Multi-Dimensional Interface Design of E-Commerce for Virtual Museum System

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Abstract— **This research focuses on the interface design for E-commerce for virtual museum system that can be displayed in multi dimensions. The existing system (muziummaya.terengganu.gov.my) has proved that information presented with the existing interface cannot be presented effectively through mobile device. Navigation is also difficult to the human cognitive since a lot of information displayed in one screen. Furthermore, the existing system is only available in Malay language and the digitized artifacts are only 10-20% from the whole collection. The existing virtual museum was analyzed to obtain user's perspectives from the aspect of information displayed and the results of this analysis serves as an input and guideline in designing the model and interface of a virtual museum system. The finding of these analysis also determines the best techniques in displaying information in the context of multi-dimensional designs, the information needed in a virtual museum's system and the most suitable e-commerce platform. These findings are used in designing a multi-dimensional interface design for an e-commerce system for a virtual museum. The result of this study proved that information presented is more effective due to ease of navigation of the system. Thus, it shows an increase in the usability and users gained more experience while using the system.**

Keywords— **virtual reality; virtual museum; e-commerce; multi-dimensional interface usability; user experience.**

I. INTRODUCTION

A museum is an institution that does not generate profits; however, they are devoted to provide their services to the community, researchers, students and public at large. A museum also provides facilities and activities that allow citizens to possess, chat, research, communicate and exhibit for reasons of researching, education and entertainment [1] [2]. Museums in Malaysia have the duty to maintain, preserve and spread knowledge on historical heritage, culture and nature of the country to create awareness among the present generation. Malaysia is rich with historical heritage since we are diverse in multi-ethnicity and possess beautiful natural environment. Thus, it is the duty of the Museum Institution to assist the government in promoting the tourism industry by creating a society that is harmony and has high morals.

UNESCO [3] states that Malaysia is one of the *Intangible Cultural Heritage* that brings the meaning of practice, representation, expression, knowledge, skills together with instrument, artifacts and cultural practices that accepted to be a part of their cultural heritage. Awareness amongst Malaysian to visit museums are low compared to Western

countries that shows the entry for museums is the highest after activities like the cinema, library and sports [4], [5]. This is mainly because most of the exhibition in Malaysia applies conventional method by displaying high number of texts, pictures, and passive modelling called static interpretation display techniques [2] and may cause poor understanding and learning process towards an individual as displays of information is made passive.

Nowadays, most museum experts use websites as an opportunity to attract public towards their museum. The Industry Revolution 4.0 (IR 4.0) offers online museum activities as a strategic planning: 1) culture: to create dialogue with public on exchange of information, promote cultural and artistic awareness; 2) commercial: to increase the promotion, advertisement and generate profit like E-commerce, purchase of souvenirs and tickets for tours. Moreover, multimedia exhibition in museums has resulted in an improved visitor experience [6], [7]. Value added in multimedia especially in constructing the design of virtual museum has promote an increase on education, research and entertainment all to for the better of visitors' experience [8], [9]. Initially, there are a lot of experts in museum industry that was concerned about the existence of virtual museum that could potentially replace physical museum and

discourage public to visit museum traditionally. However, there is awareness on archive, displaying and educating that is similar like a physical museum which is the main feature of a museum [10]. Other researches agreed that a digital museum could represent a physical museum [11]–[13]. Through this innovative approach, not only museum spreads information regarding historic relics and artifacts of the nation, but it has potential to be a complete learning institution [14] and a source to promote access towards culture and encourage participation of the public [15]. According to [16] and [17], virtual museum is a new manner of communication that creates a good learning environment that could cultivate student's ability to get information in detailed and interactively.

However, there are several institutions that are facing challenges to be more efficient and communication problems between old generations with newer ones. Digital innovation has brought radical changes towards the pattern of the market lately, and now it can be a fundamental transformation factor for the cultural sector [15]. Situated learning approach focuses on the importance of cultural and social context where learning process takes place. Situated learning approach context is not binding towards the norm of development and knowledge, as for now schools are not the only place to get knowledge. Educational experience especially on historical heritage must take place at a different place, to allow students observe and study the artifacts and relics firsthand [16], [18].

Therefore, the objective of this research is to create an interface design to display museum exhibits including E-commerce transactions to increase the usability and user experience while using the system.

II. MATERIALS AND METHOD

The existing virtual museum project (muziummaya. terengganu.gov.my) has shown that presented information via mobile device could not be displayed effectively and has difficulties to navigate as it serves as a burden to consumers' cognitive with information overload. Besides, the system is only available in Malay language and the artifacts displayed are only 10-20% of the whole collection that has been digitalized. This system is vital towards the museum institution to educate generation Y and Z to continue take interest in searching, exploring, handle artifacts and gallery through online. This project will benefit students, educators, public is interested to learn and recognize historical heritage through the ability of Information Computer and Technology (ICT). Furthermore, this project will also aid cultural heritage to move towards professionalism by managing the museum and organizational operations, plus preserving and conserving the cultural heritage via digitally and made portable. This study conducted analyses of five overseas museum, pay a visit to the Terengganu State Museum and existing system to identify problems encountered while identifying the best interface design for a virtual museum e-commerce website.

The analysis involves five overseas museums which are Brooklyn Museum, United States Museum, British Museum, England Museum, National History Museum, The Louvre, France and Cooper Hewitt Smithsonian National Design Museum that practically uses the concept of E-commerce

virtual tour. The aim of this analysis is to observe the trend of information displayed in multi-dimensional and the application of E-commerce concept in virtual tour system. For example, web designing techniques, how the information display in multi-dimensional, information required in a virtual museum system and the appropriate platform for E-Commerce. Results of these analysis, indicates that the entire museum has used responsive design technique to build the system. Techniques were created at a flexible grid by using media queries to control the design and content depending on the size of the screen of the desktop, tablet and mobile device. In addition, designers do not have to design various and different formats of websites that is arrange for different devices [19].

Meanwhile, the purpose of the visit to Lembaga Muzium Negeri Terengganu is to acquire the comments and opinions of the museum curator on virtual museum system that has been develop before. The virtual museum system phase 1 (muziummaya.terengganu.gov.my) was launched on 2nd February 2016 at Dewan Batu Bersurat, Lembaga Muzium Negeri Terengganu (LMNT). The system is applied and used widely by students, museum officers and visitors through desktop. The system was valued by 82 respondents via method of questionnaire on factors of efficiency, satisfaction and effectiveness. Results of the analysis on efficiency showed 90.2%, satisfaction was 87.8%, effectiveness was 87% that agreed on the usability of the virtual museum system. Each comment on suggestions made by users and curator will be made as a guideline to improve the virtual museum system.

Therefore, other requirement that must be highlighted is the information display technique that is suitable with the virtual museum system. Firstly, is panorama image functionality to allow user to visualize the facility of the museum. The image functionality represents a high-quality physical object that gives a good impression in producing good quality and impactful image towards users. In a virtual museum visit that possesses full functionality of the image processed, the user is able to experience walking throughout the museum, looking through all the artifacts via the panorama view that can be handle with different options like, rotate, pan, zoom and navigate [20], [21]. Secondly, scaled image with text, where the scaled image gives an opportunity to users to observe and witness the artifacts as a whole or in parts, in more detailed manner through functions like zoom at a high-resolution image. This function allows users to see image that cannot be seen through the naked eye because of the object being small or limited to distance allowed between the object and users. Virtual museum visits can be more interactive as it can increase the user experience with the function of image exploration.

Next, is the database that offers multiple search option and increasing operation of function towards image. A complete database includes photo and object scanner together with metadata that is uploaded to the search engine. The database allows searching option mixed with context, concept or metadata that allows users to key in search criteria based on keywords. Other features that could increase user experience would be usage of 3D environment that allows user to undergo authentic experience to search and venture the virtual museum system.

Digital exhibition or virtual visit is an ensemble interlinks aimed to spread multimedia digital contents to deliver innovative presentation of information while increasing the customer interaction [22]. A virtual visit shall have the following features:

- Localization: To put users / visitors in context and make them familiar with the cultural elements displayed,
- Relevance: To attract more visitors to virtual tours,
- Interactions: To give users the opportunity to interact with applications that showcase virtual tours. For example, through the photo zoom functions or selecting an object / image for detailed description,
- Maintenance: To enable the system to be updated whenever new elements appear in the gallery or developers want to add or correct artifact descriptions,
- Accessibility: To reach users who have difficulty visiting museums or physical exhibitions.

Kravchyna dan Hasting [23] in the journal *Information Value of Virtual Museum* has listed information that is required to be present in a virtual museum. One of it is the availability and use of multimedia software. Information regarding the museum collection and videos will help create reality for the users. If virtual visitor can perceive with their senses during their time visiting the virtual museum system, they would probably remember their experience for a long period of time. Multimedia usage could increase the learning experience because each visitor would learn and interpret differently through their previous acquired knowledge, experience and beliefs [24], [25]. In addition, information acquired through the virtual museum system (see Table I) could be standard of measurement towards the advancement in technology for the users towards the museum.

TABLE I
INFORMATION IN A VIRTUAL MUSEUM SYSTEM

Information	Feature of Information
Recent exhibitions	Duration, time, location, ticket prices and exhibition information.
Special events	Special events include exhibitions, presentations, workshops and talks.
Museum collections/artefacts	History, artwork, natural resources and cultural values.
Additional material	Additional material for use by researches.
Contact information	General information about exhibitions, working hours and directions to location
Museum directions	Guide to museum locations, exhibitions and facilities.
Purchase of tickets/ Souvenirs Online	Purchase of Tickets
Collection/ exhibition images	Can be used for personal, educational and commercial use.

Frequent visits to the museum website must be a value information considered. Falk and Dierking [24] agreed that public visits museum with individual agendas of their own. The conscious of a visitor is the biggest influence in user experience to a museum. It is vital for a museum expert to realize the importance of the user's agenda to visit and realize that visitors can be influence by a museum.

Theoretically, manipulation is the basis towards the success of a museum to create a successful museum tour experience. Based on a research [23], the main information that is searched and wanted by museum visitors are listed in Table 1. Table 1 shows main information that is always searched by visitor of virtual museum system. First is information about the recent exhibition. Recent exhibition, whether it's a tour or a permanent exhibition will attract the attention of visitors, museum staff, teachers and students. Do visitors need information on the exhibition (duration, time, location, ticket price), or are they searching a detail or specific information on the exhibition (types of artistry displayed, how the art is presented, what are the extra information about the art that can be found on the web)? Secondly, a special event that is held at the museum also includes talks on the recent exhibition, workshops and sketch class. Virtual visitors are searching for these events to fill their leisure time in a pleasant environment, at the same time gain knowledge and having a chance to meet up with the museum staffs or the artist.

Thirdly, visitors are searching for information on the museums' collection or artifacts. One of the benefits of online search is the access to the database that can oversee arts that cannot be access physically in detail. A newer image can be produced, and existing image can be made for comparison. Most of the research made is to value the need of art historian and art studio teacher, but never made to value the need of a teacher, student and visitors. Historical period, artwork, natural resources and cultural value become clear to visitors when they are presented in a series of arranged exhibition that is in order. Virtual visitors require contextual information to understand a certain artwork, and such information is a priority for visitors.

Fourthly, the researcher that is searching or conducting research on the collections or artifacts that needs additional information for their research purposes. With the help of the virtual museum system, the researches no longer need the go to museum physically, as this can save their time and energy. After that, contact information regarding the museum includes the direction to the location, working hours, general information regarding their exhibition and museum facility also needs to be displayed in the virtual museum system. By having this information on the museum's website, this will prevent users from contacting museum employees directly. Next, there are some virtual visitors that expect a three-dimensional guide and a map or text that gives information on directions from one exhibition point to another. Lastly, analysis made towards the virtual museum system shows usage on museum's website as a channel to purchase tickets and online souvenirs at a lower price. However, there are several museums that offer E-commerce services to their customers. Hence, visitors often seek museum's website to seek lower purchase price value for both tickets and souvenirs. Based on all the information needed for an e-commerce virtual museum, the functional and non-functional requirements for system design are displayed in Table 2.

Functional Needs	Information
Artifacts Display	Users can view artifacts in 3D objects. Users may view artifacts information. Users can manipulate artifacts (zoom and rotate).
Information Search	Users can search for information using keywords, floor plans, or hotspots.
Recent or Upcoming Programs	Users can find information about recent or upcoming programs or exhibition.
Virtual Tours	Users can view the museum environment from a 360-degree images using virtual reality techniques.
Language	Users may choose to browse the web in: • Malay Language • English Language
E-commerce	• E-commerce users can purchase tickets. • Users can purchase program / exhibition tickets. • Users can find additional material for research purposes.
Hotspot/ Floor Plan	Users can find navigation in museums, galleries and facilities.
Non-Functional Information	**Information**
Speed and Time	Display the right information at a reasonable speed and time.
Reliability	System reliability can provide the correct representation of objects
Mobility	System is browsable on any device including desktops, laptops, tablets and mobile phones (responsive).
Security	System can provide a secure payment gateway.
Maintenance	System can be updated whenever new elements appear or when developers want to enrich the information or correct it.

Based on a system that has analyzed on the user's usage, a conceptual module is designed to fulfil the needs and requirement of the users. Figure 1 shows a conceptual module for the development of an e-commerce virtual museum system.

Figure 1 shows a module that is designed to improve E-commerce virtual museum system. Module that is involved includes virtual tours, artifacts and additional modules which are E-commerce. In the virtual tours, a panoramic image with a 360 view is used for 8 galleries in Terengganu's museum however in .fla files. In order to ensure that panoramic gallery can be viewed to mobile devices without any hassle, the image format must be change to.html. Besides, the change of format also will reduce the storage usage in a mobile device. In addition, images of artifacts displayed in 3D are enhance thus allowing users to

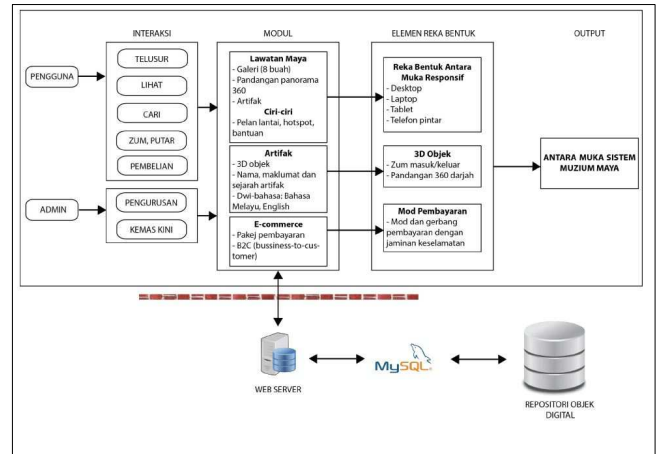manipulate and apply the functions of rotate and zoom more efficiently.

Fig. 1 Conceptual Module for the development of an E-commerce virtual museum system

Information of artifacts is also improved to ensure information is beneficial towards all types of users, students, teachers, visitors and researcher. Nonetheless, information will also be displayed in both Malay and English language. Furthermore, E-commerce modules that are prepared includes package to purchase exhibition tickets, artifacts information and high-quality resolution of image.

In addition to modules, responsive design elements are also among the improved display designs. This responsive design will allow users to browse and venture virtual museums system in different platforms such as the desktops, laptops, tablets and smartphones. Payment modes and gateways are also provided with security guarantees to ensure the best user experience when using E-commerce. All the information in the virtual E-commerce museum system will be stored in a digital object repository to make it easier for users to find information wherever they are.

In order to make sure that the interface design for this system based on requirements, the design phase involves two stages: low fidelity interface design and prototype development of the virtual museum system.

A. Low Fidelity Interface

During this phase, the interface design of the E-commerce virtual museum system is built based on the context of user interaction with different needs and multi-dimensional designs. In addition, the system flow charts as well as low fidelity were also built based on the analysis of virtual campus visits and user needs.

B. Prototype Development of E-Commerce Virtual Museum System

Subsequently, the system prototype was developed based on user needs and system analysis. Some activities carried out was converting the output of file format for the gallery's panoramic image from .fla to .html and scanning the artifacts using 3D Einscan Pro+. The scanning of artifacts takes time throughout the process due to differences in size and texture of the artifacts. Larger artifacts take roughly a week to complete while small-sized artifacts usually take 1-2 hours. The uniqueness of the shape and type of artifacts is also a

factor in delayed time to scan artifacts. Once the artifact is scanned, the information and 3D files are stored in the repository for any future retrieval. Figures 2 to 8 show the interface of the virtual museum system upon completion of the module development.

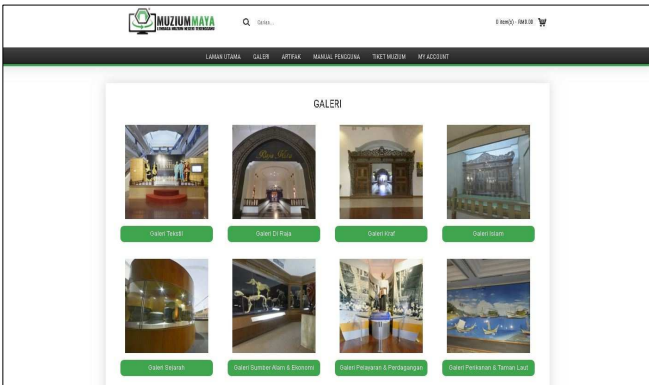Fig. 2 Main Homepage of the E-Commerce Virtual Museum System

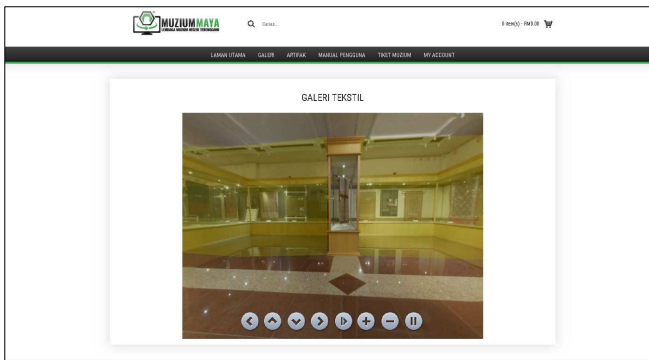Fig. 3 Gallery Page of E-Commerce Virtual Museum System

Fig. 4 360 Panoramic Widespread View of Gallery
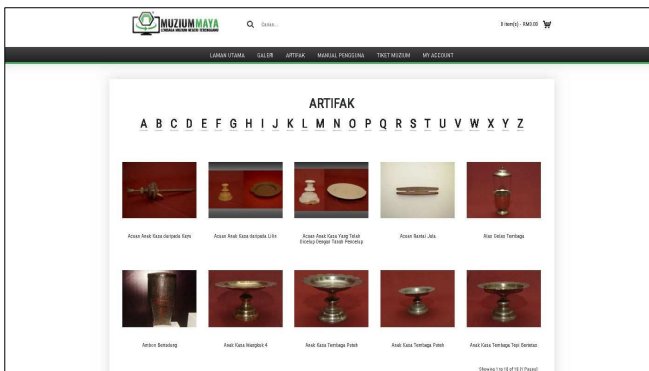

Fig. 5 Artifact Page of the E-Commerce Virtual Museum System
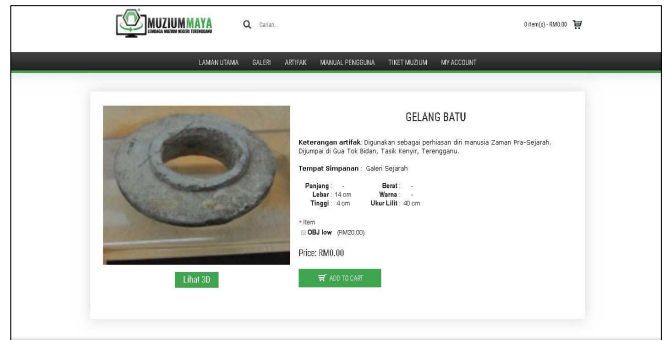

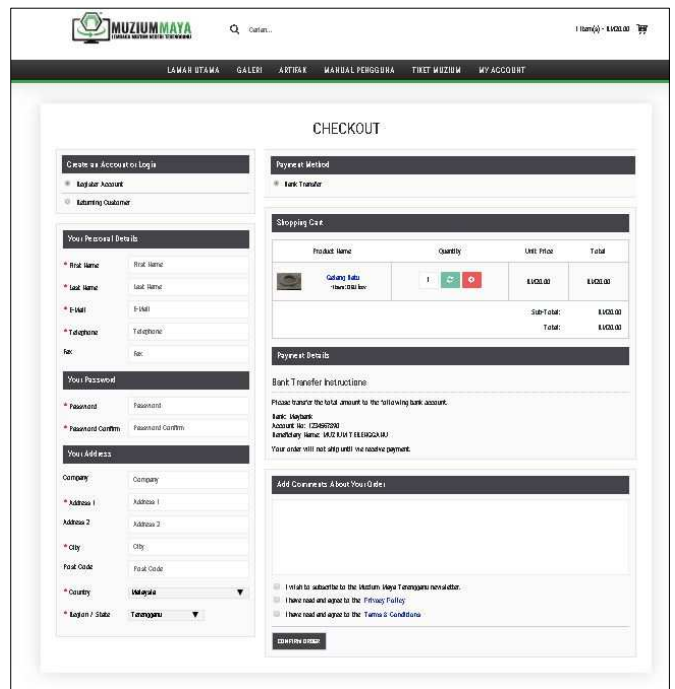Fig. 6 Artifact Display Page

Fig. 7 3D Artifact Display

Fig. 8 Mode of Payment Homepage

III. RESULTS AND DISCUSSION

For testing phase, usability testing has been conducted to assesses the level of convenience and usable of the user interface. The term "usability" also refers to methods to improve user convenience during the design process [26]–[28]. Usability can be defined by 5 quality components [29] that includes:

- Learnability: How easy is it for users to complete basic tasks for the first time once they are exposed to the interface?

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- Efficiency*:* How long would the user need to complete tasks once they are familiarized with the interface?
- Memorability*:* When the user returns to the interface after a period of inactivity, how memorable would it be for them to re-learn the interface?
- System *errors*: How frequent do users make mistakes, and how easy is it for them to recover from such mistakes?
- Satisfaction: Is the designed interface easy to use?

Based on these usability components, an evaluation using nominal group technique and heuristic testing was conducted on the design interface of e-commerce in the virtual museum. The aim of this evaluation is to assess the usability and to improve the system design in order to upgrade user-friendly interaction as well as to reduce cognitive loads.

A. Evaluation of E-Commerce System in Virtual Museum

An evalutation of the developed virtual museum's E-commerce system was carried out in a meeting room at Hotel Bangi-Putrajaya to ensure that the assessment environment can be regulated easily. The main objective of this evaluation is to identify the level of system usability.

1) Participant: A total of 14 participants including researches from the Faculty of Information Science and Technology and the Terengganu State Museum Board. Participants were divided into three groups according to their respective institutions. Among the demographic data collected were age, gender and background of participants. Participants were of the age group of 25 - 58 while the genders consist of 43% being male and the other 57% were female.

2) Materials: All participants are provided with a set of Heuristic checklists to serve as a guideline in executing the tasks given while browsing the virtual museum's e-commerce system as well as brainstorming and jotting down notes for further explanation and discussion. The facilitator enlightens and displays the system on a projector.

3) Nominal Group Technique (NGT) process: The Heuristic evaluation approach uses a nominal collection technique that is comprised of several phases which are as follows:

- Participant is required to fill in personal information such as age, sex, and background on the Heuristic checklist.
- The facilitator will begin with a greeting and will then proceed in explaining every task required to be completed by the participants during the process. Among these will be the gallery browsing, artifact information search and interaction with 3D artifacts, making sales transactions for artifact information and finally to make a transaction in purchasing museum tickets.
- Participants are informed that they have 5-10 minutes to silently come up with ideas when completing a task. The time limit provided only serves as the participants guide. However, participants can continue this process until no more ideas are generated. The facilitator then decides when the phase of coming up with ideas has ended.

- Each participant will then present their idea one at a time to be recorded by the facilitator. This process will end when participants no longer possesses new ideas.
- Every idea and suggestions presented are discussed for clarification or evaluation. This process is sequential, starting with the very first idea/proposal generated and ending with the last. Suggestions for incorporating ideas/suggestions are only accepted with the consent of all participants involved. The result is a list of ideas/suggestions brought forth, with a few categorized into clusters.
- Participants select ideas/suggestions from the list and organize them accordingly.
- The final discussion took place with the dissemination of voting results to the participants and they were able to comment on the results.

Participants are required to complete a checklist based on their experience in completing the given task. The checklist should be filled in separately and participants are not allowed to discuss or talk during the process.

B. Results Evaluation

After completing the Heuristic evaluation by way of NGT, a checklist was compiled and the results were analyzed. The results of usability testing can be referred to in Table 3.

TABLE III
RESULTS OF USABILITY TESTING OF VIRTUAL MUSEUM SYSTEM

No.	Usability Factor	Agree, no improvement required (%)	Disagree, in need of improvements (%)
1	Application status visibility	83	17
2	Real-world application compatibility	75	25
3	User control and freedom of access	42	58
4	Consistency	83	17
5	Error Prevention	100	0
6	Recognition rather than Memory	100	0
7	Flexibility and Effectiveness	100	0
8	Aesthetics and Minimalistic Design	83	17
9	Helping users identify, diagnose and recover.	92	8
10	Assistance and Documentation	58	42
11	Responsiveness	58	42

Table 3 enshrines the results of usability testing conducted on 14 participants including researches from FTSM and LMNT. The results of this evaluation indicates that eight out of the eleven usability factors were approved and found to not require any further improvements namely 83% on the application of status visibility, real-world application compatibility at a 75%, consistency at 83%, error prevention, recognition rather than memory, and flexibility and

effectiveness respectively at a 100%. In addition, aesthetics and a minimalist design make up 83% and finally factors in helping users identify, diagnose and recover recorded at 92%.

At the same time, three remaining factors that are (a) user control and freedom of access; (b) assistance and documentation and (c) responsiveness only records the statistics of 42% and 58% that agree however there are still room for improvement to ensure users could optimize the system to the best extent they are able to do.

Apart from the results of the Heuristic checklist, there are some ideas and suggestions gathered from the participants from the conduction NGT. These ideas are classified according to tasks including the display of 3D artifacts, sales transaction process of artifact information, *order history*, and ticket purchase transactions for museum entry. This is as follows:

1) Display and manipulation of artifacts in 3D:

- 3D object file format: Convert the file format from .swf to .html to reduce loading time.
- Navigation: Add a navigational system on the pop-up page of 3D artifacts.
- Artifact information: Add descriptions on the pop-up page of 3D artifacts that the user wishes to purchase.
- 3D pop-up page color: Change background color to highlight a contrast in the display of 3D objects.

2) Sales Transaction of Artifact Information:

- Use of button: Upgrading the "Continue", ' button, adding "My Account on the main menu/menu bar, reducing the use of "Back", button, and removing the "Product Returns" function.
- Adding a "Disclaimer" to ensure that users are aware that every purchase is non-refundable or reimbursed.

3) Artifact information purchase transaction:

- Ticket Package: Inserting several discount packages with every ticket purchase in large amounts, establish promotional packages for school students.
- Proof of Purchase: Provide a proof of purchase to avoid an exploit of tickets. For example, using a barcode of QR code as proof of purchase.

4) Order History:

- Use of session feature: Adding an automatic logout feature in the events of an idle user for a long period of time to keep users in safety in the virtual realm.
- Proof of Purchase: Adding the function of printing an invoice as proof of purchase.
- Adding a time-limit function to download artifact files that has been purchased: This is to prevent the information from misuse or excessive downloads.

IV. CONCLUSION

The main objective of this study is to design a multi-dimensional interface system for virtual museum based on the context of user interaction and develop an e-commerce system based on a low fidelity prototype, and ultimately usability testing through the Nominal Group Technique and Heuristic Techniques towards experts. Usability testing provides a reliable and meaningful feedback. Feedback from the participants agree that the system functions and can be used in general despite several usability issues in certain areas. Although there is some negative feedback that requires attention either from usability perspective or execution process, it aids in terms of system development. Among the implications of this study is to get a complete visualization of the level of usability of e-commerce virtual museum systems as well as identify usability issues and discuss solutions to improve the system. As an overview, the findings of this study fulfill the objective of this study identified in the beginning of this research.

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