Evaluation of Interface Design Principles' Usability in Permanent Museum Exhibition

Norfadilah Kamaruddin[1], Hafizah Rosli[1], Ira Wirasari[2], Maisarah Marman[3]

[1] Creative Visual Exchange Group (CREATe), College of Creative Arts, Universiti Teknologi MARA, Shah Alam, 40450, Malaysia, [2] Telkom University, School of Creative Industries, Bandung, 40257, Indonesia, [3] Department of Museum Malaysia, 50566, Malaysia

norfadilah@uitm.edu.my, hafizahrosli@uitm.edu.my, irawirasari@telkomuniversity.ac.id, maisara@jmn.gov.my
Tel: +60123486324

Abstract

The majority of museums today provide us with an unforgettable experience through interactive digital exhibitions. Due to the failure of the interface design usability of the exhibition systems and implementation, it was discovered that several digital projects failed to achieve the results promised in previous studies, which negatively impacted the interaction and experiences of visitors. With this in mind, an empirical usability study on interface design principles was done to determine how interface design concepts may be applied to a permanent museum exhibition. The findings reveal how to implement interface design concepts in a museum exhibition effectively.

Keywords: Interface Design; Interactive Digital Exhibition; Museum

1.0 Introduction

Introducing interactive exhibitions into people's lives in the modern era has stimulated many different human senses and is now commonplace. Nonetheless, when an interactive exhibition fulfils the users' requirements and advances the display's beneficial outcome, evaluating the exhibit's usability becomes the primary focus of discussion. In this regard, applying and integrating technologies such as Virtual Reality (VR), Augmented Reality (AR), and Web 3D with technology may facilitate the presentation of museum exhibitions and educate the general audience in a novel and appealing manner. Furthermore, the rapid digital transformation required providing an incomparable learning experience through active learning engagement (Sulaiman & Kamaruddin, 2020) among the digital native generation, equipped with media and technology advancement.

Earlier research found that 3D multimedia tools are used to record and visualise archaeological ruins using computer graphics (Cosmas et al., 2001). Additionally, interactive Augmented Reality (AR) provides guides for visualising cultural heritage site information (Gleue & Dahne, 2001). Earlier researchers discovered this. Another research has concluded that 3D technology in museum exhibitions presents a wealth of options for the general audience (Shaw et al., 2004). In addition, these new emerging technologies are used because of their allure and because they offer an improved experience to those visiting virtually.

An exhibition that merged technology in recent years demonstrates the variety of manifestations, and it occurs in various settings. The interactive digital exhibition devoted to technology should focus on the user experience as its primary objective. This means that the organisers should be concerned with both positive and negative comments made by visitors to the interactive platform during the show. Because of this, usability testing is required for interactive products because the results of these tests directly impact the interaction between businesses and their customers. In addition, exposition exhibitions are frequently offered with an assortment of different display methods.

As a consequence, given the rapid development of new technology in the modern period, it is imperative that the challenges faced by users be considered. The user experience resulting from unsuccessful interface design is the critical factor determining the show's effectiveness. Due to the failure of the interface design usability of the exhibition systems and execution, which further caused the visitor interaction and experiences, numerous digital initiatives had yet to deliver the result as promised in previous research. This is due to the fact that numerous digital initiatives have yet to deliver the result promised in previous research. This study focuses on the usability problems of interface design performance within permanent museum exhibitions. Using observation and empirical analysis, the study could investigate whether the interactive digital exhibition system operated effectively through the performance of interface design or whether the display content through interface design could be misunderstood. This was done so that these issues could be addressed.

2.0 Literature Review

2.1 Interface Design.
While creating interfaces, the designer must have a solid understanding of the requirements of the target demographic. In order to have a decent interface, it is important to have a deeper understanding of the possible end-users before the development begins. According to Kamaruddin, Park, and Nam (2012), the screen's surface facilitates a particular interpretation of the medium on the way that the user perceives the communication process is what the term interface means. They further elaborated and said there are four different kinds of interfaces: presentation, discussion, navigation, and explanation. Before that, the design of the user interface should not only be appealing and should establish a look and feel that users will respond to (Mohd Zuhana, Mohd Radzuan, & Legino, 2022). In addition, it should assist users in locating and remembering information, as well as assist them in the tasks that they need to complete.

According to interface design types, the findings of a comprehensive review of the relevant literature, there are three distinct types of interface design for museums: standard, virtual, and augmented. The utilisation of conventional input devices, such as keyboards, mice, and computer monitors, is what is meant when one speaks of a "standard interface" in particular contexts. However, a virtual interface is created when the interfaces are used to construct a reality block off the real world. In the final category, the augmented interface describes a situation in which the interface does not obscure the external environment but generates reality (Kamaruddin, 2019). Which interface design at the museum as a means of communication tool that moved from the object-based presentation (the exhibition of artworks in the museums) to the information-based presentation that changed from object-based presentation (the display of artworks in the museums) (images or texts in museums halls, information kiosks, etc.).

2.2 Usability Evaluation
Usability is an essential word in human-computer interaction (HCI). Fundamentally, usability was coined in the early 1980s to replace "user-friendly". Additionally, usability is related to the ability to function effectively and efficiently while offering subjective satisfaction to its consumers. According to Jacob Nielsen (1993), the usability of an interface design is typically related to the following five factors, which are directly derived from this definition:
- *Learnability:* Refers to how easily the user can quickly use the system,
- *Efficiency*: Refers to how quickly a user can do activities once familiar with the design.
- *Memorability*: Refers to the ease with which the user is able to re-establish proficiency with the design after a period of time during which they have not used it.
    - *Reduced Mistake*: Refers to how readily they can get back on their feet after making mistakes.
    - *Enjoyable To Use:* Refers to how enjoyable it is to utilise the design.

Many different approaches can be taken to evaluate the usability of a product or service. Usability testing is a method that evaluates the performance of a product by putting it to the test on people who will be using the product in the future or its final form. Its purpose is to determine whether or not the product satisfies the requirements and goals that have been established. Regarding evaluating usability, the literature identifies two primary evaluation approaches: formative evaluation and summative assessment. These two approaches are most commonly used (Scriven, 1976). The formative assessment is carried out during the project phase, in which the design and construction are carried out.

In contrast, the summative evaluation is carried out after the product has been delivered to the end user. To go into more detail, the formative evaluation results are primarily used for fixing bugs (detecting problems and shortcomings) and further improving the performance of the interface design. In contrast, the results of the summative evaluation are used to improve the interface design as a whole and meet more user needs in an upgrade that will take place in the future.

Similarly, usability evaluation may also be expressed as a user-centred evaluation method that focuses on the usability of the user interface. Therefore, the measurement and usability metrics most commonly used in relation to user interaction and interface design performance can be broken down into three distinct categories. These categories are as follows: user behaviour (which should be gathered information about using observation), user thoughts and opinions (which should be gathering information about using surveys or interviews), and captured data (which refers to the source of responses like eye-tracking heatmaps). Figure 1 presents illustrative examples of such measurements for your perusal.
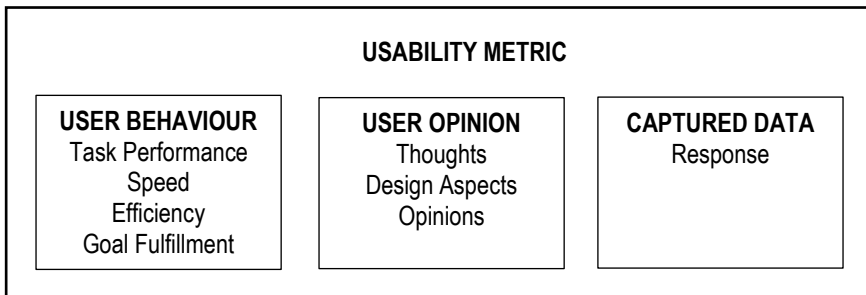
USABILITY METRIC

USER BEHAVIOUR	**USER OPINION**	**CAPTURED DATA**
Task Performance	Thoughts	Response
Speed	Design Aspects	
Efficiency	Opinions	
Goal Fulfillment		

Figure 1: The most commonly used usability testing metrics

2.3 User Experience.

The word "user experience" has become increasingly commonplace in today's innovative and technologically advanced world. Mostly, these terms refer to fields and concepts that have been present for some time and are hence appropriate for using shortened language. The word "user experience" is commonly used to describe a customer's emotional, cognitive, and behavioural responses to a service or product from when they first learn about it until the moment they stop using it. Moreover, this definition covers the board

regarding the user's journey. According to Abdul Kadir, Raja Ahmad Effendi, Dolah, and Ramli (2020), "user experience" refers to the sum of the user's emotional and cognitive responses to a service, product, or feature.

Several perspectives, such as the experience's complexity, have been used to interpret the concept of user experience, and different evaluation components, such as usability and emotions, have been identified and joined together to form an overall score (Pucillo & Cascini, 2014; Yang et al., 2019).

3.0 Methodology

3.1 Study Design
As recommended by the literature, this action research study used participant observation to counter how the interface design principles used in interactive museum exhibitions affected the visitor's experience. The participant observation was conducted within one month at Nagasaki Atomic Bomb Museum, which is located in Nagasaki, Japan. The observation was focused on how museum visitors interact and react towards the interface design of the interactive museum exhibition. The data gathered from the observation further are documented through handwritten observation notes, recorded video footage, and still photographs. All those empirical data have been analysed using a content analysis procedure.

3.2 Study Settings

Figure 2: The exhibition room in the Nagasaki Atomic Bomb Museum

In light of the fact that Japan is home to the greatest number of museums in all of Asia, the Nagasaki Atomic Bomb Museum was selected to serve as a case study for this action research study. The Nagasaki Atomic Bomb Museum commemorates the atomic bombing of Nagasaki in 1945 that the United States of America carried out. The museum can be found in Nagasaki, which is located in Japan. The museum was finished in April of 1996 and told the tale of the development of nuclear weapons and the event's history. This museum's exhibition focuses on the narratives of the pain and loss endured by local people during the conflict between the United States and Japan. The war was fought between Japan and the United States. The historical timeline as it is presented in this museum gives

the impression of reading a pure historical chronology, which can be roughly categorised as before and after the bombing, the detonation of the atomic bomb on Nagasaki, the damage that resulted from nuclear fallout, and the current status of nuclear weapons around the world. Every artefact in the show includes a narration presented in one of four languages: Japanese, Chinese, Korean, or English.

4.0 Results

4.1 User Observation Data

The non-participant observation was done using video recordings and observation notes sheets to respond to the research question and the overall study topic. At the museum, three cameras were placed strategically to record what visitors view and how they respond to the exhibits. The observer also made notes on the user's behaviour and reactions to the various interface design performance issues they encountered. The information gleaned from the observations was broken down into the following categories: (1) Interface design usability evaluation for interactive museum exhibition; (2) Interface design principles performances; and (3) users' interactions concerning interface design performances.

The participants in this study were split into three categories based on their ages: teenagers (between the ages of 15 and 18), adults (between the ages of 19 and 55), and seniors (above the age of 55). (over the age of 55). The sample for the research is chosen at random from among the visitors. The most fundamental information about those who participate in sampling is provided in Table 1 below.

Table1: Basic Information of Sampling Users

LEVEL	USER CODE	AGE	GENDER
Youth (15-18 years old)	01	16	Female
	02	17	Male
	03	16	Male
	04	15	Female
	05	16	Female
	06	17	Female
Adult (19 to 55 years old)	07	22	Female
	08	35	Female
	09	43	Male
	10	44	Male
	11	35	Male
	12	42	Male
	13	53	Female
	14	49	Female
	15	45	Female
	16	28	Female
	17	23	Male
	18	33	Male
	19	32	Male

	20	60	Female
	21	66	Female
	22	68	Female
	23	65	Male
	24	66	Male
Senior (over 55 years)	25	70	Female
	26	55	Male
	27	58	Male
	28	59	Female
	29	61	Female
	30	66	Female

From the table, the total of participants involved in observation is 30. Participants covered 6 from the youth level, 13 from the adult level and 11 participants from the senior level.

4.2 Interface Design Usability Evaluation For Interactive Digital Exhibition In The Nagasaki Atomic Bomb Museum

Table 2: Interface Design Principles Based On Scholar's Recommendation

REFERENCE	PRINCIPLES	MOST COMMON PRINCIPLES
Constantine (1994)	Structure Simplicity Visibility Feedback Tolerance Reuse	
Nielson (1993)	Visibility User Control And Freedom; Aesthetic Consistency	
Preece, Rogers, and Sharp (2002)	Effectiveness Efficiency Safety Utility Learnability Memorability	Consistency Familiarity Aesthetic Balances Simplicity
Mayhew (1992)	Consistency Familiarity Simplicity Flexibility Efficient Feedback Responsiveness Aesthetically Pleasing Invisible Technology	
Shneiderman (1998)	Consistency Familiarity Simplicity Reversibility Constraints Reduce short-term memory load	

35

Table 3: Interface Design Usability Evaluation Metrics

INTERFACE DESIGN USABILITY EVALUATION BASED ON PRINCIPLES			YES	NO
1	CONSISTENCY	Consistency Of Font, Colour, And Style	/	
2	FAMILIARITY	Clearly Showing The Level Of Important Content	/	
3	AESTHETIC	Elements Used To Show Contrast And Avoid Visibility	/	
4	BALANCES	Suitable Content Arrangement		/
5	SIMPLICITY	Functional And Appropriate Text, Visual And Other Technical Items	/	

As was previously mentioned, to evaluate the interface design's usability, metrics for usability evaluation were developed with consideration given to a literature review that focused on the principles underlying interface design. For example, Nielsen (1993) focused on several criteria, such as the system's consistency, the aesthetic, and the visibility of the system's condition. While Preece, Rogers, and Sharp (2002) defined six criteria: effectiveness, efficiency, safety, utility, learnability, and memorability, these were not the only concepts discussed. Table 2 provides a complete overview of interface design principles and discusses in detail the most frequent principles that scholars have established. An evaluation of the usability of the interface design is carried out with the help of a list of established common criteria to evaluate the effectiveness of the interface design used for the Interactive Digital Display in the Nagasaki Atomic Bomb Museum in Japan.

In the thematic analysis done throughout the literature, the principle of consistency was found to be the one that occurred the most frequently as an important principle of interface design. This principle emphasises the importance of maintaining consistency in the usage of all elements of interface design, such as font type, size, and colours, as well as the placement of contents such as title, text, image, animation, audio, and navigation across all of the pages of multimedia content in order to facilitate ease of use and user understanding.

An evaluation of the usability of the interface design is carried out using a metric called Interface Design Evaluation Metric that was developed previously. This metric is based on the five interface design principles advocated by academics. The individual scores for each of these interrelated concepts of user interface design are presented in Table 3.

Based on the evaluation metrics for interface design usability, it has been determined that the concept of balance is the principle that still needs to comply with the evaluation criteria. Various displays support this within the system, such as those presenting blank screens before particular options, while other alternatives do not function. In addition, the error messages displayed were incomprehensible and led to the formation of broken links. In addition, the option to "assist" the user is not present on practically any of the screens used in digital exhibitions. Table 4 presents the findings concerning the Balances concept and their respective particulars.

Table 4: Ranking of the Interface design principles usability evaluation checklist

Interface Design Principle: CONTRAST		YES	NO
1	The visual used is clear and attractive	/	
2	The button returns to the previous screen and functions well.		/
3	The screen goes blank on the log-off		/
4	The system is slow in loading.		/
5	The text is easy to read.	/	
6	The screen goes blank by selecting the "option" button.		/
7	Broken links		/

4.2 Interface design principles performance in Interactive Digital Exhibition

The old city of Nagasaki is depicted in the first section of the interactive digital exhibition in the Nagasaki Atomic Bomb Museum. This segment is located in the Permanent Exhibition Hall 1, showing the city before the bomb destroyed it. The very first area of the hall had a clock that had been stopped at 11:02, representing the exact moment that the bomb impacted the city of Nagasaki. In the next phase of the exhibition hall, viewers can enter a chamber that shows Nagasaki immediately after the bombings. This area included a Keiko Middle School water tank with twisted legs. The location of the tank was Keiko Middle School. This area is a permanent exhibition displaying huge materials exposed to the explosion. One of the exhibits is a duplicate of a sidewall of the Urakami Cathedral, which was damaged by the bomb.

Figure 3: The Interactive Digital Exhibition In The 1st Permanent Exhibition Hall At Nagasaki Atomic Bomb Museum

The museum's first room houses the first interactive digital exhibition that visitors can view while visiting the Nagasaki Atomic Bomb Museum. A physical three-dimensional model is on show in this room as part of the exhibition, in addition to a video presentation comprising two stations, each consisting of a set of monitors (see Figure 3). The text displays included with the three-dimensional models serve as a helpful guide that describes

the model. The video presentation supplements the three-dimensional model. The audience can see what effect the bomb had on the city, the reconstruction and development of the city, as well as the long-term effects of the atomic bomb, according to what has been observed, which shows that the museum was designed in such a way that this information is presented to the visitors.

The majority of the principles metric utilised by the curators were discovered through observation concerning the performance of interface design principles on interactive digital exhibitions. Although it contains valuable information, the film's duration gives viewers a negative impression. Nevertheless, in this particular instance, there is no actual play, stop pause, or playback button, and the interfaces for managing the film's duration do not display anywhere on the screen. At the very least, the guests should be allowed to pause the movie or switch to another one. As a result, this deficiency contributes to the low level of interaction between the presentation's content and the visitors, as the vast majority of them only spent a very brief amount of time watching the video. Because the Nagasaki Atomic Bomb Museum is intended to house informational exhibits, more efficient digital presentation methods are required to improve the museum's capacity for a two-way connection with its patrons.

Table 5: Interface Design Usability Evaluation on Permanent Exhibition Hall 1

INTERFACE DESIGN USABILITY EVALUATION BASED ON PRINCIPLES			YES	NO
1	CONSISTENCY	Consistency Of Font, Colour, And Style	/	
2	FAMILIARITY	Clearly Showing The Level Of Important Content	/	
3	AESTHETIC	Elements Used To Show Contrast And Avoid Visibility	/	
4	BALANCES	Suitable Content Arrangement	/	
5	SIMPLICITY	Functional And Appropriate Text, Visual And Other Technical Items	/	

Figure 4: The Interactive Digital Exhibition In The 2nd Permanent Exhibition Hall At Nagasaki Atomic Bomb Museum

The observation then moves on to the second of the museum's permanent exhibition halls at the Nagasaki Atomic Bomb Museum. In the second permanent exhibition hall of

the museum, it was discovered that most visitors could access and interact with the entire digital wall. This wall functions very well, as evidenced by the fact that visitors can walk up to and interact with all of the objects being displayed (Figure 4).

Two of the Interface design principles, namely aesthetics and balances, are only partially implemented in the exhibition's interactive digital displays, according to the responses of those principles' performances on the displays. The curators did not appropriately arrange the content in how it was presented. Concerning the aesthetic standards, the elements employed did not display contrast because they used a bright background with a darker typeface, which was done intentionally.

Table 6: Interface Design Usability Evaluation on Permanent Exhibition Hall 2

	INTERFACE DESIGN USABILITY EVALUATION BASED ON PRINCIPLES		YES	NO
1	CONSISTENCY	Consistency Of Font, Colour, And Style	/	
2	FAMILIARITY	Clearly Showing The Level Of Important Content	/	
3	AESTHETIC	Elements Used To Show Contrast And Avoid Visibility		/
4	BALANCES	Suitable Content Arrangement		/
5	SIMPLICITY	Functional And Appropriate Text, Visual And Other Technical Items	/	

Figure 5: The Interactive Digital Exhibition In The 3rd Permanent Exhibition Hall At Nagasaki Atomic Bomb Museum

The observation was also conducted in the third permanent exhibition hall at the Nagasaki Atomic Bomb Museum. This hall contained additional information on the movement after the war, including the beginning of nuclear development, the people involved, a petition submitted by scientists to the American President against the use of the atomic bomb, a world map indicating countries that have nuclear weapons, and an exhibition on atomic bomb survivors. In addition, this hall featured an exhibition on atomic bomb survivors. To be more specific, this third hall features an interactive digital exhibition that presents a chronology of the combat to help visitors better understand Japan's role in the war. The information presented on the panel is shown in Japanese, even though the

topic line is composed in English. In a tucked-away multimedia nook, there is a recording booth where one can listen to voices reading the English explanations. Even though it is essential and offers considerable information, this section needs to capture the visitor's attention (Figure 5).

With regards to the principles of interface design usability evaluation, observation at permanent exhibition hall 3 confirmed that three principles which are familiarity, aesthetics and simplicity, were emphasised clearly. In particular, the similar screen layout and styles and similar colour themes, even for different sections of content, are used in the interactive digital exhibition.

Table 7: Interface Design Usability Evaluation on Permanent Exhibition Hall 3

	INTERFACE DESIGN USABILITY EVALUATION BASED ON PRINCIPLES		YES	NO
1	CONSISTENCY	Consistency Of Font, Colour, And Style		/
2	FAMILIARITY	Clearly Showing The Level Of Important Content	/	
3	AESTHETIC	Elements Used To Show Contrast And Avoid Visibility	/	
4	BALANCES	Suitable Content Arrangement		/
5	SIMPLICITY	Functional And Appropriate Text, Visual And Other Technical Items	/	

4.3 Users Interaction and Experience Towards Interface Design Performances.
The usability evaluation metric developed in this study is mainly based on the usability evaluation metric for interface design. According to Law and Hvannberg (2004), the effectiveness of usability evaluation closely depends on the importance of selecting usability guidelines. Accordingly, this study has developed a usability evaluation metric based on 5 interface design principles.

On a qualitative note in regards to users' interaction and experience towards interface design performances, observation data was established that many visitors at the Nagasaki Atomic Bomb Museum gave positive reactions towards the interface design of the interactive digital exhibition in the second permanent exhibition hall where most of them show positive responses through facial expression and body gestures (in the sense of frustration towards the bombing). Moreover, most of the visitors also could easily read the complete information displayed on the screen of the digital exhibition. Therefore, some visitors needed clarification, help knowing what to do, and more time to familiarise themselves with the exhibition.

In reflecting on user interaction based on the interface design principles performance, the videos were seen as an important element to capture visitors' attention and keep them focusing more on the digital exhibition. Additionally, most visitors have a better imagination through video presentation than other elements such as text and still visuals. Visitors also showed more interest and better involvement when the video was used in the interactive digital exhibition, and they enjoyed continuous access to the information within the digital

exhibition. Consequently, effective interface design in the interactive digital exhibition contributes to the visitor's interaction and further controls visitors' experiences.

5.0 Conclusion

The individuals who go to the museums are considered the primary audience, and the purpose of each exhibition is to communicate with and satisfy the museum patrons. In this direction, interface design and exhibition design are the basic tools for producing effective communication. Hence, exhibition design is all about constructing a bridge between the visitors and the exhibition presentation on any subject of collections that are being displayed.

This paper has presented the data that explained how the interface design principles of the interactive digital exhibition at a museum are experienced and perceived by visitors in terms of facilitating their interaction and supporting the overall experience of the visitors. The interactive digital exhibition is located in a museum. The qualities of their visitors, as well as what they will see, learn, and perceive from the exhibition, must first be understood by museums' curators to comprehend the position of efficient museum exhibitions. In addition, visitors to museums tend to fall into one of three primary categories: (1) visitors who only glance at the exhibition headlines, (2) visitors who only read about the issues that are interesting to them, and (3) visitors who read everything. As a consequence, museums are required to organise their exhibitions so that the three primary types of visitors can satisfy their requirements within a time frame of forty-five minutes to one and a half hours while viewing the show. This time frame is the typical amount of time that guests spend perusing exhibits in museums.

This study used a measure that had been devised based on the principles of interface design in order to evaluate the usability of the product. The metrics utilised to evaluate the product's usability are appropriate and complement one another. If those fundamentals are applied jointly, the visitors will have a much easier time comprehending the item they are viewing through the digital exhibition.

This action research found certain issues with the interactive digital exhibitions at the Nagasaki Atomic Bomb Museum through observations. However, it also found that these exhibitions must be improved in certain areas for improvement in the interface designs where discordance in coupling information is displayed together. Frustration among visitors was the cumulative result of all these problems, and this irritation affected their experiences. In conclusion, the findings of this research indicate the extent to which interface design principles may be generalised across different media platforms, as well as what should be considered when dealing with interaction design and user experiences in general. This research, taken as a whole, demonstrates that the design of the user interface is a very significant factor that museum curators need to consider to achieve the desired levels of interaction and experiences for museum visitors.

Acknowledgement

Article Contribution to Related Field of Study

The data presented in this article has contributed to the interface design and museum studies field of study.

References

Abdul Kadir, A. N. ., Raja Ahmad Effendi , . R. A. A. ., Dolah, M. S. ., & Ramli , . S. H. . (2020). User Experience (UX) and User Interface (UI) as a New Recipe of Academic Culture in Creative Industry. *Environment-Behaviour Proceedings Journal*, *5*(SI3), pp. 231–236. https://doi.org/10.21834/ebpj.v5iSI3.2551

Cosmas, J., T. Itegaki, D. Green (2001). 3D MURALE: A Multimedia System For Archaeology. *In Proceedings of the ACM-SIGGRAPH Conference on Virtual Reality, Archaeology and Cultural Heritage VAST 2001*, Athens, Greece. pp. 297–305.

Gleue, T., and P. Dähne (2001). Design And Implementation Of A Mobile Device For Outdoor Augmented Reality In The Archeoguide Project. In Proceedings of the Virtual Reality, Archaeology, and Cultural Heritage International Symposium (VAST01), Athens, Greece.

Goodman E, Stolterman E, Wakkary R. (2011). Understanding interaction design practices. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. p. 1061–1070.

Hafizah Rosli and Norfadilah Kamaruddin (2020).Visitor Experience's on Digital Media Technology for the Museum Exhibition in Malaysia: A Preliminary Findings, International Journal of Scientific Research 7(2):245-248

Jakob Nielsen (2012). Usability 101: Introduction to Usability. Nielsen Norman Group. https://www.nngroup.com/articles/usability-101-introduction-to-usability/

Kamaruddin, N. (2019). Interface Design Assessment of Museum Permanent Exhibition at the National Museum of Malaysia. International Journal of Research and Innovation in Social Science (IDRISS), 3(5), pp.295-300 (ISSN 2454-6186)

Law, E. L., & Hvannberg, E. T. (2004). Analysis of strategies for improving and estimating the effectiveness of heuristic evaluation. Proceedings of the Third Nordic Conference on Human-Computer Interaction (pp. 241–250). New York: ACM Press.

Morgan J. (2012).The multisensory museum. Journal of the Ethnographic Institute, 60(1):65–77.

Mohd Zuhana , N. U. ., Mohd Radzuan, L. E. ., & Legino, R. . (2022). Visual Design Aspects in Designing User Interface Application for SMEs. *Environment-Behaviour Proceedings Journal*, *7*(SI7), 593-597. https://doi.org/10.21834/ebpj.v7iSI7.3834

Nielsen, J. (1993). Usability Engineering. Academic Press, San Diego.

Norman D. (2002). The design of everyday things. New York: USA. Basic Books, Inc. ISBN: 9780465067091

Preece J, Rogers Y, Sharp H. (2002). Interaction design: beyond human-computer interaction. United States of America: John Wiley & Sons, Inc. ISBN: 9780470018668

Pucillo, F., and Cascini, G. (2014). A framework for user experience, needs and affordances. *Design Stud.* 35, 160–179. Doi: 10.1016/j.destud.2013.10.001

Ralph, P., & Wand, Y. (2009). A proposal for a formal definition of the design concept. Design requirements engineering: A ten-year perspective, pp. 105–110.

Rahim, Normala, et al. (2016). Usability Evaluation of a Virtual Museum Environment: A Case Study in Terengganu State Museum, Malaysia. Advanced Science Letters, vol. 22, no. 10, 2016, pp. 2780–2784., Doi:10.1166/asl.2016.7109

Rowe A. (2014). Designing for engagement in mixed reality experiences that combine projection mapping and camera-based interaction. Digital Creativity 2014; 25(2):1–14.

Scriven, M. (1976). The methodology of evaluation. In R. Tyler (Ed.), Perspectives of Curriculum evaluation. Rand McNally, Chicago.

Simon, N. (2010). The Participatory Museum. Museum 2.0. ISBN:0615346502

Shah, N. F. M. N., & Ghazali, M. (2018). A Systematic Review on Digital Technology for Enhancing User Experience in Museums. In International Conference on User Science and Engineering (pp. 35-46). Springer, Singapore. Doi: 10.1007/978-981-13-1628-9_4

Shaw, N., M. Spearman, J. Hemsley & M. Kaayuk (2004). Report on Current Practices and Needs. ORION (Object Rich Information Network), Deliverable 5. http://www.orion-net.org/orion_library.asp (retrieved 7 Oct 2022).

Sulaiman, S. ., & Kamaruddin, N. . (2020). A Thematic Analysis of Interface Design on Multimedia Teaching Aid of Non-Creative Design Lecturers. *Environment-Behaviour Proceedings Journal*, *5*(SI3), 161-166. https://doi.org/10.21834/ebpj.v5iSI3.2562

Yang, B., Liu, Y., Liang, Y., and Tang, M. (2019). Exploiting user experience from online customer reviews for product design. *Int. J. Inf. Manag.* 46, 173–186. Doi: 10.1016/j.ijinfomgt.2018.12.006