



# A Systematic Literature Review: User Experience (UX) Elements in Digital Application for Virtual Museum

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## ABSTRACT

This paper presented a review of user experience (UX) elements in digital application and proposed a conceptual framework of UX for virtual museum application. The aims of this paper are to identify the elements of UX and propose a conceptual framework according to the UX elements that were identified. The research was conducted by using systematic literature review (SLR) approach based on Scopus and Web of Science databases, with specific inclusion and exclusion criteria. The UX elements that were identified were used to formulate UX model for virtual museum application. This study had identified effectiveness, efficiency, satisfaction and attractiveness as the most reliable UX elements for conceptual framework based on the findings in the SLR analysis. In addition, the conceptual framework contained three groups of constructs to improve the performance quality of virtual museum application, namely virtual museum features, UX factors and UX response. The proposed conceptual model can be a guideline for virtual museum application development.

**Key words:** Emotion, User experience (UX), Usability, UX elements

## 1. INTRODUCTION

Recently, the studies of digital application usage in museums have been increasing dramatically. Most of the museum institutions have started to digitalize the artifact collections for preservation and presentation. Some of the research showed that cultural heritage has a new perspective and will be raised up to a better position in the community when it is being delivered to the digital technology [5]. Therefore, virtual museum is an alternative to the digital form of museum which functions as an archive or repository of artifact and heritage culture, likewise the real museum. Instead of only exhibiting contents, the application is also able to provide knowledge to visitors or users through interactive informal learning [37]. A proper guideline or virtual museum model should be proposed to develop excellent performance of virtual museum and provide positive emotion toward user.

However, most researchers had focused on the aspect of usability of the product without considering the element of user experience (UX)[29] and UX perspective has not consider seriously in technology application [42]. Although, according to [41], value in UX is very important and should be considered from the holistic point of view to develop a good application and UX also become the main focus in order to create emotion quality into interaction. Then, the objectives of this paper are to identify the elements of UX using systematic literature review (SLR) analysis and propose a model of UX for virtual museum development.

## 2. METHODS

### 2.1 Final Stage

This paper is based on a few considerations in which the following research questions that are related to UX of virtual museum application have been designed:

[Q1] What type of UX elements has been used in digital application?

[Q2] How have the UX elements contributed to virtual museum development?

### 2.2 Data Collection

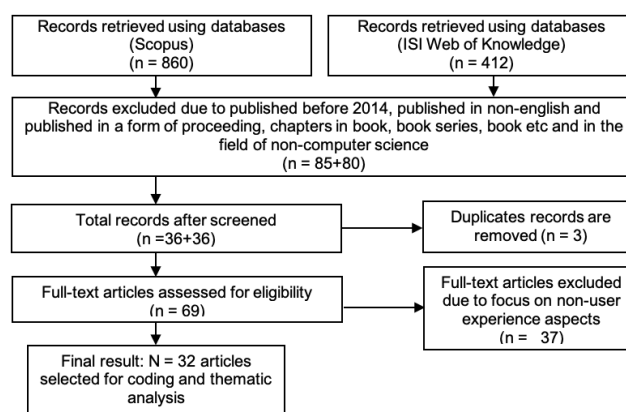


Figure 1: Data Abstraction and Analysis

The literature of the research was conducted by performing a systematic search in Scopus and Web of Science databases with data abstraction and analysis process, as shown in Figure 1. The keywords "Virtualmuseum" or "Digital Museum" or "Application" and "User Experience" were used. Only articles published after 2014 until 2020 were selected. The total number of articles found by using the keywords with specific exclusion criteria was 165, as shown in Table 1.

**Table 1: Screening Criteria**

Criteria	Inclusion	Exclusion
Publication timeline	2014-2020	2013 and before
Document type	Article (research journal, proceeding) and review	Chapters in book, book series, books etc.
Language	English	Non-English
Nature of the study	Focus on User Experience	Not focus on User Experience

**2.3 Inclusion Criteria**

According to the selection criteria, the data extraction should be relevant to computer science field and subdisciplines under UX. Qualitative analysis questions were developed to extract potential articles from the online databases, and as a guideline to gather papers that are related to the research. The qualitative analysis questions that were used during the analysis process and articles screening are shown in Table 2 below. All collected articles were screened and selected based on the Q1, Q2, Q3 and Q4 analysis questions.

**Table 2: Qualitative Analysis Questions**

Questions	Answers
Q1: Was the article about application or system related to computer science discipline?	Yes/No
Q2: Were User Experience (UX) elements mentioned in the article?	Yes/No
Q3: Did User Experience (UX) measured in the article?	Yes/No
Q4: Did article proposed a model of user Experience (UX)?	Yes/No

**3. FINDINGS**

Table 3 shows the number of articles found by using the systematic search, as described in Section 2.2. Articles that did not fulfill the inclusion and exclusion criteria, as mentioned in Table 1, were eliminated. Moreover, extensive screening was conducted to gain the most relevant articles according to the field of the research. A total of 32 articles were selected and analyzed according to the qualitative analysis questions in Table 2.

**Table 3: List of Selected Reviewed Articles**

Paper ID	Authors	Title	Data base	Q 1	Q 2	Q 3	Q 4	Themes
P1	[35]	Influence of Design Elements in Mobile Applications on User Experience of Elderly People	Sci-Direct	Y	Y	Y	N	Health
P2	[38]	Measuring Mobile User Experience Instruments for Research and Practice	AIS	N	Y	Y	N	Measuring UX instrument
P3	[13]	Exploring children experience with educational mobile technology	ALT	Y	Y	N	N	Learning
P4	[19]	Mobile Serious Game Design Using User Experience: Modelling of Software Product Line Variability	iJET	Y	Y	N	N	Game
P5	[36]	Towards a Model of User Experience in Immersive Virtual Environments	Hindawi	Y	Y	Y	Y	Learning
P6	[6]	The Introduction of a Novel Virtual Reality Training System for Gynecology Learning and Its User Experience Research	IEEE	Y	Y	Y	N	Health
P7	[20]	Programmer experience: A Systematic Literature Review	IEEE	N	Y	N	N	Review paper
P8	[18]	Experience over time: evaluating the experience of use of a squeezable interface in the medium term	Springer	Y	Y	Y	N	Entertainment
P9	[7]	The MUSETECH model: A Comprehensive Evaluation Framework for Museum Technology	ACM	N	Y	N	Y	Cultural Heritage
P10	[25]	Digital depression screening in HIV primary care in South Africa: mood in retroviral + application monitoring [MIR + IAM]	GMH	Y	Y	N	Y	Health
P11	[19]	Personality and taxonomy preferences, and the influence of category choice on the user experience for music streaming services	Springer	Y	Y	Y	N	Entertainment
P12	[15]	Vehicle Politeness in Driving Situations	MDPI	Y	Y	Y	N	Learning
P13	[26]	The Effects of the Floating Action Button on Quality of Experience	MDPI	Y	Y	Y	N	Design
P14	[32]	Design and Evaluation of a Short Version of the User Experience Questionnaire (UEQ-S)	Web of Science	N	Y	Y	N	Measuring UX instrument
P15	[33]	Design and Validation of a Framework for the Creation of User Experience Questionnaires	Web of Science	N	Y	Y	N	Measuring UX instrument
P16	[27]	Bringing the Illusion of Reality Inside Museums- A Methodological Proposal for an Advanced Museology Using Holographic Showcases	MDPI	Y	Y	Y	N	Cultural Heritage
P17	[3]	Mobile Health Apps to Facilitate Self-Care: A Qualitative Study of User Experiences	PLOS ONE	Y	Y	N	N	Health
P18	[22]	User Experience Evaluation of Immersive Virtual Contexts: The Case of The Virtual Museum of The Tiber Valley Project	Web of Science	Y	Y	N	N	Cultural Heritage
P19	[11]	User Experience of Marker less Augmented Reality Applications in Cultural Heritage Museums: 'Museum Eye' as a Case Study	Springer	Y	Y	Y	Y	Cultural Heritage

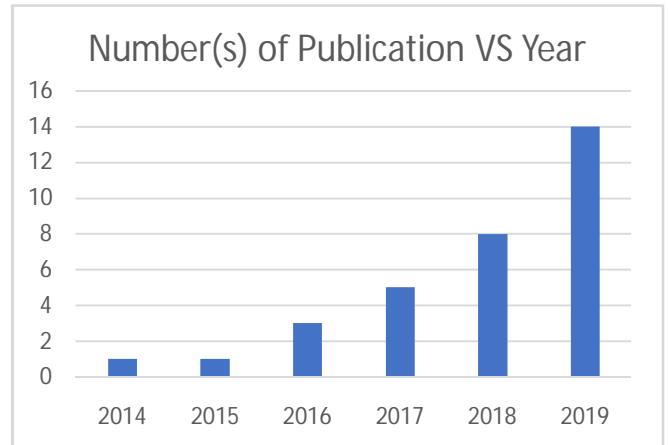
Paper ID	Authors	Title	Data base	Q 1	Q 2	Q 3	Q 4	Themes
P20	[4]	An End User Development Approach for Mobile Web Augmentation	Hindawi	Y	N	N	N	Cultural Heritage

**Table 3:** List of Selected Reviewed Articles(Continued)

Paper ID	Authors	Title	Data base	Q 1	Q 2	Q 3	Q 4	Themes
P21	[30]	Helping Elderly Users Report Pain Levels: A Study of User Experience with Mobile and Wearable Interfaces	Hindawi	Y	Y	Y	N	Health
P22	[21]	Heuristic Evaluation: Comparing Generic and Specific Usability Heuristics for Identification of Usability Problems in a Living Museum Mobile Guide App a Living Museum Mobile Guide App	Hindawi	Y	Y	Y	N	Cultural Heritage
P23	[16]	Kano Model Analysis required in APP interactive design based on mobile user experience	IJMUE	Y	Y	Y	Y	Measuring UX instrument
P24	[1]	Mapping Gamification Mechanisms to User Experience Factors for Designing User Interfaces	Scopus	Y	Y	N	Y	Health
P25	[8]	mLUX: Usability and User Experience Development Framework for M-Learning	iJIM	Y	Y	Y	Y	Learning
P26	[10]	Multimodal Affective Computing to Enhance the User Experience of Educational Software Applications	Hindawi	Y	Y	Y	N	Learning
P27	[17]	Presence and User Experience in a Virtual Environment under the Influence of Ethanol: An Explorative Study	Nature	Y	Y	Y	N	Health
P28	[12]	Reframing HRI Design Opportunities for Social Robots: Lessons Learnt from a Service Robotics Case Study Approach Using UX for HRI	MDPI	N	Y	Y	N	Robotic
P29	[40]	Understanding freehand gestures: a study of freehand gestural interaction for immersive VR shopping applications	Springer	Y	Y	Y	N	Shopping
P30	[28]	User Experience Design of Stroke Patient Communications Using Mobile Finger (MOFI) Communication Board with User Center Design Approach	iJIM	Y	Y	Y	N	Health
P31	[2]	User Experience in Mobile Augmented Reality: Emotions, Challenges, Opportunities and Best Practices	MDPI	Y	Y	Y	N	Campus Tour
P32	[39]	Virtual Reality for Learning Fish Types in Kindergarten	iJIM	Y	Y	Y	N	Learning

Meanwhile, Figure 2 shows the number of publications from 2014 until 2019. The highest number of publications was in 2019, with 14 articles, whereas the lowest number of publications was in 2014 and 2015, with one article each. Three articles were found in year 2016, 5 articles in 2017 and 8 articles in 2018. The number of publications on the topic of UX in technology had increased drastically along the years.

According to the analysis findings, the number of publications showed that UX of digital technology field, such as virtual reality, augmented reality and mobile technology has become more popular and is becoming a trend recently. This might happen due to the demands of industry, society and user toward the research area. In addition, the study of UX of technology is deemed as important to increase the performance of the technology and at the same time provide positive emotion impact to users.



**Figure 2:** Numbers of publications vs years

#### 4. DISCUSSION

This section discussed the research questions that were highlighted in Section 2.1.

[Q1] What type of UX elements has been used in digital application?

Nowadays, museums use digital technology to increase visitor attraction toward cultural heritage contents. Virtual museum application, software or system had been developed to provide the best experience to visitors. Some museums embed virtual technology elements to create different ambience and experience for museum exhibitions. According to the findings in Table 3 above, UX has been used in various fields of study, such as health, learning, games, entertainment, cultural heritage and many more. However, there is no standard model for UX in the process of designing virtual museum applications.

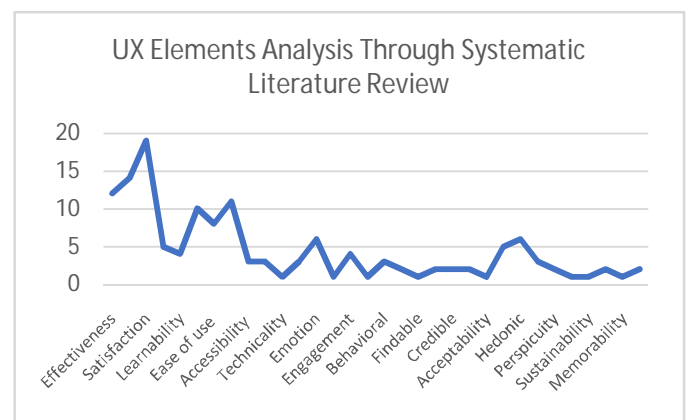
There were approximately 7 articles from 32 selected articles on UX model implementation, which were P5, P9, P10, P19, P23, P24 and P25. From these seven articles, the UX model was used in different domains and aimed at different purposes. P5 presented the UX model in education domain though the virtual reality technology application in which the researcher had proposed User eXperience in Immersive Virtual Environments (UXIVE) model in education. The UXIVE conceptual model was based on UX elements such as usability, skill, emotion, engagement and judgement [36]. Meanwhile, research paper P9 proposed a conceptual framework for cultural heritage domain. According to [7],

museum technology (virtual reality) was seen as one of the elements which permeated the visitor's UX. Based on the museum technology (MUSETECH) Matrix model that was developed, effectiveness, learnability, engagement and behavioural could affect visitor experience in museum exploration.

The Theory of Change (ToC) framework and themes in P10 by [25] stated that UX was the main theme that consisted of safety or privacy and acceptability elements in developing digital tools. They also highlighted that UX was fundamental to the success of digital display tools. The paper had developed a framework to design and evaluate the digital screening for health care, which emphasized the UX in tools development. Turning now to the experimental evidence in P19, the research by [11] was also based on cultural heritage domain which focused on UX of marker less application for cultural heritage museum. Mobile devices were used in the research to drive the application whereby a UX design model was developed to evaluate the UX and usability of the application. The researchers proposed functionality and simplicity as the visual aspects in their design model to construct an emotional bond between the application and the user. Meanwhile, article P23 that was written and discussed by [16], clearly mentioned that usability, affect and user value elements in application would be used in their UX model. The research proposed Kano model to show the relation between the user needs and user satisfaction toward the application. This model has three main UX components to be measured as a whole application whereby the three UX components were further divided into 18 sub-elements; for instance, efficiency, satisfaction, learnability, attractiveness and simplicity to allow the designers or developers to measure the UX value in product development. On the other hand, article P24 by [1] had proposed usability, usefulness, ease of use, accessibility, desirable, valuable and credible as factors of UX which could lead to user behavioral stages. This seven-factor UX model was proposed to map the gamification mechanism in UX of health domain. In addition, the research highlighted that UX element was interconnected to user behavioral, attitudes and feelings toward particular products, services or systems. They also mentioned that considering all components of UX is vital in preparing a successful application for users.

Finally, according to the findings in the systematic literature, article P25 was the last article that proposed a conceptual model or framework consisted of UX elements in application production. The article was written by [8] in which the researchers proposed mLUX framework, a model that is based on user-centered design for learning application development. The researchers applied four UX criteria for measurement such as satisfaction, security, adjustability and reliability in their mLUX framework. Besides, the researchers had significantly discussed about emotion factors and user enjoyment element in their research. Another 25 articles did not propose any conceptual framework or model. However,

most of the articles used UX elements in measuring application performance and successfulness. Various UX elements were used in various fields of research, as shown in Table 3. According to the usability findings in Table 4 and Figure 3, satisfaction (n=19), efficiency (n=14) and effectiveness (n=12) were the most often UX elements that have been used in developing any application across fields of study, such as health, learning, games, cultural heritage and others. The second most often used UX elements were attractiveness (n=11), followed by emotion and hedonic quality (n=12), usefulness (n=10), ease of use (n=8) as well as other UX elements which were less considered for use in application development; for instances, functionality (n=5), learnability (n=4), accessibility (n=3), safety and privacy (n=3), memorability (n=1) and others, as shown in Table 4 and Figure 3.



**Figure 3:** Frequency of user experience elements analysis based on article collection

[Q2] How have the UX elements contributed to virtual museum development?

Each UX element that has been used or measured in any application was different. The element depends on the objective or aim of the application. In fact, the UX definition itself was different and relied on the background and interest of the researcher. According to [14], UX was explained as interplay of personal perception, emotion, motivation and behavioral. Besides, according to [34], UX was related to a set of emotional, evaluative perception and responses of the user during interaction with the application. Meanwhile, according to ISO 9241-210, UX has been defined as “the user's perceptions and responses resulting from the use of a system or a service [ . . . ]” [36]. ISO also described that UX had something to do with belief, preferences, perception, emotion, physical and psychological responses, and behavioral of the user during or after the application, products or system has been engaged [23]. However, [31] had different perspectives on UX whereby according to their findings, UX could be considered as an extension of usability concepts which consider the effectiveness, efficiency and satisfaction of the product, system or services. These perspectives were similar

to [24], who wrote that usability component should be counted to measure the UX parameter.

Considering the standard definition of UX from literature and findings from the SLR, UX of digital application for virtual museum should consist of three types of elements, namely pragmatic quality, hedonic quality and UX response. Pragmatic quality refers to virtual museum application quality by measuring and evaluating usability element. Effectiveness and efficiency will represent usability to measure the pragmatic quality of the virtual museum application. These elements were chosen because they were the most often pragmatic quality factors that had been used in measuring UX, as stated in articles P1, P2, P4, P5, P7, P8, P9, P24, P26, P27, P28 and P32 for effectiveness element, while efficiency element was mentioned in articles P1, P2, P4, P5, P7, P8, P14, P15, P23, P24, P26, P27, P28 and P32.

Hedonic quality refers to factors that could affect human feelings, perceptions, psychological responses and preferences during or after anticipation of virtual museum application. Attractiveness and satisfaction elements will represent the hedonic quality of virtual museum application. These elements will be measured, evaluated and analyzed to investigate the relation between UX factors and UX response. Attractiveness and satisfaction were chosen due to literature support and data from the SLR. According to the data from Table 4, satisfaction is the most often used element in measuring UX, as mentioned in articles P1, P2, P4, P5, P6, P7, P8, P10, P11, P12, P16, P23, P24, P25, P26, P28, P29, P30 and P32. Meanwhile, attractiveness was mentioned in articles P1, P8, P12, P13, P14, P15, P18, P21, P22, P23 and P27.

UX responses refer to the effect of the UX factors, namely hedonic and pragmatic qualities. According to ISO 9241-210, [14], [23] and [36] UX was related to emotion, perception, pleasure, behavioral and psychological response while or after anticipating with the application. In addition, article P5 highlighted the UX response to UXIVE model, which is considered as UX consequence.

Based on the above discussion, a UX model of virtual museum application was proposed to visualize the interconnection of virtual museum features, UX elements and UX responses, as shown in Figure 4.

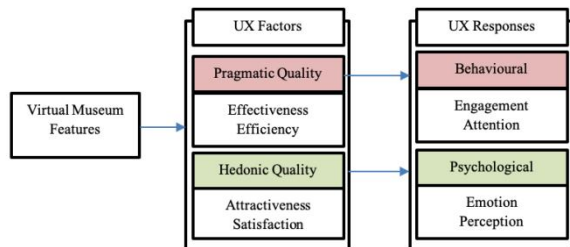


Figure 4: User experience model for digital application development

Table 4: User experience elements analysis through systematic literature review

Effectiveness	Efficiency	Satisfaction	Usability	Learnability	Usefulness	Ease of use	Attractiveness	Accessibility	Safety	Technically	Enjoyment	Emotion	Engagement	Judgment	Behavioral	Goal-ful	Immersive	Valuable	Credible	Simulation	Acceptability	Pragmatic	Hedonic	Dependability	Engagement	Novelty	Sustainability	Feasibility	Maintainability	Simplicity	UX Elements/ Experience
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5. CONCLUSION AND FUTURE WORK

The UX elements are able to increase the performance quality of virtual museum application up to the level of exhibition and give positive emotions to user during and after application usages. Visitors can immerse, engage, interact and explore the virtual environment of the exhibition like real experience. Furthermore, the UX elements are able to provide visitors or users with the unique experience of museum visiting which consists of extra experiences, such as excitement, fun, learning and interaction that cannot be obtained from conventional museum visiting. This research proposed a conceptual framework that contained three groups of constructs to improve the performance quality of virtual museum application, namely virtual museum features, UX factors and UX response. The UX factors of virtual museum in this research consisted of four UX elements, which are effectiveness, efficiency, satisfaction and attractiveness. The UX factors can lead to UX responses which will directly

affect user behavior and user psychology. In addition, the conceptual model that was proposed also showed the relation between UX elements and UX responses. Therefore, all the UX elements were found through the SLR analysis of articles taken from two databases, namely Scopus and Web of Science by considering the inclusion and exclusion criteria. This UX model could become a guideline to designers or developers to develop any virtual museum application by considering all the elements that were highlighted in the conceptual model in order to produce good performance quality of virtual museum application. Finally, the researchers of this study hope that this research could be extended and the interconnection of UX elements could be proven by experiment and empirical data.

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