodology

2.1. Search strategy and screen papers

We are conducting a systematic review employing the search strings shown below. Figure 1 shows the screening process for these articles. A total of 59 papers were identified.

("Augmented Reality" OR "AR" OR "Virtual Reality" OR "VR" OR "Mixed Reality" OR "MR" OR "extended reality" OR "XR") AND ("Cultural Heritage") AND ("Education" OR "Learning") AND ("User Experience") AND ("User Study")

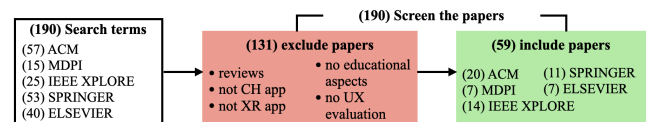


Figure 1: Search and screen process.

2.2. UX perspectives

Achieving the expected behavioural goals in the work settings is related to the instrumental value of the product. Ensuring the interactive product's instrumental value became the major endeavour of UX [HT06]. Besides "the instrumental" perspective, Hassenzahl and Tractinsky suggested another three UX research threads to stimulate further research: addressing human needs beyond the instrumental, affection and emotion, and the nature of experience [HT06]. Each perspective contributes a facet and also sharing ideas and arguments with other perspectives. We use this as a lens to understand current approaches to UX.

3. Findings and discussion

3.1. Integrating UX in educational XR CH application

Based on Hassenzahl and Tractinsky's theory, from "the instrumental", research focuses on user-centred analysis and technology evaluation, such as testing usability [HGLS22], effectiveness [CBL*22], dependability [LTC19] and presence [FZX*20] to ensure the achievement of the expected interaction and experience by

*Specific UX evaluation methods are clarified in the cells

methods \ UX aspects	usability	ease of use	satisfaction	attractiveness	emotions	engagement	usefulness	presence	knowledge
Questionnaire	UEQ, SUS	SUS		UEQ, AttrakDiff	UEQ, GEQ, PANAS	GEQ, UES, NTS		GEQ, IPQ, ITC-SOPI, QoP, NTS	
Interview									×
Observation			×	×	×		×	×	×
Think-aloud protocol	×		×				×		×
Focus group				×	×		×	×	
Other qualitative methods	AttrakDiff					O'Brien's measurement	×	×	
Objective methods	×	×	×			mEEG, screen recording	×	×	×

Figure 2: Evaluation methods for most frequent UX aspects.

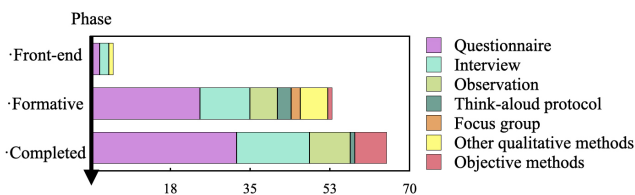


Figure 3: Distribution of UX methods in different phases.

using XR. Associated with “the instrumental”, “beyond the instrumental”, including aesthetic and hedonic aspects (stimulation, identification and evolution) are considered to enrich the overall experience. Among them, stimulation and evolution [KPV*20] related to stimulating learning behaviour and knowledge acquisition are highlighted. Aesthetics and identification are relevant [FAMR19, FP18] but not as emphasized. “affection and emotion” focuses more on positive emotional outcomes, such as enjoyment and satisfaction [HT06, KBBC15, GRW20], and pays attention to users’ emotional needs [LHF*15]. “the experiential” emphasises the situational and temporal nature of technology use [HT06], which are related to the provided CH content, such as stories, and the essential experience through the process of Pre-, During-, and Post Visit. Unfortunately, for UX evaluation, more evidence is required as the current research from this perspective is limited to the design stage.

3.2. UX evaluation in educational XR applications in CH

UX evaluation methods vary by stage of the project. Although evaluation is seen more commonly later in the project, a range of work demonstrates it at the formative phase (Figure 3). Furthermore, while quantitative methods such as Questionnaires are the most common, qualitative methods like Focus Groups [NMK*21], Think-aloud Protocol [KPS*22], and Observations are also prominent in understanding the experience, particularly at the formative stage. Figure 2 summarizes the nine most common UX aspects of educational XR CH experience from previous research and shows whether evaluation methods were used to measure them. Although Ease of Use and Satisfaction are components of Usability, they are sometimes evaluated separately based on the user needs of the application [KPS*22, PLW20]. And, some classic UX methods have been introduced into this field. For example, User Experience Questionnaire (UEQ) is successfully adopted

to assess the overall UX of these educational XR CH applications [DBNN17, LTC19, SJZ*21, RSKI21]. However, it does not fully cover all UX content that researchers seek to measure, such as flow and emotion [DBNN17], satisfaction [RSKI21], and sickness [LTC19], so work has adopted other specific UX methods or developed the bespoke methods. In summary, for the cross-field of XR, CH and education, an integrated UX methodology or model specifically designed for this area has yet to be found within the scope of current research.

3.3. Future work

High-quality UX is the core competitive factor for product development in the CH field [KC20]. So in the future, our work on methods of understanding such UX in educational XR CH is expected to be divided into four stages to be pushed on. The current research is in the first stage, which includes the scope of state-of-the-art UX evaluation methods in educational CH applications with a focus on XR. This research reports the UX trends and expected UX characteristics, which will become the basis for designing the new evaluation criteria. Besides the methods discussed in this research, UX evaluation models proposed and empirically validated in relevant fields, such as Othman’s The Museum Experience Scale (MES) [OPP11] and VMUXE (an evaluation of UX aspects applied to virtual museums) [GGP*13], will also be studied to help map out UX methods for this area. In the second stage, the potential of these selected models will be evaluated through experiments and compared with the current results based on our definition of UX for educational XR applications in CH in the first stage. In the third stage of our research, exploring the learning experience will be focused on as it has been under-explored in previous studies. From an experiential perspective, learning involves transforming experiences into knowledge [Kol14]. Authentic tasks and contextual events are essential in engaging users in an active sense-making process [CLCL20]. Some XR CH applications have already integrated experiential learning theory in their design and development of learning opportunities [MJ*17, CLCL20, BRR*19]. To further understand the learning experience in XR CH education, experiments will be conducted to assess the performance and potential of experiential learning theories in this area. Based on these, a new UX evaluation method for educational XR applications in CH domain is expected to be proposed and validated in the fourth stage.

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