Design and Development of Interactive Exhibit at the Sarawak Museum

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Abstract

Current trends reveal a shift in the role of museums from a traditional conservation role into one with educational responsibility for enhancing visitors’ learning experience. Constructivist theory reveals museum learning to be an active process where visitors are actively constructing their own knowledge and experience. These trends have raised concerns in the museum exhibition studies. The role of interactive technology today enables museum learning to be more flexible and allows visitors to actively create their own knowledge. However, there is a concern that excessive interactivity may distract the original purpose of museums (from learning to entertainment) and may replace the authenticity of artifacts.

The exhibitions at the Sarawak Museum are facing challenges due to its conventional displays. This study aims to design and develop an interactive exhibit at the Sarawak Museum to enhance the conventional exhibitions and visitors’ learning experiences through a multi-disciplinary approach by incorporating the constructivist learning theory, relevant display technology and interactive exhibit design requirements based on the Sarawak Museum visitors’ preferences. The interactive exhibit prototype serves as a foundation for understanding the related artifacts available in the Sarawak Museum.

The interactive exhibit prototype design emphasises the use of narrative context in the organisation and presentation of content. The narrative context is mapped onto two alternative points of access: chronological and geographical. This allows for flexible active learning with a consistent and intuitive interface. This study has resulted in the design and implementation of an effective interactive exhibit prototype for the Sarawak Museum, specifically for the Archaeology exhibits.
I would like to thank Mr Gregory Wee and Mr Wilson Suai in particular for offering me the chance to conduct this research and for their enthusiasm, ideas, supervision, support and substantial feedback throughout the research. I greatly appreciate the time that both of you have spent for this research. Without both of you, this thesis could not be real. Thanks to the helpful librarians in Swinburne Sarawak University of Technology Sarawak Campus for assisting my literature review resources.

Special thanks to the Sarawak Museum and team for the extensive support provided – Mr Ipoi Datan, Mrs Lim, Mr Mohd Sherman Saufi, Jonathan and staffs in the Archaeology Department. Unforgettable relationship I had with the staffs and experienced being a museum guide which I have never done before. It was a good team and the collaboration was truly awesome! Thanks to all of the museum visitors and participants who took time from their visits for the evaluation and for the helpful comments.

Thanks very much to my dear family – Dad, Mom, Nia and Eka – for your endless encouragement of all things I do. Thanks to Hudy for his never-ending care.

Finally, thanks to Dhita and to my best pals for caring and cheering for me, even though we were separated in space.

Thank God for his blessings and love upon me.

You all have been wonderful! Thank you.
Declarations

I hereby declare that this thesis is my own work and that it has not been submitted previously for any award or other qualification in other university and that I have acknowledged all sources of information that have been used.

_________________________
Dian Valeria Ng, April 2014
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Chapter 1. Introduction

This chapter introduces the overall context of the research, consisting of background of the study, aim and objectives, scope and limitations of the study, research methodology and, lastly, the structure of the thesis.

1.1. Background of the Study

The museum is often associated with education and artifacts. It communicates the significant message behind the collection of artifacts to evoke public awareness on the value of heritage. Therefore, the museum emphasises on the selection and knowledge about the artifacts for the purpose of education. Traditionally, the artifacts are organised and presented in an array for the exhibitions with printed labels around them. Visitors walk through the exhibition path to look at the artifacts and are expected to stop and read the interpretation on the labels. In this context, communication and learning are assumed to be achieved when visitors spend some time reading and looking at the objects. However, in museum communication displays today, the objectives and expectations of both the museums and visitors have changed and this is evolving the concept of museum exhibitions. A review of the relevant literature reveals the current shift in approach and concerns in museum exhibition studies.

Learning in the museum is primarily influenced by personal context and is driven by various motivational factors, such as social interaction or physical setting (Falk & Dierking 1992). Visitors have dissimilar interests and learning purposes in the museum that requires the exhibit designers to discover and satisfy. What knowledge do they want to acquire and how do they acquire it? These questions mean that there is a need to identify the objective of the exhibition and the essential aspects that an effective exhibit should offer. Museums need to shift their focus onto visitors rather than onto artifacts (Weil 1999; Hooper-Greenhill 1999).

The public is increasingly taking an interest in museums to experience the moment of their history and culture. Visitors enjoy being in an authentic environment where they can feel a special connection with certain artifacts. Visitors are now seeking not only cognitive experience, but also affective experience (L. Roberts 1992; de Rojas & Camarero 2008; Daniela Petrelli et al. 1999). They will find it worthwhile if significant knowledge and memories are assimilated during the museum visit. Hence, the museum is expected to be a learning and enjoyable environment. Not all visitors are as passive as it seems (Hooper-Greenhill 1999; Hein 1998). They move freely in the museum and look for fun while capturing knowledge. Hence, the exhibitions must be able to excite the visitors’ intellect and emotion to be optimal. It seems that museum educational experience is not focusing solely on the intellectual aspects, but also on the emotional aspects (Falk & Dierking 1992; Hennes 2002).
The technology used in museum exhibitions has shown tremendous results, in both museum and visitor perspectives. The innovation of technology today – from high-tech displays to social networking systems – has evolved visitors’ learning experience, from passive audiences into active participants. Many museum exhibitions have applied digital media that enable interactions with various forms other than only visual perception. The interaction involves physical manipulation on the exhibits that give visitors the ability to engage in activities and to learn at their own pace (Tallon & Walker 2008). The implementation of interactive technology in museum exhibitions appears to improve the dissemination of information that increases visitors’ learning, engagement, and sensorial experiences (Tallon & Walker 2008; Stogner 2009; Wheat et al. 2012; Wojciechowski et al. 2004; Cucchiara et al. 2012; Haywood & Cairns 2006; Linge et al. 2012; Danks et al. 2007; Morgan 2012; Geller 2006). As a result, it facilitates museums to achieve the aim of providing an effective learning and enjoyable experience. However, studies support the view that the role of interactive exhibit must not suppress the authenticity of museum artifacts as the primary interpretative media and must not distract visitors’ primary purpose, which is learning (Stogner 2009; A. Griffiths 2003; Morgan 2012; Damala 2007). On the other hand, interactive exhibits need to augment the exhibitions for visitors to achieve the balance of learning and entertainment. Therefore, it is essential to identify the relevant interactive exhibit design approach, utilising an effective display technology and information design, when designing a new interactive display system.

The local museums in Malaysia have not taken full advantage of the potential innovations in exhibition design (Hasan 2006; Elottol & Bahauddin 2011). Most of the exhibitions are still presented in a conventional way that offers one-way communication, which is a simple form of presentation. A study conducted by Hasan (2006) on Malaysia’s museums performance revealed that there is a decline in interest and attention from the general public towards the exhibitions of natural history museum in Sarawak due to the traditional methods of displaying the artifacts in the museums which have become ‘mundane’ and ‘unexciting’. Considering the potential of display technology, further study in this area is required. It is an opportunity for the Sarawak Museum to develop an interactive exhibit that offers a more dynamic learning environment.

This research will look into multiple relevant aspects (taking into account, the aspects from a pedagogical, technological, and Human-Computer Interaction perspective) to design and develop an interactive exhibit that serves the purpose for visitors’ museum education. This study will evaluate the visitors’ perspective on the conventional exhibitions at the Sarawak Museum to identify the potential problems and solutions for an interactive museum exhibit.
1.2. Research Aim and Questions

This study aims to design and develop an interactive exhibit in the Sarawak Museum in order to enhance the current conventional exhibitions and visitors' learning experiences through a multi-disciplinary approach by incorporating the theories of learning in museums, relevant display technology, and application design requirements based on visitors’ perspectives on the Sarawak Museum’s current exhibitions.

More specifically, the objectives of this study are embedded in the following research questions.

RQ1: What is the role of museums today?
RQ2: What are the learning theories in museums that aid their role today?
RQ3: What is the role and implication of using various display technologies in interactive exhibits?
RQ4: What are the factors to be considered when designing an interactive exhibit?
RQ5: What is the learning preference of visitors at the Sarawak Museum? What are the problems of the current exhibitions at the Sarawak Museum and what are the solutions?
RQ6: What is the relevant and applicable display technology and application design suitable for the prototype in order to be effective?
RQ7: How is the effectiveness of the prototype in enhancing the current conventional exhibitions and visitors’ learning experiences?

The outcome of this study is expected to enhance the conventional way of exhibitions in the Sarawak Museum in order to motivate visitors’ learning in a more enjoyable experience. Most of the museums in Malaysia are still employing the conventional exhibit technique that is non-technology based. The experiment is conducted at the Sarawak Museum (Dewan Tun Abdul Razak), which is one of the galleries in Sarawak Museum, Kuching, Malaysia. The Sarawak Museum is the administrative center for all museums in Sarawak, Malaysia. Therefore, the Sarawak Museum is an ideal platform for this study. The research questions will be reviewed and answered through the various stages (chapters) of this study.

1.3. Scope and Limitations of the Study

This study focuses on the design and development of an interactive exhibit for the Sarawak Museum through a multi-disciplinary approach, covering the aspects of pedagogical (the theories of learning in museums), technology (relevant display technology), and human-computer interaction (application design requirements based on visitors’ perspectives on the Sarawak Museum’s current exhibitions). The limitations of the study are described as follows:

- The study is limited to the exploration, implementation, and evaluation of an interactive exhibit prototype that takes place at the new building of the Sarawak Museum, which is the Sarawak Museum (Dewan Tun Abdul Razak). Throughout this thesis, the term “Sarawak Museum” is used to refer to the Sarawak Museum (Dewan Tun Abdul Razak).
• The prototype is developed and evaluated for a single exhibit theme (Archaeology) presented at the Sarawak Museum (Dewan Tun Abdul Razak) for a contextual emphasis.
• All the materials and information related to the topic presented in the prototype are sourced from the staff at the Sarawak Museum. The materials provided are limited to text and images.
• The prototype will not include social networking capabilities as the time frame of this study does not allow for this.
• The prototype will be designed for general visitors at the Sarawak Museum. Therefore, the design will adopt conventionally accepted principles that will appeal to the wider general users.

1.4. Research Methodology

This study employs two types of research methodologies, which are qualitative and quantitative methods. Both research methodologies are appropriate to be used together to identify the solutions for research problems (Breach 2009). Qualitative method is used to generate descriptive data (e.g. words) to gain an understanding of an issue and is subjective-based, such as in the form of open-ended responses, interviews, observations, and document review. Quantitative method is used to generate statistical data (e.g. numbers) to make predictions, such as questionnaire survey. This method is more objective-based; therefore, it is more reliable (Wells & Butler 2002; B. Johnson & Christensen 2008). In the implementation, quantitative research is cheaper, faster, able to collect information from large sample, and easier to be analysed (Wells & Butler 2002). The research methodology for this study is illustrated in Figure 1-1.

This study will look into multiple relevant aspects to design and develop an interactive exhibit for the Sarawak Museum, covering the aspects of pedagogical (the theories of learning in museums), technology (relevant display technology), and Human-Computer Interaction (application design requirements based on visitors’ perspectives on the Sarawak Museum’s current exhibitions).

Stage 1 consists of the review of current and relevant literature in the field of interactive museum exhibition, the learning theories and the technologies involved. This will help to establish the relevant framework to inform the other stages of study.

Stage 2 consists of a preliminary quantitative front-end survey to gather information on visitors’ behaviour, preferences, and learning experiences and to evaluate the current exhibitions’ performance at the Sarawak Museum. A front-end evaluation is necessary in the initial stage to identify issues on current exhibitions to allow for the selection of relevant display technology and solution design (Wells & Butler 2002). Front-end evaluation focuses more on the pedagogical
and technological aspects, that is, to identify the needs of museum visitors and to explore the potential display technologies that address the visitors’ needs.

The processes in stage 1 and stage 2 will inform the design and development of the interactive exhibit prototype. An informal formative evaluation is also conducted during this development phase (stage 3) to evaluate the usability and visual interface design of the interactive exhibit prototype before the final installation. The evaluation includes usability testing, observation and interviews with a smaller number of visitors at the development site. Formative evaluation focuses on the Human-Computer Interaction (HCI) aspects, such as the design requirements for the usability of the prototype.

After the completion of the prototype (stage 4), a summative evaluation is carried out to assess the overall effectiveness of the interactive exhibit prototype in enhancing visitors’ learning experiences. Summative evaluation is conducted to evaluate the aspects of pedagogical, technological, and human-computer interaction (HCI). The evaluation is performed by the use of paper-based questionnaires and observations.

Figure 1-1 Overview of research methodology

1.5. Overview of Thesis Structure

This thesis is divided into six chapters, which are arranged as follows:
Chapter 1 (Introduction) presents the introduction of the research, including the research background, research aims and questions, research methodology as well as scope and limitations of the research.

Chapter 2 (Literature Review) explores the relevant literature about the study, including the role of museums, theories of learning in museums, and the role of technology to derive parameters to be considered for designing the prototype.
Chapter 3 (Front-End Evaluation) discusses the entire process of front-end evaluation to gather visitors’ information and perception towards the current exhibitions at the Sarawak Museum, involving the participants, instruments, procedures, and data collection. Finally, the discussion of the survey result.

Chapter 4 (Prototype Design and Development) discusses the prototype design and development process, including the prototype design concept and the development tools. Lastly, formative evaluation of the prototype is presented.

Chapter 5 (Summative Evaluation) outlines the summative evaluation process to determine the effectiveness of the prototype design and implementation at the Sarawak Museum. The discussions of the findings are also presented.

Chapter 6 (Conclusion) draws the conclusion of the study and discusses the future work for further research.
Chapter 2. Literature Review

This chapter attempts to cover as comprehensive as possible, the current and prevalent literature review related to the research area. The first section in this chapter attempts to understand the role of museums today, as they shift from an archiving institution into one with a stronger educational responsibility (Section 2.1). Subsequently, the following section attempts to understand how museums carry out that educational role in reviewing the learning theories that traditional and interactive museum exhibits employ (Section 2.2). Thirdly, a review on the role of technology in museum exhibitions in this section attempts to identify the relevance of display technology and their impact on museum learning (Section 2.3). Lastly, a summary of the literature review is presented (Section 2.4).

This chapter aims to answer four research questions of the study which are:

RQ1: What is the role of museums today?
RQ2: What are the learning theories in museums that aid their role today?
RQ3: What is the role and implication of using various display technologies in interactive exhibits?
RQ4: What are the factors to be considered when designing an interactive exhibit?

2.1. The Role of Museums

Museums are important to society for archiving, documenting, preserving, and exhibiting massive collections of cultural and historical artifacts. The collections are stored and preserved and the public has access to these specific artifacts and memories. The more traditional role of a museum is clearly defined by the International Council of Museums (ICOM) in 1946 as "museums include all collections open to the public, of artistic, technical, scientific, historical or archaeological material, including zoos and botanical gardens, but excluding libraries, except in so far as they maintain permanent exhibition rooms". The statement explains that museums have the functions to collect, to preserve and to exhibit. The mission of museums appears to be accomplished as long as the exhibition hall exists for the public.

However, the role of museums has shifted and evolved over time as the institution started taking up more specific objectives. Donald (1991) mentioned, “Museums have always played an important role as repositories of knowledge or artifacts of knowledge, but in the 20th century they have increasingly become active disseminators of knowledge.” By being “active disseminators of knowledge”, museums today conduct many kinds of learning activities, such as workshops, school field trips, tours for the public, and dissemination of information online.

The shift in the role of museums from passive exhibition to active dissemination of knowledge has resulted in the re-definition by ICOM in 2007. “A museum is a non-profit, permanent
institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment" (ICOM 2007).

Each museum has its own uniqueness in the range of displays, from a large institution that houses different categories of exhibit to a small institution that focuses on a specific category of exhibit. The types of museum include natural history, archaeology, ethnology, zoology, craft, arts, science and technology. Different types of museum provide different kinds of learning experience. This illustrates that the educational role is crucial for all museums (Hein 1998; Hooper-Greenhill 1999).

The community is increasingly taking interest in museums as a source of both knowledge and leisure. Most visitors spend their vacations visiting museums to experience their moment in history and culture. When visitors discuss about their museum experiences, they will not only share what knowledge they acquire but also how they feel in the museum visit. Visitors are expecting to obtain knowledge and, at the same time, to create good memories about their visiting in museum (Falk & Dierking 1992). In this context, the educational role of museums is not only related to intellectual experience, but also to emotional experience (Falk & Dierking 1992; Hennes 2002; Daniela Petrelli et al. 1999). This implies that for a museum to be effective in its role, it needs to provide for an educational experience.

Studies support the view that the primary role of museums is strongly hinged on the educational aspect (Hein 1998; Hooper-Greenhill 1999). However, from the visitors’ perspective, museums are not only a source of knowledge, but are sites for different types of experiences (Pekarik et al. 1999). As a result, there are now two outcomes in the educational role of museums: knowledge and experience. The experience can refer to the various activities, such as looking at artifacts, reading text, discussing the artifacts with friends, and participating in interactive exhibit, for the purpose of intellectual and emotional stimulation. Therefore, learning is the main objective that is supported through experiences. To summarise, the role of museums today is to provide an educational experience that will stimulate both the intellect (cognitive experience) and emotion (affective experience) of visitors.

The next question naturally is how this is done. What are the learning strategies that museum employs to assist the educational role?

2.2. Museum Education

Museum curators and exhibit designers have looked for a better understanding of learning theories to design the museum exhibitions. This section attempts to understand the learning
approaches in museum setting and the underlying contexts involved in museum learning. Several educational theories have been created by museum educators and researchers (Hein 1998; Falk & Dierking 1992; Stephen Bitgood 1993; Litwak 1993; Falk & Storksdieck 2005; Stephen Bitgood 2000) to facilitate museum exhibition designs for enhancing visitors’ learning experiences and assisting museums to accomplish their educational responsibility. This study discusses the educational theories developed by George Hein (1998) that discusses from the traditional didactic approach to the modern constructivism. Subsequently, the Interactive Experience Model developed by John Falk and Lynn Dierking (1992) is discussed to understand the three significant contexts involved in constructing visitors’ learning experiences. These theories present a framework to draw the optimum museum learning approach for this study to facilitate the prototype design.

Constructivist learning theory

George Hein (1998) adopted four pedagogies by incorporating theories of knowledge (in the vertical axis) and learning (in the horizontal axis) (Figure 2-1). The theories of knowledge are described as “realism”, the concept that knowledge exists outside the learner and “idealism”, the concept that knowledge is constructed by the learner. The learning theories are classified as “passive” where learning is gradual increments and “active” where the learner constructs learning. The four educational theories formed are (1) Didactic/expository, (2) Stimulus-response, (3) Discovery and (4) Constructivism (Table 2-1).

Figure 2-1 Educational Theories by Hein (1998)
Table 2-1 Descriptions and characteristics of museums (adapted from Hein, 1998)

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<td>Didactic/Expository</td>
<td>• The traditional lecture and text mode</td>
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passive learners who absorb knowledge incrementally, which is normally found in the traditional schools. The content to be learned for both approaches is structured according to the subject and knowledge is conceptualised and transmitted from the instructor to the learner. Each learner is understood to receive the same message in the same way.

On the contrary, the focus of discovery-based teaching and constructivism is on the learner. The theories emphasise that learner is active in the process of knowledge construction. Hein (1998) suggests that the environment for both learning approach needs to be challenging and stimulating to motivate the learners’ exploration. Discovery-based learning and constructivism is more applicable for interactive museum teaching as they involve active learning in the exhibit gallery. However, being different from constructivism which does not set boundaries for knowledge to be constructed, discovery-based learning is sometimes structured for the intended outcome to be obtained (Hein 1998). Nevertheless, each of the learning theory can be applied in the museum setting (Hein 1998), depending on the purpose of exhibitions.

Hein (1998) mentioned, “Learning in the museum and understanding visitors’ learning has become a matter of survival for museums”. Several studies have discussed the theory of constructivism and suggested its relevance in museum education (Griffin et al. 2005; Falk & Storksdieck 2005; Illeris 2006; Hooper-Greenhill 2000). Correspondingly, Hein (1998) proposed to utilise the constructivist learning approach to understand learning in museum setting. He outlined some learning principles of constructivism and the influences in museum education that aid in developing for educational exhibitions.

- Learning is an active process of constructing meaning from sensory input and happens in the mind (Hein 1991). This suggests that learners need to be active in the learning process by being engaged, mentally and physically. Visitors are not passive audiences who will do nothing in their museum visits. On the contrary, they are active learners who will walk around to attend certain exhibits, to read the labels, to chat with their partners, and to participate in hands-on exhibits. Dewey (1986) emphasised that learning is not the “passive acceptance of knowledge”; it involves engaging in activities that stimulate learners to think and to do. Thus, museums need to provide an opportunity for visitors to make sense of their experiences through participatory exhibits that excite visitors’ intellectual and engagement, such as physical involvement displays.

- Learning is contextual and is facilitated with prior knowledge and experience (Hein 1998). Learning in constructivist museums does not lead to only one construction of meaning, but also to a contextual meaning (Griffin et al. 2005) by extending the learners’ previous knowledge that enables them to grasp the complete meaning of information. Therefore, the museum exhibitions must allow visitors to assimilate new knowledge based on their previous knowledge for learning to be contextual, for example by providing multiple points of access on the exhibit to provoke visitors’ exploration.
Learning involves learners to learn about the process and content of learning, as they learn (Hein 1991). In museums, the intended information is disseminated through the exhibitions. In order to grasp the exhibit message properly, visitors need to understand the exhibit concept. For example, the exhibits orientation in petroleum museum is fixed for the visitors to walk accordingly and sometimes require the visitors to move certain objects with the purpose of educating them about the oil drilling process. The knowledge will be constructed when the visitors comprehend the exhibition concept. It is important for the exhibits to be well-organised for visitors to learn without difficulty and to avoid failure in understanding the message.

Learning is "a social activity" and is influenced by language (Hein 1998). Learning is associated with others in the learning setting (Vygotsky 1978), for example students with tutors and visitors with museum staff or other visitors. Verbal communication occurs habitually amongst the visitors to discuss about a thought-provoking exhibit. When the knowledge is shared, learning becomes more effective as it enhances visitors’ prior knowledge. This implies that museum exhibitions must encourage social interaction amongst visitors to exchange information for better learning experiences, for example through a participatory exhibit that supports multi-users and operates in multi-languages.

Learning is not immediate; it takes time (Hein 1998). In the museum gallery, there are a large number of educational exhibits for visitors to visit. The majority of visitors spend some time with an exhibit to create their own meaning and to reflect on them, in which is not likely to be done in a short time. However, not all visitors are able to engage in the museum gallery for a long time, as they are restricted with their own prior agenda (Falk & Dierking 1992). Hence, in order to create optimal museum learning, the information conveyed through the exhibits must allow visitors to absorb in a relatively short time without eliminating the intellectual aspect and hindering visitors’ involvement on the exhibits.

Learning is motivated (Hein 1998). It is undeniably true that motivation is a very crucial aspect in learning (Falk & Dierking 1992; Mihaly Csikszentmihalyi & Hermanson 1995; Rennie & Johnston 2004). Similarly, in museums, the visitors are naturally motivated to make sense of things by exploring the exhibits. This requires museums to be an inspiring learning environment that provides opportunities for visitors to construct their own educational experiences actively.

Dean (1996) mentioned that, “there is no compulsion – no force allowed, needed, or wanted – in a museum visit. With the possible exception of school and guided tours, visitors can do as they wish within reason. They can learn at their own pace, in their own way, or not at all if they choose.” Museums provide an educational environment for visitors' learning that is “open-ended”, responding to the needs and interest of visitors. This suggests that learning in museums is personal, self-directed and free choice that leads to changes in visitors’ personalities, such as perceptions, attitudes and behaviour. In constructivist museum
approaches, the visitors have full control over what they engage with as well as how and when they engage with the museum in which result in significant learning experiences (Hein 1998).


Hein (1998) argued that learning is “a complex interplay”. Visitors’ learning experiences is not a single fact, but a dynamic process that is constructed by the influences of different contexts (Sheng & Chen 2012; Ek et al. 2008). So, what are the contexts involved in museum learning? What is the framework that fits into this study to develop an exhibit by utilising the constructivist museum approach?

**Interactive Experience Model**

As discussed earlier, the outcome of a learning process is generated through different influences such as prior knowledge and experience, interest, social activity, and exhibition concept. The interaction between these factors will result in either a positive education or an undesirable experience. Falk & Dierking (1992) have presented a comprehensive research by studying the museum visitors and sharing thoughts with other museum researchers and educators to draw the museum learning experience from the visitors’ perspective. They introduced the Interactive Experience Model (Figure 2-2), conceptualising the three contexts involved in museum learning which are (1) personal context, (2) social context, and (3) physical context.

Falk and Dierking (1992) defined learning, as “an active process of assimilating information within the three contexts and it requires accommodating new information in mental structures that enable it to be used later.” The framework suggests that each context has a definite influence in the construction of museum learning experience. Museum exhibit designers are informed about the significance of the three contexts in designing for museum exhibitions. This study looks into the Interactive Experience Model to gain a better understanding of the ideal contexts for an effective exhibit design in the constructivist museums.
1. Personal Context

Museum visitors are varied in nature. Each individual has a unique personality and bears different culture, education, and experience. Hence, learning has to be universal in order to be flexible and to allow for these variations. The personal context that helps in determining visitors learning experiences include demographic, prior knowledge and experience, motivation, interest, belief, emotion, and learning style (Falk & Dierking 1992). Understanding visitors’ personal context, in general, is important to expect the differences in visitors’ behaviour and learning experiences in museums. Visitor study aids in defining the exhibition design concept that fits into their level in order to allow museums to fulfil their roles effectively (Falk & Dierking 1992; Hein 1998; Hooper-Greenhill 1994).

Visitors have different level of knowledge and experience towards museums and their collections. There may be groups of novices or professionals, where each group will construct different amount and different type of information, based on their previous knowledge. Roschelle (1995) believed that learning is impossible without prior knowledge as it underpins the construction of meaning. Hein (1998) pointed out that when the exhibition concept is found not relevant to visitors’ every day’s life experiences, learning will not or may be difficult to be constructed. Therefore, the visitors’ prior knowledge must not be neglected when assessing museum learning (Dewey 1986; Roschelle 1995).
Learning, in all contexts, needs motivation (Falk & Dierking 1992; Hein 1998; Mihaly Csikszentmihalyi & Hermanson 1995). It suffers when there is no motivation. Motivation is understood as a driving force toward a goal that can be generated externally or internally (Goldman & Schaller 2004; M Csikszentmihalyi & LeFevre 1989) that encourages someone to act. External motivation is often under controlled by something such as an award or a prize, whereas internal motivation is generated internally from the learners to achieve a goal; it could be driven by interests, curiosity, personal needs or enjoyment (Mihaly Csikszentmihalyi & Hermanson 1995). Visitors come to museums with different purposes and predetermined expectations (Falk and Dierking 1992). When the consequences are perceived to have personal value, visitors are likely to spend more time and effort to achieve it. Studies suggest that successful learners tend to be internally motivated (Falk & Dierking 1992; Mihaly Csikszentmihalyi & Hermanson 1995) and interest is of the key motivator in learning (Mihaly Csikszentmihalyi & Hermanson 1995; Moussouri & Roussos 2013; Roschelle 1995). Museum setting needs to be able to appeal and to be relevant to visitors’ interests to invoke their curiosity and attention to learn.

Visitor attention is defined by Bitgood (2010) as “a group of psychological and physiological processes that involve a continuum of three-stages (capture, focus, and engage) with each stage sensitive to a unique combination of independent variables”. Learning takes place when the attention progresses from capture to engage. Visitors’ attention at each stage is influenced by the personal factors (such as perceived value and interest), the psychological-physiological factors (such as cognitive and affective factors, distractions and mental or physical fatigues) and also the environmental factors (such as social or physical). Visitors go to an exhibit that captures their attention; and their attention sustains when the exhibit is perceived meaningful and engaging. Csikszentmihalyi & Hermanson (1995) suggested that the use of contextual stimuli or ‘hooks’ to attract visitor attention (such as sounds or colours) may in turn stimulate visitor’s personal interest. However, too powerful stimuli, such as loud noise or flashes of light are disruptive and may turn into a distraction that take visitors’ attention away from the exhibit. Hence, it could be said that a highly salient stimulus must be avoided in order to keep visitors’ attention to focus on the exhibit.

The quality of attention is often measured by the frequency of the attended display (attraction power), time spent on the display (holding time) and the ratio of time spent to understand the message (holding power) (Screven 1990; Shettel 1973; Stephen Bitgood 2000). Studies support the view that visitors recall more on the exhibit that they spend more time on (Barnard & Loomis 1994; Shettel 1973). The degree of visitors’ viewing time influences the acquisition of the information. This implies that visitors’ attention is very important in learning to understand the contextual message (Screven 1990; Jacobson 1999; Stephen Bitgood 2010; Falk & Dierking 1992; Hooper-Greenhill 1994).
Learning is also greatly influenced by affective aspects such as belief, attitude and emotion (Falk & Dierking 1992; L. Roberts 1992; Vermunt 1996; Hennes 2002) that form the basis for motivation. When the visitors are in a state of negative belief or attitude, learning might not be possible. The curiosity of visitors arises when the exhibit is found fascinating. Consequently, they will be inspired to explore more on the exhibit to satisfy and to augment their prior knowledge.

Contextual learning is constructed by visitors when they are able to perceive and process the information effectively, in their own different ways (Falk & Dierking 1992; Fleming 2001; Kolb 1984; Hein 1998). Some researchers have developed models of learning styles that assist museums in accommodating a wide range of visitors. Kolb’s model of learning style (Figure 2-3) is suggested to be one of the widely used learning style theories (Kolb 1984). Kolb (1984) defined learning as “the process whereby knowledge is created through the transformation of experience”. He developed the Experiential Learning Theory (ELT) which is represented by four stages of learning cycles; (1) concrete experience (feeling) followed by (2) reflective observation (watching) to form (3) abstract concept (thinking) and cause (4) active experimentation (doing) (Kolb 1984). Kolb suggested that all four stages must exist for an effective learning experience to take place.

![Figure 2-3 Kolb’s learning styles](image)

The basic learning styles developed by Kolb (1984) (Figure 2-3) based on the four-stage learning cycles are as follows:

1. Diverging
These learners prefer to watch rather than do. They perform better in the brainstorming process and like to work in groups to gather information. They depend on concrete experience (feeling) and reflective observation (watching).

2. **Assimilating**

These learners are more interested in ideas rather than people. They enjoy reading and having time to think through. They are good at understanding wide-ranging information. They rely on reflective observation (watching) and abstract concepts (thinking).

3. **Converging**

This type of learners likes to experiment with new ideas and to work with practical applications. They have less focus on social or interpersonal issues. These learners depend on active experimentation (doing) and abstract concepts (thinking).

4. **Accommodating**

These ‘hands-on’ learners prefer an experiential approach and active engagement rather than reading. They apply what they have learnt to real-life situations. These learners tend to rely on active experimentation (doing) and concrete experience (feeling).

Fleming (2001) defined learning style as “an individual’s characteristics and preferred ways of gathering, organising, and thinking about information.” He discusses the different way for learners take in new information by sensory modalities, which include visual learners, auditory learners, read/write learners, and kinaesthetic learners. Each visitor learns through different style to attain information through the museum exhibits that contain a similar range of knowledge. Hence, recognising the learning styles of visitors assists the exhibition designers to understand and to respond to their uniqueness.

### 2. Social Context

Learning is not only a personal matter, but also involves social contexts such as social interaction or social activity (Vygotsky 1978; Litwak 1993; Falk & Dierking 1992; Hein 1998; Stephen Bitgood 1993). Lev Vygotsky (1978) discusses the important of social mediation in the learning process. He points out that knowledge is constructed within the interactions between individuals that enhance each individual’s previous knowledge. What and how the knowledge is acquired in museums can be mediated by the social groups or even by the museum crowd. Learning experience created by each individual differs depending on the social knowledge and behaviour (Falk & Dierking 1992; Vygotsky 1978). Therefore, it is necessary to understand the social context in museum learning to design an exhibit that motivates social interactions learning.

Vygotsky (1978) revealed that the more knowledgeable group member scaffolds the less knowledgeable member in the learning process. For example, adults are more experienced than children are; as a result, children are usually questioning the adults to make sense of
things. The less experienced learner tends to learn from the other people in order to learn effectively, such as by “modelling” other people (Falk & Dierking 1992). Modelling also takes place in the museum setting such as when the visitors learn how to control an interactive kiosk from the demonstrations of the museum staff. It could be said that the level of knowledge acquired by the visitors is influenced by the experience and behaviour of the other party.

As have been discussed in museum studies (Falk & Dierking 1992; Litwak 1993; Vygotsky 1978; Stephen Bitgood 1993; Hein 1998; Kelly & A. Museum 2001), frequently, museum visits are social activities, such as in a family, students on a school trip, or an organised company group. It appears that visitors have expected to include their companions in creating their museum experience. The social groups discuss and share their thoughts on the exhibit they are visiting. The conversation developed may, or may not, directly connected to the exhibit (Falk & Dierking 1992). However, the information exchanged allows them to learn something new. Therefore, the museum exhibition is expected to support group activities and discussion to augment the prior knowledge of visitors.

3. Physical Context
Apart from the social environment, learning is also influenced by the physical environment of museum (Falk & Dierking 1992). The physical factors that influence museum experience include the building design, atmosphere, and all displays contained within (e.g. artifacts, labels, etc.). One of the significant elements in the museum setting that strongly determine visitors’ learning is the museum exhibition. This is because museums have been relying on the exhibitions to carry out their educational role (Hooper-Greenhill 1999). What knowledge to be conveyed and how it is disseminated to the visitors are depending on the exhibition design; hence, it influences visitors’ behaviour and attitude in constructing knowledge. There is a need to consider the importance of physical setting in museum learning, especially in the exhibition design, to provide an enjoyable learning environment that allows for successful museum education.

As learning is the process of being engaged mentally and physically (Hein 1998), the learning environment must be comfortable and competent for the visitors to prevent “museum fatigue” (Davey 2005; Hein 1998; Stephen Bitgood 2009). Museum fatigue describes the decline of visitors’ interest in museum visit due to physical and mental exhaustion. The causes of museum fatigue may come from the visitors and (or) the learning environment (Davey 2005; Stephen Bitgood 2009). For example, the visitors who are having a mental distraction from their personal matters or physically tired of walking will decrease their attention to the exhibits. An uncomfortable environment or exhibition concept will also cause the visitors to attend less, for instance the overload information on labels that pressures the visitors to spend time to read.
Learning needs to be enjoyable to reduce tension and to increase attention of the learners. The museum exhibitions need to be comfortable (e.g. an ergonomics exhibit without the aggressive use of sensory or stimulus) and competent to enhance visitors’ learning and enjoyment. Additionally, the exhibition design must not overwhelm visitors with unfamiliarity that is incomprehensible for learning (e.g. excessive advanced technology exhibits or improper use of digital media) (Hein 1998). It is important to ensure that visitors’ attention in the museum visit is continual for a better learning and experience to follow.

All exhibitions evoke feelings and meanings. The arrangement of content in museum exhibitions influences the construction of knowledge (Hein 1998). Therefore, the museum exhibition designed under the visitors’ familiarity is important to assist their learning process. Narration is a practice in constructivism as an essential way of making sense of texts, due to its structure and consistency (Plowman et al. 1999). Bruner (1991) argued that one’s memory and experience is organised mainly in narrative form. Traditionally, people have been learning by using stories to represent a series of events. Bedford (2001) revealed that stories are encouraging personal and social learning. Besides, stories also enhance the understanding of justifications, such as for scientific presentation. Roberts (1997) supports the view that narrative “as a legitimate, alternative form of meaning making has been advocated by social scientists and specifically applied as an explanatory scheme for meaning making in the museum”, describing the narrative context as a way to facilitate visitors’ engagement in museum. The potential of narrative concept has been explored by museum researchers and discussed to be an effective way in educating visitors about the collections over time and place (Bruner 1991; L. C. Roberts 1997; Bedford 2001; Allen 2004).

Figure 2-4 The model of museum education

The underlying contexts that play significant roles in the museum education are identified, which consists of personal context, social context, and physical context. It appears that learning in
museums is personalised and reinforced by the social and physical environment. Visitors’ educational experience is driven by the interaction of the three contexts to engage in the museum exhibits (as illustrated in Figure 2-4). Therefore, understanding how the overlapping contexts can influence visitors’ learning experience is necessary for this study to develop an exhibit design that motivates visitors’ affective (emotional) and cognitive (intellectual) engagement. The exhibit design considerations for a constructivist museum are framed in the contextual framework (Table 2-2).

Table 2-2 Exhibit design considerations based on the three contexts: personal, social, and physical

<table>
<thead>
<tr>
<th>Contexts</th>
<th>Principles</th>
<th>Design Considerations</th>
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| Personal | • Learning is personalised - independent  
           • Learning is motivated, intrinsically and extrinsically  
           • Learning is facilitated by personal interest and preference  
           • Learning is constructed from prior knowledge and experience  
           • Learning is controlled by learners as they learn in their own way  
           • Learning is not only for intellectual satisfaction, but also for emotional stimulation | • Provide multiple points of access to allow for self-control and choice  
• Provide comprehensive information to augment learner’s knowledge and for contextualisation  
• Provide layering of information to personalise the information and for contextualisation  
• Engage exploration  
• Multi-lingual for different cultures  
• Narrative contextualisation  
• Allow for physical interaction with the exhibit to evoke emotions |
| Social   | • Learning is a social involvement  
           • The construction of knowledge and experience is scaffolded through social interactions | • Allow for multi-users and social interaction for collaborative learning |
| Physical | • Learning is reinforced by the physical environment | • A comfortable and competent exhibit to avoid museum fatigue  
• An easy navigated exhibit and provide clear feedbacks  
• Well-organised interpretation  
• Attractive exhibit to reinforce intrinsic motivation  
• Considerable use of contextual stimuli |
2.3. Technology in Museums

The principles of learning discussed in the previous section have underlined the importance of exhibition design in determining the success of museum education. As museums have become increasingly popular, the exhibitions approach has also changed greatly. The innovation of technology has allowed different types of digital media to be deployed in museum exhibitions to deliver information that can be organised attractively and interactively to aid visitors’ engagement. The implementation of technology has substituted the printed labels and has involved computer-based application that is more sophisticated. Museums have embraced interactive technology to offer contextual information on the exhibits and to boost museum attendance (Hirose 2006). Understanding how technology plays its role in museums, especially the impact on museum learning, is necessary for the considerations on utilising digital technology in this study.

Multimedia interactivity – an integrated digital media which include texts, images, audio, video, animation, and interactivity – has facilitated museums in disseminating information in a more engaging way that enhances visitors’ acquisition of knowledge and experience (Morgan 2012; Tallon & Walker 2008; Cucchiara et al. 2012; Dipaola & Akai 2006; Thom-santelli et al. 2006; Marchetti & Brooks 2012; Bearman 1995). Multimedia applications in museums range from interactive games, interactive storytelling, interactive problem solving and audio tours to museum websites.

Multimedia applications have been embedded in digital technologies that are widely used in modern museums exhibitions; including mobile phones, PDAs, interactive tabletop, Virtual Reality, 3D display, Augmented Reality, hologram, etc. Such technologies have changed the static and passive exhibits into the active and entertaining exhibits. Visitors will not experience the exhibits in a linear manner any longer; they can move freely and make use of the available display media for their information exploration.

Interactive exhibits are more attractive and educative (Haywood & Cairns 2006) as it offers mutual feedback from the display to visitors. Additionally, visitors are given the ability to touch the screen or wall, push buttons, play games, solve puzzles and experience forms of sensorial display through interactive exhibits. The more current and widely used display technology in the museum exhibitions includes mobile devices, interactive digital signage, and virtual reality (VR). Each display technology provides advantages and drawbacks on the implementation, which requires a careful planning on the development to achieve their full potential for museum learning.
Mobile devices
Mobile devices are referred to as handheld computers that typically have a multi-touch display screen or keypad. Mobile devices are widely accessible and the price is relatively affordable. Most people engage with mobile devices (e.g. smart phones) in their everyday activities. Mobile devices that are increasingly used in museums include smart phones, PDAs, MP3s, and iPods. Multimedia applications on handheld devices range from museum database collections, tour guides, mobile websites and interactive games.

In 2002, the Tate Modern museum in London launched the first trial of an interactive multimedia tour system which was implemented using PDAs on the wireless network (Wilson 2004). In 2004, the Tate Modern museum improved its Multimedia Tour programme to include three types of handheld tours to cater for a range of visitors. The three types of handheld tours were: the Multimedia Highlights Tour targeted to 16-25 age groups, a tour in British Sign Language targeted to deaf people, and a Collections Tour that offered rich digital information for the artwork in the Collection displays (Wilson 2004). Visitors had improved their museum experiences by accessing different types of multimedia information such as audio, video, image, text, interactive games and peer-to-peer communication through the PDAs (Wilson 2004). The interactive games included in the Highlights Tour were successful in encouraging visitors to think and learn about the particular artwork. It was concluded that the implementation of mobile interpretation in Tate Modern had facilitated visitors’ learning experience and enhanced their engagement with the displays (Wilson 2004). However, the interface design was found to be problematic as the symbols were small and difficult to view by visitors.

Linge et al.(2012) introduced the mi-Guide multimedia visitor guide at the Museum of Science and Industry (UK) on PDAs that could determine the visitor’s location within the gallery and deliver relevant information to the visitor about specific artifacts at his/her location. Their experiments proved that mi-Guide had added value to visitors’ experience as it offered greater interest and activity (Linge et al. 2012). The PDA interpretation was found to be absorbing, educational, and entertaining by visitors (Tallon & Walker 2008).

Damala (2008) developed a multimedia museum guide for the Museum of Fine Arts in Rennes, France, by incorporating Augmented Reality (AR) interface on Ultra Mobile PC (UMPC) (Damala et al. 2008). Augmented Reality (AR) is related to the superimposed graphics or information that appears in real time environment on the display screen (Hirose 2006). The AR display system held by visitors was directed towards the painting to view the captured video in real time on the screen, augmented with 2D or 3D virtual objects. Visitors were provided access to other digital documents interactively by using the UMPC buttons or the touch-sensitive screen. The field study revealed that Augmented Reality-assisted interface facilitated visitors to
intuitively switch their attention from the physical to the digital space and vice versa (Damala et al. 2008).

Mobile devices for visitor guides are perceived to be more personalised (Richards 2010) because visitors keep their own devices throughout the exploration and are able to interact with it wherever and whenever they want without time limitation. However, the display range for viewing the information through mobile devices is restricted by the small screen. In addition, multi-users on a single mobile device are not supported as users’ physical interaction on the screen is limited. Hence, a larger screen device that allows for multi-users engagement is preferable for the visitors. Nevertheless, mobile devices support collaborative learning through social networking systems.

Interactive digital signage
Interactive digital signage displays include interactive tabletops and interactive walls. Interactive digital signage displays multimedia application on a big multi-touch screen and allows gestures interaction. The interactive wall is attached to the wall, while the tabletop is an interactive multi-touch table. The interactive wall and tabletop has high levels of interactivity as it allows multiple users to input together on the same time (Geller 2006). Both types of display are effective forms of display due to their large format display that are easily viewable by a large number of visitors at once.

The museum of Copenhagen and its collaborators launched a gigantic WALL (Museum of Copenhagen 2013) on 2010 with highly interactive multi-touch screens which displayed a mixture of the museums’ collections and contemporary photographs of the city (Figure 2-5). The interactive wall was found to be very ‘attention-grabbing’ and attractive.

![Figure 2-5 A part of the WALL’s cityscape](image-url)
Tabletop systems and interactive walls are interactive sharable displays which enable visitors to have face-to-face discussion in museums (Buisine et al. 2012; Speelpenning et al. 2011) and its implications are found to be enjoyable as well as able to promote playfulness and learning (Buisine et al. 2012). The Churchill Museum in London uses advanced technology and multimedia displays to bring the exciting story of Winston Churchill to life (Figure 2-6). It has a 15-metre-long interactive table on which visitors can access information about Churchill. Visitors can touch the screen to change the information being displayed. Its uniqueness draws visitors’ attention to explore the information.

![Figure 2-6 Churchill Lifeline at the Churchill Museum and Cabinet War Room (© Small Design Firm)](image)

The ‘Tree of Life’ table implemented at Berlin Museum of Natural History revealed how interactive application design that did not resemble the computer display aroused repertoire of multi-fingered and bimanual gestures, with organic elements evoking rich multi-fingers gestures, and button like objects mostly pointing and button-pressing (Hornecker 2008). Analysis of the interaction patterns appeared that visitors mostly perceived the table as a ‘toy’ for children, which indicated the information-browsing applications of interactive tabletop was still imperfect in its functionality and did not approach the versatility of the desktop (Hornecker 2008). It implies that the application design for interactive exhibits indeed plays a significant role.

The interactive digital signage supports both personalisation and collaborative learning through its large display. Besides, it also promotes high interactivity that accommodates multi-users to engage in the display. Better learning is achievable through the interactive digital signage as it allows for multiple layers of information and multiple access points for users to choose and control. Besides, the intuitive interface allows users to use it without difficulty. However, as interactive digital signage is a high-tech display system, the hardware is comparatively still
expensive (Geller 2006). Therefore, an alternative way of creating the display technology must be seek to reduce the development cost.

**Virtual Reality (VR)**

Virtual Reality is a computer-simulated environment that simulates environment in the real world. VR is used for visual experiences and displayed through stereoscopic displays or on a computer screen (virtual museum) (Hirose 2006). The multimedia application for Virtual Reality ranges from static display to dynamic interactive display for a single user to multi-users. Some simulations consist of additional sensory information, such as sound, or force feedback. VR can be performed in the actual rooms augmented with wearable computers that allow users to feel the environment. 3D environment is one of the display contents in virtual systems that have been developed to build an immersive perceptual experience (Brooks, Frederick P 1999).

The China Water Museum developed a 3D virtual experience system to provide real time experience to the visitors. For example, visitors can walk into the virtual scene and interact with the models by changing the model’s colour, texture and perspective and so forth (Chai 2009). The Gold Museum, in Bogotá, Colombia, has created a VR multimodal interface that allowed visitors to touch, hear, and see the small artifacts. The technologies have incorporated 3D visualisation, haptic feedback and sound reproduction to give more experience to the visitors on the artifacts. Users can interact by selecting an artifact to be cleaned and to be weighed by following the audio instruction (Figueroa et al. 2009). Virtual Reality systems have been successful in engaging responsive interactions from the visitors.

Virtual Reality is very interactive and has great potential in enhancing visitors’ experience through its immersive technology. However, the construction of the models takes time and needs to be designed in detail to provide better visuals. As a result, the cost and maintenance of this immersive display technology are relatively high (George 2003; Roussou 2001).

**2.3.1. The Impacts on Museum Education**

Technology has changed the nature of physical environments in museums, which in turn transformed the experience of visitors. Interactive exhibit has appeared to be popular with visitors and has been accepted as the interpretative media that facilitate visitors’ learning experiences (Economou 1999). The use of technology has given positive influence in the personal context (e.g. personalisation), social contexts (e.g. collaborative learning), and physical context (e.g. the practice of museum exhibitions).

Technology has introduced a high level of interest and engagement through its visualisation and interactive capability. The additional manuscripts that are not presented in museums can be
digitised and presented in a well-organised and appealing manner. Therefore, visitors’ learning will be more contextualise to enhance their previous knowledge and experiences.

Technology offers various types of interaction and multi-sensory experience in the museum exhibitions, which motivates visitors into activities, and therefore, actively participating in learning. In addition, visitors can learn through active learning modes that are supported by technology-based exhibits: by reading, listening and physical interaction (kinaesthetic). The technology has allowed for more experiential exhibitions and has enhanced the dissemination of information and the types of content being produced. It could be said that museum learning is facilitated by the technology to be an active process that involves visitors to engage physically and mentally.

The use of interactive technology allows flexibility for the users to construct their own learning. Visitors are able to choose and control the content they want to learn based on their interest, such as in the audio tour. Furthermore, interactive technology supports collaborative learning that engages social interactions which is achievable through a larger display, such as interactive tabletop and interactive walls. With the availability of social networking systems today, visitors are able to socialise with other visitors within or outside the museum. This creates a new experience and knowledge in the museum learning. Moreover, a better learning will be constructed when there are social interactions. In this way, interactive technology plays a vital role in enhancing constructivist learning and experiences.

However, the implementation of interactive exhibits has raised questions regarding the technological impact on the authenticity of the museum artifacts (Stogner 2009; Griffiths 2003). They caution that the interactive exhibit may divert visitors’ attention from the real knowledge and undermine the originality of education role in museums (Stogner 2009). It is important that the use of technology does not overwhelm and draw visitors’ attention away from the original aim, which is to convey the meaning and the story of the original artifacts (Stogner 2009; A. Griffiths 2003; Morgan 2012; Damala 2007). Visitors’ attention should not be distracted from the real objects in museum, as they are intended to augment the conventional interpretation to facilitate learning opportunity (Morgan 2012; Kuflik et al. 2011). Damala (2007) discussed the important of traditional printed labels and artifacts as the foundation on which visitors’ experience is built. Hence, it seems that the most effective museum exhibition strategy is the integration of actual objects and digital. Studies claim that it is still a challenge for museums to find a balance between education and entertainment.

“The effectiveness of a successful museum interpretation lies not only in the content chosen, but also in its organisation and the chosen display” (Damala 2007). The choice of display technology is an important factor as it affects visibility, input possibilities, and interaction with the
display (Hinrichs et al. 2008). Hence, the content and the display technology for the interactive exhibit must be planned and designed properly to tailor to visitors’ expectations.

Studies have suggested some design and technology issues to be considered when designing interactive exhibits (Dipaola & Akai, 2006; Allen, 2004), mostly related to the usability of technology and content design. The selection of appropriate interactive technology also depends upon factors such as cost, accessibility, usability, speed, portability, durability, maintenance, as well as the learning-related factors. Underneath (Table 2-3) is the evaluation of the display technologies (mobile devices, interactive digital signage, Virtual Reality) by considering the aforementioned factors. The comparison of these factors depends on the interaction devices and the interface design of the display technologies. This assessment will aid this study to identify the applicable display technology for the prototype based on the visitors’ requirements.

<table>
<thead>
<tr>
<th>Consideration Factors</th>
<th>Mobile Devices</th>
<th>Interactive Digital Signage</th>
<th>Virtual Reality (VR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Low - Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Accessibility</td>
<td>High</td>
<td>High</td>
<td>Low - High</td>
</tr>
<tr>
<td>Usability</td>
<td>Medium – High</td>
<td>High</td>
<td>Low - High</td>
</tr>
<tr>
<td>Speed</td>
<td>Low – High</td>
<td>Low - High</td>
<td>Low - High</td>
</tr>
<tr>
<td>Portability</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Durability</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Medium – High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Learning curve</td>
<td>Short</td>
<td>Short</td>
<td>Short - Long</td>
</tr>
<tr>
<td>Personalisation</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Collaborative learning</td>
<td>Low - High</td>
<td>High</td>
<td>Low – High</td>
</tr>
<tr>
<td>Interactivity level</td>
<td>Medium - High</td>
<td>High</td>
<td>Low - High</td>
</tr>
</tbody>
</table>

To summarise, the use of technology in interactive exhibits requires high maintenance of time and costs. In addition, it has a relatively short life span. Therefore, the application designed for the interactive exhibit should be robust enough to withstand the use it will receive and that it is being used to its full potential. Since the visitors are using all interactive exhibits intensely, the technology may not be working properly due to this reason. Thus, the technology has to be applicable and easy to maintain to ensure its durability to engage visitors’ exploration. The selection of display technology for the interactive exhibit must be usable and applicable to all general visitors to be flexible. Finally, the use of interactivity feature in the interactive exhibit must be competent and do not overwhelm visitors. There is a need to ensure the authenticity of the artifacts despite the use of technology.
As the focus of museum exhibitions is on the users, the design and development for the interactive exhibit prototype need to involve museum visitors right from the beginning of the innovation process and to keep them constantly at the centre of the design itself (Cucchiara et al. 2012; Hooper-Greenhill 1999; Screven 1990). As suggested by museum studies, three levels of evaluations are necessary to evaluate the exhibition design (Screven 1990). As suggested by museum studies, three levels of evaluations are necessary to evaluate the exhibition design (Screven 1990).

1. Front-end evaluation (before the design process)
   This evaluation is performed at the planning stage to find out the visitors’ needs and perceptions on the current exhibition displays at the museum.

2. Formative evaluation (during the design stage)
   This evaluation is conducted during the exhibition design process to identify the usability and potential problems to be improved before the interactive exhibit prototype installation.

3. Summative evaluation (after the implementation of the design)
   This is the final visitors’ evaluation to assess the effectiveness of the exhibition in achieving its goal.

2.4. Summary of Chapter

This chapter reviewed the role of museums today which revealed a shift from the traditional conservation role into one with educational responsibilities. The constructivist theory has been reviewed to be the relevant learning theory in museums in performing this educational role. The learning theory involves learners to actively construct their own knowledge in the environment, mentally and physically, and to reflect on their experience. The Interactive Experience Model by Falk & Dierking (1992) offers valuable insight into the major concerns of the three contexts (personal, social, physical) in constructivist museums. It appears that learning is not only about personal motivation, but is also influenced by the environment (social and physical). These contexts are inseparable, intertwined and are essential for the success of museum learning. Therefore, they must be assessed during the exhibition planning in this study.

The role of technology in museums has greatly influenced the exhibition approach as it has shifted from a passive communication method into an active and engaging interactive one. This shift has also influenced the change in visitors’ experiences in museum learning. Interactive exhibit allows visitors to be engaged in activities, suggesting active participation in learning, such as through interaction with the exhibit display. The use of digital technology has also substituted the traditional labels and enhanced the organisation’s capability to provide contextual information and an attractive visualisation.
Today, learning in a museum is not only about attaining intellectual experience, but also about emotional satisfaction. The role of technology has revealed to increase visitors’ engagement and to provide flexibility in knowledge construction, which implies its vital role in facilitating constructivist museum. However, the use of interactive technology must be balanced to preserve the focus on the original artifacts. There are issues to be taken into account when designing the interactive exhibit prototype, involving the three contexts of museum learning (Table 2-2) and the effective use of display technology (Table 2-3).

The studies reveal that there is a need to explore various aspects to allow for the development of an effective interactive exhibit for museum education, from the pedagogical aspects (the role of museums and the theories of museum education) to the technological aspects (the relevant display technology in museums) and Human-Computer Interaction (HCI). In addition, understanding the underlying three contexts (personal, social, and physical) in the museum education is significant as it influences visitor’s learning experience. The three contexts (personal, social, and physical) and the multiple relevance aspects (pedagogy, technology, and Human-Computer Interaction) must be assessed collectively for developing an effective interactive exhibit for museum education.

The next chapter (Chapter 3) will discuss the process of front-end evaluation to collect visitors’ information (e.g. demographics, behaviour, preferences) and their perceptions towards the existing exhibitions’ performance at the Sarawak Museum. The evaluation is intended to identify the visitors’ preferences and to explore problems on the Sarawak Museum exhibition in facilitating visitors’ learning experiences.
Chapter 3. Front-End Evaluation

Discussion in the previous chapter (Chapter 2) has described a change in the museums' role from collecting artifacts to educating visitors. Today, visitors are not only keen to satisfy their intellectual learning, but also to fulfill their emotional needs. This leads to a shift in visitors' learning from being passive audiences into active participants as they expect newer experiences. At the same time, the role of technology has transformed the traditional didactic exhibition into the active experiential exhibition which facilitates for visitors’ active learning needs. These changes require museums to identify and understand the visitors’ perspective and to investigate the effectiveness of the current exhibitions in meeting their expectations.

This chapter details how a survey questionnaire was designed to gather visitors' information at the Sarawak Museum. The latter section of the questionnaire assesses the limitations of current Sarawak Museum’s exhibitions and suggests possible solutions to enhance the museum displays. This chapter will discuss front-end evaluation process and the survey results that were derived.

3.1. Methodology

This section aims to address research question 5 of the study (RQ5): What is the learning preference of visitors at the Sarawak Museum? What are the problems of the current exhibitions at the Sarawak Museum and what are the solutions? The survey results would contribute to the ideas of designing an interactive exhibit prototype for enhancing visitors' learning experiences at the Sarawak Museum.

The relevant data were to be collected through a front-end evaluation to gather information on the trend of current visitors’ behaviours and preferences, as well as their expectations of the Sarawak Museum exhibitions in facilitating their learning experiences.

The methodology used in the front-end evaluation was based on a quantitative approach which involved paper-based questionnaire survey to measure the variables for visitors’ information, learning experiences, and performance of the exhibitions. The evaluation was carried out in the Sarawak Museum (Dewan Tun Abdul Razak) during the opening hours, in February, 2012.

The Sarawak Museum has two wings (galleries), namely, the Sarawak Museum (Old Building) and the Sarawak Museum (Dewan Tun Abdul Razak). The Sarawak Museum (Old Building) has been incorporated in Kuching, the capital of Sarawak state in Malaysia, since 1891. The museum exhibits the collections of ethnography and natural history of Sarawak. It is well-known among the museums at South-East Asia for having the most comprehensive collection of Borneo artifacts. The Sarawak Museum (Dewan Tun Abdul Razak) was converted into a
museum exhibition in 1982. It houses most artifacts related to pre-historical era and archaeological materials found from various excavation sites in Sarawak. The strategic location and large space of the building were also taken into consideration for conducting the survey.

![Figure 3-1 Exhibition rooms in the Sarawak Museum (Dewan Tun Abdul Razak) (S. Museum 2013)](image)

### 3.1.1. Participants

The target population for this study was the general visitors in the Sarawak Museum. The participants were not predetermined, following a random sampling procedure. This study was targeted to 50 respondents as the number of sample is sufficient for generalisations (O’ Brien & Wetzel 1992). It was preferable to have participants from 12 years of age or above as they would be more capable in answering the questions based on their prior knowledge and experiences. As the study needs to assess the visitors’ experience of the conventional exhibits at the Sarawak Museum, this evaluation would be a post-visit assessment. The targeted participants must have experienced the museum exhibitions before taking part of the evaluation. In order to obtain reliable and effective responses, the participants must be motivated to fill-in the questionnaire and must not be constrained in time. Apart from that, there are no other significant requirements for the targeted respondents.

### 3.1.2. Instruments

This study adopted a questionnaire survey to collect visitors’ personal information and perceptions towards the existing exhibitions’ performance at the Sarawak Museum. The variables to be measured in the questionnaire (as can be found in Appendix 3) were related to the research question 5 (RQ5) and the result were evaluated.

The questionnaires comprised both open-ended and close-ended questions which were divided into four sections. The design of questionnaire was framed from the Interactive Experience Model (Falk & Dierking 1992) as discussed in the previous chapter (Chapter 2 in Section 2.2). The contextual framework was used to assess visitors’ learning experiences at the Sarawak
Museum as the result of the interaction of personal factors and environmental factors (social and physical).

The first three sections of the questionnaire aimed to identify the personal context of visitors, involving visitors' demographics, behaviour during museum visit, and preferences in museum education. The fourth section of the questionnaire aimed to assess the influence of environmental factors (social and physical) towards visitors' learning experiences, to identify the problems and to suggest possible solutions for the interactive exhibit prototype. The latter part of the fourth section comprised open-ended questions to assess visitors’ perspective towards the communication method in the current exhibitions.

Details of each section are discussed below:

1. Participants' demographic information
   The first section of the questionnaire comprised questions related to the participants' demographic information. The variables investigated were:
   - gender (two possible values: male, female)
   - age group (six possible values: under 18, 18-24, 25-34, 35-44, 45-54, over 55)
   - nationality
   - language (two possible values: English, other)
   - education level (four possible values: high school or equivalent, college/university, postgraduate, other)
   - profession (seven possible values: professional, self-employed, trader/proprietor, educator, student, retiree, other)

2. Participants' behaviours
   The second section of the questionnaire intended to identify the participants’ behaviours in museum visit, at the Sarawak Museum and at other museums (in general). The variables investigated were:
   - frequency of visit (at the Sarawak Museum) (two possible values: first time, non-first time)
   - visiting type (at the Sarawak Museum) (five possible values: alone, family, friends/relatives, organised group, other)
   - reasons for visiting (to the Sarawak Museum) (six possible values: for leisure time, for personal interests, to experience something new, to expand knowledge, for entertainment, other)
   - usual time spent in visiting museum (in general) (four possible values: 1 hour or less, 2 hours, 3 hours, more than 3 hours)
   - activities during museum visit (in general) (six possible values: look at things, touch things, play, read and learn, talk with friends, other)

3. Participants' preferences
The third section aimed to analyse participants’ preferences, focusing on the participants’ interest in the Sarawak Museum exhibits and their learning style. The variables investigated were:

- interested exhibit category (at the Sarawak Museum) (open-ended questions)
- not interested exhibit category (at the Sarawak Museum) (open-ended questions)
- preferable learning method in museums (seven possible values: through touching & physically interacting with the display, through reading the text labels & printout, through images/photo stills, through audio or video shows, through multimedia and interactive application, through interaction with friends or tour guide, other)

4. Participants’ learning experiences and exhibitions’ performance

- The last section of the questionnaire consisted of two sub-sections to assess participants’ learning and experiences at the Sarawak Museum and the current exhibitions’ performance. The questions related to learning and experiences and exhibitions’ effectiveness was converted into statements and were evaluated with agree-or-disagree choices. The opinions from the participants were measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree).

The ten statements incorporated in “Learning and Experience”, attempted to evaluate visitors’ educational experiences generated from the cognitive and affective engagement (Figure 2-4). Therefore, it covers both the cognitive aspect (item no: 1,2,3,5,6,7) and the emotional aspect (item no: 4,8,9,10) as follows:

1. I discovered things I didn’t know.
2. I learned more about things I already knew.
3. I shared knowledge and experience with other people.
4. I got curious about finding out more.
5. I can understand the information conveyed by the exhibit.
6. I learnt through interaction with the exhibit.
7. I can recall the information from the exhibit.
8. I found the exhibit emotionally engaging.
9. I had a lot of fun during my visit.
10. It was a worthwhile visit in exchange for my time.

These statements were taken and modified from those used in a study of museum learning (Griffin et al. 2005).

The fifteen statements incorporated in “Exhibition Usability” tried to assess the effectiveness of the social context (item no: 12) and the physical contexts (item no: 1,2,3,4,5,6,7,8,9,10,11,13,14,15) as follows:

1. The sign posting and directions for the exhibits is visible.
2. The overall exhibition is attractive.
3. The content appeals to hold attention.
4. The exhibition provides up to date information.
5. The overall information of the displays is accurate and comprehensive.
6. The written materials encourage creative thinking.
7. The information can easily be comprehended.
8. The information takes less time to absorb.
9. The whole exhibits can be seen as one narrative.
10. The exhibition arouses interest and imagination.
11. The exhibits encourage viewers to learn more.
12. The exhibit facilitates social interaction among members of the group.
13. Museum activities and the displays are interactive
14. The exhibition has effective use of audio and video as communication techniques.
15. The exhibition has effective use of multimedia technology.

These statements were adapted from a recent study of museum exhibit design (Pei Mey & Mohamed 2010; Steve Bitgood & Patterson 1987).

- In the section that followed, the participants’ overall expectation and overall satisfaction were questioned in rating questions, from (1) dissatisfied to (5) satisfied.
- In order to avoid possible bias in the Likert scale measurements, the subsequent part of the questionnaire contained questions that were reformulated from certain statements taken from previous sections. This is to allow triangulation to strengthen the result from the Likert scale measurements. The questions were asked in open-ended formats to review visitors’ opinions about the exhibition elements.

The questions designed such as: “Of all the displays you saw, did any catch your eyes? What was it? Is there any reason you favoured this display”, “Do you have any other comments about the written materials of the displays? Are they clear? Any suggestions for improvement?”, “Do you have any other comments about the communication techniques? Any suggestions for improvement?”.

- The participants’ acceptance towards the interactive exhibit was also examined in the concluding part of the questionnaire to identify the level of acceptance from visitors. It was measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree).

### 3.1.3. Procedure

The participants were selected randomly as they made their way out after visiting the Sarawak Museum exhibitions. The visitors’ flow was not disturbed since it was a post-visit survey. The targeted participants were approached and invited to take part in the survey in front of the museum cafeteria. The location was away from the exhibits, which was more comfortable for participants.
When the participants agreed to participate voluntarily, the researcher would provide the consent information letter (Appendix 2), introducing the purpose of the questionnaire and describing the type of information needed from them. The questionnaire’s relevance and protection of confidentiality or anonymity were also explained, that the questionnaire was designed for anonymous collections and the participants’ personal identity would not be recorded in any form. The researcher would not be able to identify the questionnaires corresponding to the participants. The participants were also informed in advance of the usual time taken to complete the questionnaire. This would let the participants to anticipate their time schedule for other activities. As a result, they would focus on the form without being anxious. The questionnaire forms were distributed to the participants after getting their consent. The participants were left alone to complete their questions. However, the researcher would be around to provide any assistance related to the survey, if required.

After the completion of the survey, the questionnaires were collected. The return of questionnaires was noted in numbers with anonymity assurance. Necessary follow-ups were carried out immediately after a quick review in the questionnaire form returned by the participants to enquire about their responses, such as for indistinguishable writing or for possible errors made in the way of answering the questions.

3.1.4. Data Collection

A questionnaire form returned by the respondent was counted as one sample. The forms were sorted out to identify if there were errors or missing data. The responses were considered adequate if there was no missing value, given all of the closed-ended questions were answered completely and the answers for the open-ended provided useful data.

The acceptable questionnaires were reformulated from hard-copy form (the questionnaire form) into computerised data file. The data were keyed in and entered into the computer system and was checked two times to prevent any typing error. All of the categorical (nominal) data were analysed by using the statistical analysis software, SPSS (Statistical Product and Service Solutions) version 17.0. The open-ended data was recorded and analysed manually.

3.2. Results and Discussion

3.2.1. Demographics

The survey collected 50 respondents from a heterogeneous population at the museum, consisting of 50% male visitors and 50% female visitors (Table 3-1). The majority of the participants falls into the age group of 18 and 24 years old (40%), followed by 25 to 34 years old group (34%), 35 to 44 years old group (16%) and 10% are aged above 45 years old. The
participants are predominantly college/university educated (70%) who is having professional
jobs (40%) and students (32%). This is clearly showing that museum visitors are knowledgeable
and experienced. The participants came from 9 different countries, predominantly domestic
visitors (64%) and the survey result reveals three major languages used, which are English,
Bahasa Malaysia and Chinese. Visitors in general can be assumed to be technologically able.

Table 3-1 Statistics of respondents’ demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>25</td>
<td>50.0</td>
</tr>
<tr>
<td>Female</td>
<td>25</td>
<td>50.0</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 – 24</td>
<td>20</td>
<td>40.0</td>
</tr>
<tr>
<td>25 – 34</td>
<td>17</td>
<td>34.0</td>
</tr>
<tr>
<td>35 – 44</td>
<td>8</td>
<td>16.0</td>
</tr>
<tr>
<td>45 – 54</td>
<td>4</td>
<td>8.0</td>
</tr>
<tr>
<td>Over 55</td>
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<td>2.0</td>
</tr>
<tr>
<td>Nationality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>5</td>
<td>10.0</td>
</tr>
<tr>
<td>Canada</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>Finland</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>Indonesia</td>
<td>6</td>
<td>12.0</td>
</tr>
<tr>
<td>Italy</td>
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<td>2.0</td>
</tr>
<tr>
<td>Malaysia</td>
<td>32</td>
<td>64.0</td>
</tr>
<tr>
<td>Norway</td>
<td>2</td>
<td>4.0</td>
</tr>
<tr>
<td>South Korea</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>USA</td>
<td>1</td>
<td>2.0</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or equivalent</td>
<td>8</td>
<td>16.0</td>
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<td>College / University</td>
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<tr>
<td>Post graduate</td>
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<td>6.0</td>
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<tr>
<td>Occupation</td>
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<tr>
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<td>Educator</td>
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<tr>
<td>Student</td>
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</tr>
<tr>
<td>Retiree</td>
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<td>2.0</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>6.0</td>
</tr>
</tbody>
</table>

3.2.2. Behaviours

The survey result indicates a greater number of repeated visitors (60%) than the first-time
visitors (40%). Majority of visitors come in a group – with friends or relatives (60%), family
members (24%) and organised groups (4%). The result is consistent with earlier visitors’
studies, explaining the museum visit as social activities (Falk & Dierking 1992; Hein 1998). The
statistical study (Figure 3-2) reveals that lone visitors spent significantly more time (2 hours and
more) compared to the group visitors in the museum visit. It seems that lone visitors are less
distracted in their visit as they may not be engaged in any social activities. Group visitors tend to
spend less than 2 hours in the museum as they may engage in discussions that foster their
construction of knowledge.
There are various reasons for visiting museums. The statistics (Figure 3-3) reveal the primary reason for visitors to come to the Sarawak Museum is for learning – to acquire knowledge (27.7%). The secondary reasons are for leisure activity – to spend their free time from work by visiting the museum (23.4%), personal interest (17%), entertainment – to look for an entertaining activity (17%) and others, such as to enjoy the air-conditioner at the museum. It appears that visitors’ are looking for both intellectual (cognitive engagement) and emotional (affective engagement) experiences in the museum visit.
There are many activities involved during the museum visit to create a meaningful learning experience (Hein 1998). The statistical study (Figure 3-4) reveals the activities of visitors in museum visit involve reading and learning (39.8%), looking at artifacts (37.8%), touching objects (11.8%), talking with friends (8.6%) and playing (11.8%). This result suggests that visitors’ learning is active and involves physical involvement and social interaction. However, visual-related activity is still predominant in the museum.

![Figure 3-4 Activities in museum visit](image)

### 3.2.3. Preferences

The preference of museum exhibition topic and visitors’ learning methods varies from one to another. From the survey result, the Sarawak Museum’s exhibit topic that received more responses from visitors is the Archaeology theme. The visitors found the Archaeology theme fascinating and educational. Underneath is the summary of visitors’ responses on the attractive exhibit categories at the Sarawak Museum.

1. **The history and development of Sarawak**
   All the international tourists (36%) and 34% of the locals are enthusiastic to find out the history and development of Sarawak as they are not familiar with Sarawak.

2. **Tribes’ exhibition and Sarawak’s culture**
   Different traditional costumes from different tribes have caught visitors’ attention to stop and observe the clothing accessories. They came to know the culture and the burial arrangements differ amongst the tribes. The replica of the Longhouse also drew the visitors’ attention towards the difference of the tribe’s living place between “then” and “now”.

3. **Prehistory and archaeological artifacts of Sarawak (e.g. earthenware and vases)**
   The archaeology gallery exhibits in the museum were found attractive by 25% of the visitors as the objects were excavated from different locations at different times. Therefore, it
depicted a scenario and motivated them to explore more on the information. The unique motif of ceramics and vases raised visitors’ curiosity wanting to know more about the details and meanings behind the designs. The “Painted Cave” exhibited at the main entrance also caught visitors’ attention as it engaged visitors to explore the paintings on the wall. An exhibition about the origin of humanity, their survival ability, and the ritual was found very educative as they could see the relevance with current traditions.

On the other hand, 35% of the respondents also remarked the pre-historical and archaeological exhibit category as non-attractive exhibit. The survey results suggest a need for improvement in certain exhibition components in the galleries is required. The visitors’ comments are summarised as follows:

1. The contextual information about the subject
   The story behind certain pre-historical and archaeology items displayed was not clearly explained. Consequently, visitors lost their interest on the objects.

2. The organisation of the gallery exhibit
   Visitors observed that the arrangement of objects displayed in the gallery need to be well-organised to draw a narrative behind the displays.

3. The quality of interpretation and display
   The visibility of some printed labels was found to be unclear due to aging. Some visitors have recommended improving the “freshness” of the “Painted Cave” as the visibility and readability of the images and labels were not clear. Visitors suggested that the cave could have been done more realistically for visitors since it was a significant discovery in Sarawak history. Also, visitors would want to immerse themselves in the atmosphere as if they were in the actual historical place.

Visitors learn in their own preferred way to construct their own learning experiences. The statistical study (Figure 3-5) indicates that the visitors learning preferences in general are through audio/video shows (18.6%), images/photo stills (18.0%), reading and physically interacting with the display (received 17.4% each), multimedia interactivity (13.8%), social interaction (13.2%) and others (1.8%). This can be summarised that visitors learn through different kinds of sensory modality, which are visual, auditory, read and kinaesthetic (Fleming 2001). The proportion for each modality appears in (Figure 3-5) suggesting an equal preference, which indicates the museum exhibitions are to be more effective with the availability of different active learning modalities.
3.2.4. Learning Experiences and Exhibitions' Performance

1. Visitors’ learning experiences

The evaluations of visitors’ learning experiences are summarised on two aspects – cognitive and affective – because museum education is expected to stimulate both visitors’ intellect and emotion (Chapter 2 in Section 2.1). The opinions of the visitors were measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree).

The statistical summary of visitors’ learning and experiences at the Sarawak Museum can be found in Table 3-2. The average result of visitors’ educational experiences is still under satisfactory, as majority of the statements’ mean value are fewer than scale 4 (agree). Hence, there is a challenge for this study to enhance visitors’ engagement with the exhibits to increase their learning experiences.

Table 3-2 Statistical result of respondents’ learning experiences in the Sarawak Museum

<table>
<thead>
<tr>
<th>No.</th>
<th>Statements</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cognitive Aspects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>I discovered things I didn’t know</td>
<td>4.04</td>
<td>.880</td>
</tr>
<tr>
<td>2.</td>
<td>I learned more about things I already know</td>
<td>3.78</td>
<td>.840</td>
</tr>
<tr>
<td>3.</td>
<td>I shared knowledge and experience with other people</td>
<td>3.54</td>
<td>1.182</td>
</tr>
<tr>
<td>4.</td>
<td>I can understand the information conveyed by the exhibit</td>
<td>3.60</td>
<td>.904</td>
</tr>
<tr>
<td>5.</td>
<td>I learned through interaction with the exhibit</td>
<td>3.38</td>
<td>1.086</td>
</tr>
</tbody>
</table>

Figure 3-5 Respondents’ learning preferences
6. I can recall the information from the exhibit 3.52 .814

<table>
<thead>
<tr>
<th>Statements</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Affective Aspects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I got curious about finding out more</td>
<td>3.86</td>
<td>1.069</td>
</tr>
<tr>
<td>2. I found the exhibit emotionally engaging</td>
<td>2.98</td>
<td>1.020</td>
</tr>
<tr>
<td>3. I had a lot of fun during my visit</td>
<td>3.48</td>
<td>.974</td>
</tr>
<tr>
<td>4. It was a worthwhile visit in exchange for my time</td>
<td>3.72</td>
<td>1.031</td>
</tr>
</tbody>
</table>

- **Cognitive aspect**
  
The first statement, “I discovered things I didn’t know” (mean=4.04) and the second statement, “I learned more about things I already know” (mean=3.78) implies that visitors have acquired new knowledge by reflecting upon their previous knowledge and experience. Visitors in the museum learn and experience with others, they share knowledge and experience to enhance their knowledge (mean=3.54). Visitors are able to understand the information communicated by the exhibitions (mean=3.60) and are able to recall the information on the exhibits (mean=3.52). Although the average of the evaluation achieved were above scale 3.5 (near to Agree), there is still a gap for improvement.

- **Affective aspect**
  
  It is agreed that visitors are encouraged to find out more about the information about the exhibitions (mean=3.86). In addition, they had fun (mean=3.48) and believed that the museum visit is worthwhile in exchange for their time (mean=3.72). However, they did not find the exhibitions emotionally engaging (mean=2.98).

2. **Exhibitions’ performance**

  The evaluation of the exhibitions’ performance is summarised on two contexts – social and physical – because these are the major environmental aspects that motivate visitors’ engagement. The opinions of the visitors were measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree).

  The statistical summary of current exhibitions’ performance at the Sarawak Museum can be found in Table 3-3. The average result of the exhibitions’ performance is unsatisfactory as revealed by majority of the statements’ mean value are fewer than 4 (agree). Overall, the museum exhibitions require an improvement in organising and presenting the information to enhance its usability for visitors’ learning experiences.

<table>
<thead>
<tr>
<th>Statements</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Aspects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The sign posting and directions for the exhibits is visible</td>
<td>3.70</td>
<td>.974</td>
</tr>
<tr>
<td>2. The overall exhibition is attractive</td>
<td>3.38</td>
<td>1.086</td>
</tr>
<tr>
<td></td>
<td>The content appeal to hold attention</td>
<td>3.38</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>4.</td>
<td>The exhibition provides up to date information</td>
<td>3.10</td>
</tr>
<tr>
<td>5.</td>
<td>The overall displayed information is comprehensive</td>
<td>3.40</td>
</tr>
<tr>
<td>6.</td>
<td>The written materials encourage creative thinking</td>
<td>3.30</td>
</tr>
<tr>
<td>7.</td>
<td>The information can easily be comprehended</td>
<td>3.66</td>
</tr>
<tr>
<td>8.</td>
<td>The information takes less time to absorb</td>
<td>3.28</td>
</tr>
<tr>
<td>9.</td>
<td>The whole exhibits can be seen as one narrative</td>
<td>3.36</td>
</tr>
<tr>
<td>10.</td>
<td>The exhibition arouses interest and imagination</td>
<td>3.44</td>
</tr>
<tr>
<td>11.</td>
<td>The exhibit encourages viewers to learn more</td>
<td>3.56</td>
</tr>
<tr>
<td>12.</td>
<td>Museum displays are interactive</td>
<td>3.02</td>
</tr>
<tr>
<td>13.</td>
<td>The museum has effective use of audio and video as communication techniques</td>
<td>2.52</td>
</tr>
<tr>
<td>14.</td>
<td>The exhibition has effective use of multimedia technology</td>
<td>2.44</td>
</tr>
</tbody>
</table>

### Social Aspects

- **Physical aspect**
  The sign posting and directions for the exhibits is visible for visitors (mean=3.70). The exhibit content appears to hold attention. However, visitors were not certain if the information provided is updated (mean=3.10). The overall displayed information seems comprehensive (mean=3.40) and encourage creative thinking (mean=3.30). The information can be comprehended by visitors (mean=3.66) and takes less time to absorb (mean=3.28). The overall exhibition is perceived attractive (mean=3.38). However, the exhibits can hardly be seen as one narrative (mean=3.36). The exhibition arouses visitors’ interest and imagination (mean=3.44) and encourage visitors to learn more (mean=3.56). The museum displays are not interactive (mean=3.02), do not provide audio/video means (mean=2.52) as well as not supported by multimedia technology (mean=2.44).

- **Social aspect**
  The exhibitions have not effectively aroused social interaction among the visitors (mean=3.26).

The overall expectation for the museum visit which ranged from 1 (Dissatisfied) to 5 (Satisfied) obtained 3.44 in average, while the overall satisfaction was 3.42 on average. This implies that visitors’ expectations of museum learning are yet satisfied. The lack of contextual information and visualisation quality of the exhibits (Section 3.2.3.) explains what the visitors expect from the museum visit.

An interactive exhibit, measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree), is anticipated by museum visitors (mean=4.32). This result is supported by visitors’ positive remarks as follows:
“Hey, it's a modern world!”
“We need to keep up to the time. It is time to take full advantage of the modern technologies.”
“Interactive display is more attractive and eye-catching!”
“It explains more details.”
“We can see more things around us that we have not seen through multimedia.”
“Static is boring.”
“Interactive is fun.”
“Interactive display helps us remember more and stay interested”.

The visitors suggested different kinds of interactive displays that they would like to have in the museum exhibitions, such as hands-on exhibits where they can have an experiment, interactive audio or video shows, augmented reality, virtual reality, 3D projection, social networking/virtual museum and touch screen kiosks or interactive tabletops to interact with the information they want to look up. Some visitors recommended keeping the artifacts around the interactive exhibit to maintain its authentic atmosphere in the learning situation. These remarks are consistent with the concerns of interactive exhibition studies today.

Front-end evaluation results conclude that visitors go to museums for educational experiences. Besides acquiring knowledge, they also look for affective (emotional and enjoyable) engagement, which is not presented in the current museum exhibitions. The current museum exhibition requires improvement in its dissemination of information method to be more attractive and interactive. In this manner, visitors will be more motivated to learn in the museum and will result in better learning experiences.

### 3.3. Summary of Chapter

This chapter discussed the preliminary quantitative front-end evaluation to assess visitors’ learning experiences that involved personal context (visitors’ demographics, behaviours and preferences), social as well as physical (the performance of current museum exhibitions).

The visitors study reveals that the need for museum visiting is primarily for intellectual experiences, followed by emotional experiences. Museum learning is a social activity as majority of visitors visit in social groups. Visitors are predominantly educated and experienced and they learn through various kinds of methods, through sensorial modalities (e.g. visual, auditory, read, and kinaesthetic). This further acknowledges that museum visitors are active learners. Nevertheless, visual-related learning activity is still the most ideal for the museum visitors.
The first evaluation was conducted right outside the exit of the Archaeological site. Therefore, all the respondents had gone through the Archaeological tour before being interviewed. Visitors’ are interested in the Archaeology theme at the Sarawak Museum (Dewan Tun Abdul Razak). This may be due to its prominent display at the museum. Moreover, this theme received more attention from the visitors, positively and negatively. Hence, the Archaeology theme should be considered as the content for the proposed interactive exhibit prototype. The positive feedback received from the survey supports this exhibit theme to be displayed in the prototype because it captured the visitors’ attention, which would motivate their learning. While, the negative responses received from the visitors creates a challenge for this study to improve on the exhibit theme.

Based on the evaluation, the characteristics of museum visitors are relevant to the constructivist theory where learners are active in constructing their own knowledge and experience that builds upon their previous knowledge and experience and interest. The visitors are seeking for active learning methods to augment their prior knowledge of contextual information. Additionally, the educational experiences in the survey reveals that the underlying environmental aspects, especially the museum exhibitions, indeed play a strong role in visitors’ engagement and learning construction.

This chapter also evaluated visitors’ learning experiences at the Sarawak Museum and assessed the current exhibitions’ performance. Overall, the Sarawak Museum exhibitions are still lacking in terms of organising and presenting the information. The necessity for the museum to improve its exhibition methods is also supported by the unsatisfactory results obtained from the front-end evaluation on both visitors’ learning experiences and exhibitions’ performance. Visitors today require exhibits that are more entertaining to motivate emotional engagement. This is achievable through the use technology to develop an interactive exhibit that stimulates visitors’ enjoyment in learning. The parameters for the applicable display technology selection (Chapter 2 Section 2.3) will be taken into account to develop the interactive exhibit prototype.

Chapter 4 will discuss the design and development of the interactive exhibit prototype at the Sarawak Museum to enhance visitors’ learning experiences. The detailed problems and proposed solutions for the current exhibition will be analysed for the prototype conceptual design. The design considerations framed in the previous chapter (Chapter 2 Section 2.2) will be utilised and improved based on visitors’ preferences to draw the design requirements for the interactive exhibit prototype.
Chapter 4. Prototype Design and Development

The previous chapters have reviewed the learning theories of constructivism in museums, the contextual model of learning (personal, social, physical) and also the role of display technology in facilitating museum education (refer to Chapter 2). The reviews have suggested design considerations for the interactive exhibit prototype. Nevertheless, the application for this prototype has to consider the local requirements at the Sarawak Museum visitors. In Chapter 3, a front-end evaluation has been conducted to identify visitors’ learning preferences as well as to investigate the problems of current exhibitions at the Sarawak Museum to find the effective design solutions for the proposed interactive exhibit prototype. As a result, this study integrated the constructivist principles, the three learning contexts (personal, social, physical), the relevance of display technology in museum exhibitions, and the preliminary museum visitors’ evaluation in the design and development of an interactive exhibit prototype.

In this chapter, the design and development of the interactive exhibit prototype are discussed. The development process involves design conceptualisation; by reviewing the problems on the current Sarawak Museum exhibitions and suggesting the possible solutions which draws the design requirements for the prototype. These requirements determine the applicable display technology and the application design concept. Next is the discussion on the prototype development, which involves the development tools and design rationales, and, finally, discussing the formative evaluation of the prototype for usability testing before the final installation.

4.1. Conceptual Design

4.1.1. Project Details

Problems
Based on the results from the front-end evaluation, the current exhibition approach at the Sarawak Museum requires an improvement in terms of the organising and presenting information. Currently, the exhibition at the Sarawak Museum is non-technology based, with printed labels placed around the artifacts display. This conventional exhibition method faces challenges from different point of views. Firstly, a shift in the museums’ role from being an archiving institution into one with educational responsibility has changed the purpose of the exhibition naturally. It is now not sufficient only to display but there is also a need to educate the general visitors. Secondly, visitors are no longer passive audiences. They are active learners who learn through different learning styles. This implies that the focus of museum exhibitions has evolved from the objects to the visitors – from “what to be designed” to “who it should be designed for”. Lastly, the role of technology has greatly influenced the museum exhibitions to provide more engaging, personalised, social interactions, and contextual information. These
shifts supports the view that the conventional exhibitions approach will eventually need to be improved corresponding to the current trends, migrating from a ‘didactic’ approach into an ‘experiential’ one.

Based on the visitors’ evaluation at the Sarawak Museum, visitors’ learning experience from the current exhibitions was not satisfactory (Chapter 3). Apart from personal and social context, visitors’ learning experience was strongly influenced by the exhibition design (content and physical display). The current exhibition was lack of personalisation, collaborative support, attraction, contextualisation, information organisation, physical interactivity, and active engagement.

The abovementioned problems of the current exhibition at the Sarawak Museum could be improved by integrating digital technology in its display and information design. Digital technology exhibits invoke visitors’ involvement in the learning process. The implementation of these technologies in museums has been found to be advantageous in many aspects and has influenced visitors’ learning and engagement (Buisine et al. 2012; Marchetti & Brooks 2012; Haywood & Cairns 2006; Basballe & Halskov 2010). It is believed that the application of interactive exhibit is more attractive than the conventional exhibit. The impact of technology will be more effective on the younger generation (digital natives and immigrants), rather than the pre-digital older generation (Reilly & D. Petrelli 2007; Hornecker 2008). However, the interactive exhibits need to consider the original purpose of the museum education – learning, and the authenticity of original artifacts.

This section will answer research question number 6 (RQ6): “What is the relevant and applicable display technology and application design suitable for the prototype in order to be effective?”

Proposed Solution
The interactive exhibit prototype has to be appropriately designed to motivate visitors’ learning and to satisfy their emotional needs in the museum visit. As museum visitors are unique in a personal context (Falk & Dierking 1992; Hooper-Greenhill 1994), the interactive exhibit cannot be precisely designed to meet that particular characteristic, but to be adapted for diverse individualities.

Developing an interactive exhibit is an effective solution for the problems in the current exhibition at the Sarawak Museum. Nevertheless, there are two main factors to be taken into considerations when designing the interactive exhibit prototype:
1. Minimalist
Entertainment elements can encourage the user to engage and to absorb the information in a more relaxing way. However, the interactive exhibit design should aim to be a learning tool that is engaging, instead of an entertainment device. Therefore, the interactive exhibit need be carefully designed to prevent the users from any distractions, such as the excessive use of interactivity. There is a potential danger that the interaction facility might shift to become a tool for entertainment. It is significant to keep in mind that visitors are not coming to play in museums. Therefore, minimalist and practical interactive function is desirable for the proposed exhibit design.

2. Artifacts-related
The interactive exhibit must not outperform the artifacts. On the other hand, the interactive exhibit must amplify the value and meaning of the traditional artifacts to facilitate visitors’ learning. Visitors are known to prefer an authentic environment over ‘modern’ ones in the museum settings.

Table 4-1 Problems and suggested solutions for the Sarawak Museum exhibitions

<table>
<thead>
<tr>
<th>Contexts</th>
<th>Problems</th>
<th>Proposed Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal</td>
<td>• Personalised learning is restricted</td>
<td>• Provide multiple points of access, layering on information, and exploration</td>
</tr>
<tr>
<td></td>
<td>• Lack of contextual information to enhance visitors’ prior knowledge</td>
<td>• Provide comprehensive information and narrative context to augment learner’s knowledge and for contextualisation</td>
</tr>
<tr>
<td></td>
<td>• Existing exhibition does not support multi-culture visitors, such as language</td>
<td>• Provide multi-lingual exhibit for different cultures</td>
</tr>
<tr>
<td></td>
<td>• Existing exhibition does not support physical interaction</td>
<td>• Allow for physical interaction on the exhibit to evoke emotions</td>
</tr>
<tr>
<td></td>
<td>• Lack of emotional engagement</td>
<td>• Design for appealing exhibit</td>
</tr>
<tr>
<td>Social</td>
<td>• Social activities in the museum exhibition are not supported</td>
<td>• Allow for multi-users and social interaction, for collaborative learning</td>
</tr>
<tr>
<td>Physical</td>
<td>• Static and passive involvement exhibition</td>
<td>• An interactive exhibition</td>
</tr>
<tr>
<td></td>
<td>• Not well-organised information</td>
<td>• Well-organised information</td>
</tr>
<tr>
<td></td>
<td>• Less attractive</td>
<td>• Attractive exhibit to reinforce intrinsic motivation</td>
</tr>
</tbody>
</table>

The design requirements incorporate the design considerations derived in the previous chapter (Chapter 2 Section 2.2) as well as the solutions for the Sarawak Museum exhibitions (Table 4-1) as follows.

1. Narrative context
The information design requires an effective structure and consistency, therefore, the narrative context is suitable. The Archaeology theme is associated with different period and different locations, which can organise the information in form of a timeline and a map.

2. Multiple points of access
   This can be achieved by providing two points of access for the narrative platforms: the chronological mode and geographical map mode. Multiple points of access are required to provide active learning mode and flexibility for visitors’ learning.

3. Layering of information
   This can be done by breaking down the lengthy information into two layers of information. The first layer of information will provide concise information, such as by labels or names, while the second layer will provide more detail information for deeper learning.

4. Multi-lingual feature
   It is required to design for multi-culture visitors, such as by providing three different languages (English, Bahasa Malaysia, Chinese) on the interactive exhibit display.

5. Aesthetics content
   The aesthetics aspect for the interactive exhibit prototype is important to stimulate the users’ attention and engagement. This can be achieved by selecting the earth tone colour that is in line with the exhibit theme (Archaeology) and sans-serif font types to allow visibility of the texts. In addition, the aesthetics content can be realised through chunking down the lengthy information and dividing the information into columns.

6. Collaborative learning
   The interactive exhibit prototype needs to allow for social interactions; such as through use of interactive multi-touch screen tabletop that enables for multi-users input and the application design that allows for more than one user (e.g. the geographical map mode supports multi-users interactions to view different locations on the display at the same time).

7. Physical interaction (e.g. direct-manipulation display)
   The interactive exhibit that allows for physical interactions increases the visitors’ engagement with the exhibit; therefore, the constructivist visitors can engage both their mind and physical to create better learning, such as through the interactive tabletop technology that can be manipulated directly by the visitors. In addition, the interactive exhibit will enliven the learning environment, thus, it motivates emotional engagement.

This study proposes the design and development of an interactive exhibit prototype to be delivered via a purpose-built multi-touch screen interface. The interactive exhibit prototype provides a conceptual and visual framework for understanding the related Archaeology artifacts available in the Sarawak Museum. Therefore, the role of the interactive exhibit prototype is to enhance the current conventional exhibitions and the visitors’ learning experiences. The prototype developed in this study is not a standalone display, but is a complementary communication tool that is presented along with the artifact displays. The prototype serves as
the foundation for understanding the related artifacts available in the Sarawak Museum, particularly the Archaeology artifacts.

4.1.2. Display Technology

Based on the design requirements, the type of display technology required for the interactive exhibit prototype must allow for personalisation and collaborative learning. This suggests that large display technology is preferable to support group users. The technology must be usable and accessible for universal users. Besides, it must allow shorter learning curve to facilitate visitors’ learning in museums. The prototype is expected to have high interactivity and to support multi-users interaction. By reviewing the types of display technology and the consideration factors (Chapter 2 Section 2.3) for the implementations, the prototype opts for a multi-touch screen tabletop for its multi-user input functionality and a high level of interactivity (Geller 2006).

Interactive multi-touch screen tabletop allows direct manipulation on the interface and the interaction can be done by simply touching on the screen. The direct manipulation application encourages creativity and playfulness and increases visitors’ confidence and feel in control and choice (Shneiderman 1997). Due to the widespread popularity of similar interfaces in mobile phones and tablets, visitors will intuitively know how to manipulate the application (Görlitz et al. 2011) and this familiarity is very important in constructivism theory. Hence, the multi-touch display system is an ideal display platform for the project for its accessibility to be used by all age groups and for social interaction (Görlitz et al. 2011).

The conventional touch-screen displays available in the market are normally small and do not support multi-touch input. Some manufacturers produced large-scale LCD panels with multi-touch input, however, the price was relatively high (Geller 2006). The significance of a touch system is the touch sensing. Since the responsiveness of the system depends on its touch sensitivity, additional technology is required to recognise and interpret the screen contact. Due to this matter, although the prices of the monitors have decreased, touch screens are still more expensive than the regular ones (Nichols 2007). Due to budget constraints, the multi-touch table for this study was created in an alternative way through open source application and DIY construction technique.

Table 4-2 The estimated costs for the alternative multi-touch table

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Price (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Computer</td>
<td>1,200.00</td>
</tr>
<tr>
<td>2.</td>
<td>Projector</td>
<td>1,800.00</td>
</tr>
<tr>
<td>3.</td>
<td>IR LED</td>
<td>300.00</td>
</tr>
<tr>
<td>4.</td>
<td>Electronics Module</td>
<td>300.00</td>
</tr>
<tr>
<td></td>
<td>Item Description</td>
<td>Cost</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>5</td>
<td>Web Camera</td>
<td>120.00</td>
</tr>
<tr>
<td>6</td>
<td>Mirror</td>
<td>100.00</td>
</tr>
<tr>
<td>7</td>
<td>Table Materials (Wood, Acrylic)</td>
<td>250.00</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>4,070.00</strong></td>
</tr>
</tbody>
</table>

By comparing the estimated total costs ($1,240) to the touch-screen displays available in the market that are around $10K (Ridden 2013), the DIY interactive table-touch is much more economical.

### 4.1.3. Application Design

The interactive exhibit prototype application is designed to present information in a contextual manner for a single exhibit theme (Archaeology) to engage and encourage visitors’ to explore and learn. Three predominant languages (English, Bahasa Indonesia, Chinese) are provided in the application to cater for different culture of users. The front-end evaluation (Chapter 3) found that visitors were fascinated with the significant amount of historical information available on Sarawak Archaeology. The Archaeology section is always associated with time and the excavation site. Therefore, the interactive exhibit prototype is intended to present the content from different period and different locations.

Narrative context is incorporated into the design to preserve and present the information as one connected story (a whole concept) (Plowman et al. 1999). Additionally, the narrative context is one of the learning aspects that is appropriate to present the Archaeological events, chronologically or geographically (Joyce 2008). In order to reflect to visitors’ prior experience and knowledge with the application system, the learning content is organised in a form of timeline and a map. Visitors seem to be familiar with browsing information through a timeline presentation and a map; therefore, the analogy was applied in the prototype design.

The application produces two points of access to the chronological mode and the geographical map mode. The chronological mode is designed chronologically from the prehistory era until proto-history era, whilst the geographical map mode is geographically illustrated as a direction for significant excavation sites. The intention of having two points of access is to provide active learning modes for visitors to control and construct knowledge. Some visitors may prefer to learn through locations (geographical), while others might prefer to browse by date (chronological).

The information on each point of access is to be accessed in two layers to maintain a simple and concise interface. The top layer will be the initial contact layer that the users will encounter. It will carry simplified and concise information that will point to more information in the second layer, for example, the first layer of geographical information provides labels and names and the
second layer contains more detailed information. For the chronological mode, the layers of information are designed in two pages for the same time frame. The users will have the option to access the second layer of more information, if they choose to. The overlap information between the geographical location and the time frame chronology of an artifact allows the users to construct a deeper understanding of when the artifact originated, where it was found, along with more information and details about the artifacts.

The application system, as illustrated in Figure 4-1, begins with an introduction page that presents the instructions on how to interact with the application. By default, the content is displayed in English. User can select their preferred language from the three options provided for the content – English, Bahasa Malaysia, and Chinese. User can simply tap on the preferred language to change the content in that particular language. Once the language is confirmed, the user can continue choosing either one of the two points of access to explore the information – chronological mode and geographical map mode. The user is allowed to change the language while viewing the content. When the exploration is done, the user can move to the introduction page or just leave the application.

![Figure 4-1 Application design flow chart](image)
The conceptual design for the interactive exhibit prototype, involving the display technology and the application design, was presented to the museum personnel at the Sarawak Museum to gain their feedback before the prototype development. The interactive Archaeology exhibit design concept was accepted and the museum curators provided all of the content and the accessible media (texts and images) for the prototype.

The problem currently faced by the visitors was, most of the time, they will not be able to understand or to find out more about the exhibit unless if they bump into any of the museum personnel during their visit. In general, the response gathered from the museum personnel was that the implementation of such interactive exhibit system would greatly assist the visitors to learn more about the exhibit.

4.2. Prototype Development

4.2.1. Hardware

Figure 4-2 shows the block diagram of the multi-touch tabletop system developed for this study. The physical setup of the system is housed inside a box which measure 900mm x 1200mm x 820mm (WxLxH). The central of the process lie on the computer which controls the peripheral devices to provide the input and output interaction from the user. The computer is running on Windows XP Professional operating system with Intel Core 2 Quad processor and 4 GB of RAM.

![Figure 4-2 Block diagram of the multi-touch Tabletop system](image-url)
4.2.2. Projection Setup and Screen

In order to achieve a large size display with a considerably lower cost, the system utilises an LCD projector for the display with the image projected onto the surface of the table. The image is projected using a back projection method, where the projector is placed at the back of the screen and the image is projected and diffused at the back layer of the table surface. Since the height of the table has to be limited to a specific dimension (in order to facilitate users of different body height), the projection distance is not sufficient to achieve the desired projected image dimension. This problem is solved by using a series of mirror to bounce the light ray in order to virtually increase the projection distance and hence achieving the desired screen size (Figure 4-3).

![Figure 4-3 Inner view of the interactive table](image)

The placement and size of the mirrors are estimated using the projector placement simulation software “SimProj” (Benjamin Kuperberg 2010). The software allows the users to input the parameter of the projector, the screen size and space required as well as the number of mirrors that are used for reflection. The preliminary result obtains from the simulation serves as the guide in designing the mirrors placement in the box (Figure 4-4).
To provide the information of the touch on the screen, an unconventional yet low cost solution is utilised. The conventional touch screen detects touches using digitizer that is made up of resistive or capacitive layer and they are normally available up to medium screen size (less than 29”). For this prototype, the touch detection is performed using Rear Diffused Illumination (DI) approach. This approach is made known by Natural User Interface Group (NUI Group) which is an interactive media community researching and creating open source machine sensing techniques to benefit artistic, commercial and educational applications (Group 2009).

The rear DI setup works by shining an infrared (IR) light from behind the touch surface and using an IR camera as a touch detection sensor. When a finger is placed on the surface, more light will be reflected on the touch point and hence the camera will detect a brighter spot of IR ray (Figure 4-5). The camera that is used in this project is an aftermarket USB Webcam which is fitted with an IR band-pass filter to filter out the light at any other spectrum and only letting the light in the IR spectrum to be detected by the image sensor.
As discussed in the previous section, users have to choose the language and their point of access before they are brought into the main interactive content. The points of access to the languages and content are done by touching the artificial button below the screen (Figure 4-6). The capacitive touch sensors that are mounted at the back of the projection surface capture the touch of the artificial buttons. The signal of the capacitive touch sensor is connected to a keyboard module which is connected via USB port. The keyboard module will generate a key press event on the computer once the touch sensor is triggered. In other words, the touch sensor is acting like a keyboard button on the computer.

In order to create an attention-grabbing effect on the artificial buttons, each of them were equipped with LED backlight to highlight which button was active. The LED was controlled by the RS-232 Light Controller Module which had 16 channels of output that could be connected directly to the LED light. The ON and OFF signal of the light could be controlled via software by sending a specific command via the serial communication port.
4.2.3. Software

The main application is developed using Adobe Flash CS3, which is well-known for creating interactive games, animations or dynamic advertisements. Adobe Flash is an authoring application for creating an interactive content with the support of ActionScript scripting language which facilitates the frame-based animation and logical programming environment.

The touch on the screen is sensed using an IR camera. In order to turn the streaming image from the IR camera into useful data for the interface navigation, the image has to be processed and the touch data will be passed to the application as a manipulation input.

The acquisition and processing of the camera image are done by an open-source application, namely Community Core Vision (CCV). This application handles the image streaming from the USB IR camera and process the streamed image to interpret the touch event on the screen. The CCV application provides the information on touch event in the Tangible User Interface Object (TUIO) protocol which contains the information of the detected object (position, dimension, velocity and etc.) (Kaltenbrunner et al. 2005). However, for the application of this prototype, the important parameter is the position of the detected object, which in this case, the finger of the user. This information is then passed to Adobe Flash for the interface manipulation through the XML protocol which is natively supported by the CCV application. The illustration of the process is shown in Figure 4-7.
4.2.3.1. Interface Design

An effective interface design is significant in many ways for the users. First, it excites user's attention with an attractive design. Second, it enables user to run in a smooth navigation with the consistent design. Third, it helps user in using and memorising the navigation paths with simple and clear design.

Shneiderman's Eight Golden Rules (1998) is the popular user interface guidelines, which include (1) the consistency, (2) the use of shortcuts, (3) offer feedback, (4) design dialog to yield closure, (5) offer simple error handling, (6) permit easy reversal, (7) support internal locus of control, and (8) reduce short-term memory load. The principles applied for developing the graphical user interfaces for the interactive exhibit prototype are modified from Shneiderman's Eight Golden Rules (1998), as follows:

1. Consistency
   The user interface is designed in a consistent format for usability and appealing purposes. Consistency assists user to learn and to use with ease, minimises mistakes, and increases user's confidence in carrying out the actions. Consistency provokes positive emotion on the user experience and motivates user's exploration.

2. Visibility
   All display objects must be visible and positioned at the right location with noticeable size by the users. Applying appropriate colour and contrast is essential to distinguish the navigation menu and to create visual appeal on the user interface.

3. Minimalist design and function
   The layout of the system must be simple and the system function should not be complicated. Irrelevant information should not be included in the design. In order to minimise the information loading time, an appropriate graphics' size is used.

4. Immediate feedback
Slow response from the interactive display system will decrease user’s excitement. Thus, the system performance must be efficient to provide immediate output to user’s input with no delays.

5. Error prevention

The user interface is designed for simplicity and unambiguous. The graphical information must be obvious for users’ recognition. The selectable options can be shaded or highlighted to prevent a user from selecting the incorrect option. The manipulation method of the interactive exhibit should be introduced in the beginning of the display to avoid mistakes.

6. Affordance

The breadcrumb is provided as a navigational assistance to enable users to know which page or section they are currently in. Clues should be provided for the user’s actions, such as by blinking icons or providing scrollbar to indicate the length of the page.

**Font and Colour**

Please refer to Appendix 4.

**Information Design**

The content in each of the access point is selected properly to provide meaningful and educative information that motivates visitors’ learning. The content is designed in a concise and simple manner for visitors to retrieve it a short time.

The chronological mode begins with the earliest period of prehistory to proto-history era. Each of the categories contains the related significant Archaeology findings excavated in Sarawak during each period. This access point displays three main categories, according to the timeline, which are:

1. Stone Age that was divided into two sub categories: Old Stone Age and New Stone Age
2. Metal Age
3. Protohistoric


The content in each narrative platform is offered in two layers to keep it simple and to facilitate for visitors’ own exploration for deeper information. Lengthy information is broken down and delivered through the following “simplification” techniques: (1) by layering the information into two layers and (2) by dividing the information into two pages. The simplification provides aesthetics design that will evoke visitors’ attention towards the exhibition topic.
All of the learning content and the accessible media (texts and images) for the interactive exhibit prototype are provided by the Sarawak Museum. Other multimedia elements such as audio narration or video are not available. Hence, the prototype applications do not contain any auditory media. The original version of the learning materials obtained is in English and is translated into Bahasa Malaysia and Chinese by museum staff.

Prior to the implementation, in order to ensure the authenticity of the information, the museum curators who are the experts in the field of Archaeology were invited to verify the authenticity of the information displayed on the interactive exhibit prototype.

Learning content applied to the two points of access is not identical. However, significant discoveries are included in both access points, which overlapping the information. Repetitive information is believed to facilitate visitors’ memory to recall the exhibit’s message, in same or different method (J. Johnson 2010).

Layout
The application interface is designed for usable to allow navigation from different level of visitors’ experience. Details of the user interface design are as follows:

Chronological mode
The title given to the geographical mode is “Chronology of Prehistory & Protohistory in Sarawak”. Referring to Figure 4-8, the user interface layout is contained within:

a. Main Menu
The main menus for the application are ‘Stone Age’, ‘Metal Age’, and ‘Proto-historic’. A graphical icon, by using the artifact for the specific period, represents each menu. By showing the artifacts, the development of each period will be noticeable by the users. Three different colours distinguish the menu selections. The brightness for the selected menu will be adjusted for the users’ recognition purpose.

The main menu links to the other parts. When a menu is selected, the information and design components for the introduction, the main content, and additional content will change instantly and accordingly to the option. The same response is applied when the main content page is changed; the information and design for the other parts will be adjusted immediately.

b. Menu Introduction
The introduction of the selected content is placed above the main content, describing the characteristics of each period. The introduction changes according to the selected content.

c. Main Content
The main content covers the relevant and useful information on the selected period in form of texts and pictures. The information is arranged into two columns for aesthetic purpose. Each period contains two layers of information, which can be accessed by sliding the content to the left side. The second layer provides more information.

In the main content area, the users can view the enlarged picture by selecting the ‘zoom’ button placed before the image. The enlarged image will appear at the top layer. A ‘close’ button is given to remove the additional layer. The image selection buttons are provided for information that requires more than one picture to be displayed on the interface. The main content is dynamic where the users can move the content page by selecting the ‘previous’ or ‘next’ button provided at each side of the application or by sliding the content.

d. Additional Content

A timeline is placed beneath the main content to display the years of respective period that is distinguished by the colour brightness. Below the timeline is a list of major excavation sites to present the corresponding excavation site on that particular period.

**Figure 4-8 Chronological mode interface**

**Geographical Map Mode**

The title for the geographical map mode is ‘Archaeological Sites on Sarawak’. It provides the Archaeological information related to the excavation locations. The Sarawak map is designed in a recognisable size and is positioned on the right side (Figure 4-9). Each location is numbered on the map and is linked to the location name on the left. The dotted line connects particular location on the map and its name.
The user can select the number on the map or the location name to access the second layer that provides information that is more detailed. The detailed information will be displayed on a new layer placed on the top (Figure 4-10). The new layer provides a ‘close’ button to remove it from the screen. A scrollbar is provided for the user to view more information that is longer than the frame height. The main information layer is designed moveable and resizable. The users are able to open more than one location layer on the display. The layer of the most recently selected location will always be on top (Figure 4-10).
4.3. Formative Evaluation

The interactive exhibit system is a user-centred design that involves potential users throughout the whole prototyping process, involving the museum curators and visitors. Formative evaluation is carried out during the development phase that involves usability testing on the interactive exhibit prototype, involving a small number of samples. In designing an interactive exhibit, formative evaluation is essential to be done in order to assess the interface design and the usability of the application to avoid major failures (Screven 1990).

4.3.1. Methodology

In this study, the formative evaluation adopts the qualitative method through informal observations and spontaneous interviews to gather the users’ feedback on the interactive exhibit prototype before the final installation at the Sarawak Museum. The users’ feedback is useful to transform the prototype into an effective communication system in the museum for visitors’ learning experience. Necessary alterations will be made by integrating the users’ feedbacks to ensure the prototype is accessible for all museum visitors.

Formative evaluation in this study is intended to find out:

1. The potential problems in the prototype design that hinder the users’ engagement.
2. The prototype usability in facilitating the users’ cognitive (intellect) and affective (emotion) experiences.

The evaluation focuses more on the design aspects that include the interface design and information design.

Participants

Studies suggested that a small number of sample size are sufficient for an informal formative evaluation to identify the usability problems (Nielsen 2000; Economou 2004). The usability testing is participated by eight users with different experiences, from novices to experts. Although it is a small number of samples, their responses are believed to be sufficient as a representation for a reasonable range of age and learning styles (Nielsen 2000; Economou 2004). Each user has his/her uniqueness in museum learning which establish variant responses to picture the various individualities of museum visitors (Falk & Dierking 1992). Their age group ranged from 12 to 60 years old with different professions, such as student, educator, traveller, and retiree. The museum curators also participated in the testing to share their experience with the exhibition development before the final implementation.

Procedure

Before the process of usability testing is conducted, the users are informed in advance of what the interactive exhibit prototype is about and what information they can explore. They are also informed that their interactions with the interactive exhibit prototype will be observed. Then, the
users are invited to peruse the display prototype in their own time. No specific tasks or time arrangement is given during the tryout. As the prototype is designed for constructivist learning, the users are expected to learn the interactive exhibit prototype and take action by themselves. Assistance is provided when the users make mistakes. The researcher will observe and take note on the users’ interactions with the prototype.

An informal and unstructured interview is conducted to find out how the users feel about the interactive exhibit prototype and how well the users can interpret the information being conveyed through the prototype. The questions asked were associated with the prototype’s design aspects, such as the clarity of the interface and information design, and the prototype’s usability. The museum curators were also invited to take part in the usability testing to gather their feedback on the learning content arrangement and the verification on the accessible media.

4.3.2. Results and Discussion

Overall, results from the formative evaluation reveal positive responses from the users on using the interactive exhibit prototype. The evaluation results indicate that the interactive exhibit prototype offers contextual historical information about Sarawak Archaeology. The users who knew one or two events on the display responded that they have obtained more information about the exhibit topic. All of the users (8 users) were able to grasp the message conveyed by the prototype by navigating and recognising the information in a considerably short time (after trying for three times). The users who had no prior knowledge of the exhibit topic found the application informative and learnable. They were motivated because the learning material was presented comprehensively without inappropriate information. Having two points of access (timeline and geographical map) was important because they provided flexible access point choices for the users. It was observed that different users chose different access points that appealed to them. Hence, cognitive engagement is supported by the interactive exhibit prototype.

The observation discovered that the group of users who had no interest in the topic was attracted to spend more time on the interactive exhibit prototype because of the technology. There were five users who revealed that they were not interested in the subject. However, during the evaluation, they seemed to be actively engaged with the prototype. They interacted with the multi-touch table to view the content available in the two access points. They took the time to read the information for archaeological sites that attracted them and also interacted with the chronological mode interface to view the pictures in different on the timeline. The interactive exhibit prototype was found attractive due to its novelty in the Sarawak Museum, which in turn facilitates the users’ enjoyment. All 8 users agreed that the interactive exhibit prototype refreshed the existing non-technology based exhibits while maintaining the authenticity of the
artifacts. In addition, the use of touch screen was usable and controllable by the users with minimum or no training. Some users were trained on how to use the multi-touch functions for the geographical map mode to enlarge the display. It was confirmed when the elders with no experience on a touchscreen device was able to interact with the interactive exhibit prototype in a very short time. All users could navigate intuitively with the interface design with minimal errors. However, the users’ input throughout the assessment also led to several changes on the components such as labeling and design.

**Labeling**

Based on the users’ suggestions, the descriptive heading for both application modes was modified as it misconstrued the content.

- Instead of ‘Chronology of Prehistory & Protohistory in Sarawak’, the chronological mode was labelled as ‘Chronology of Archaeological Sites on Sarawak’. The reason was that the information presented emphasised more on the events that occurred at the Sarawak excavation sites.
- The title for the geographical map mode was adjusted to ‘The Main Archaeological Sites on Sarawak’ because the sites displayed on the screen were the major excavation locations. There are many excavation sites in Sarawak; however, as advised by the museum staff, the selected areas were the main archaeological sites. Hence, “The Main” should be added in the heading to emphasise the significance of the selected sites.

**Design Rationale**

1. **Colours and fonts**

The colour selection of earth tones for the interface was found parallel with the exhibition theme. Different colours used to differentiate the areas attracted the users’ attention and assisted their information exploration. The users were satisfied with the colour and font type selections, as they were recognisable. However, the Chinese characters on the screen were hardly readable by the elders because of the small spacing between each character. Therefore, the font size and spacing for all Chinese characters were increased to maximise its visibility.

2. **Information design**

Generally, there was no issue found on the information design that hindered the users’ engagement during the evaluation. The length of the texts was found moderate, not excessive; hence, it motivated the users to spend time reading on the interactive exhibit prototype. The arrangement of information into two columns was found appealing and increased the users’ interest to read more. The balance between the empty space and the content is important, especially when many texts are involved. Besides, the information must be chunked, if necessary, for the aesthetic and visibility purpose.
Majority of the users were able to interpret the information displayed on the prototype. Moreover, they could recall certain events in the exhibit according to the time and place. The users recognized the narrative concept applied in both chronological mode and geographical map mode and they found it very intelligible. In addition, it allowed them to learn in a fun way, through range of time and different places. This implies that the use of the narrative concept in the prototype has facilitated the users’ knowledge construction and has stimulated their enjoyment in the process.

3. Interface Design

The overall interface design was found simple and clear by the users. The buttons were noticeable and controllable by the users due to the consistency in design. They could navigate the buttons without mistakes. Moreover, users could recognize the ‘close’ button to remove the layer of the enlarged picture (Figure 4-11).

Additional information on the excavation sites provided at the bottom of the page (the red box in Figure 4-12) was found confusing by the users. They could not understand the message conveyed through that particular section. As a result, this section was removed from the interface design to prevent misperception and to sustain the users’ attention on the engagement. The information in the second bar (the red box in Figure 4-12) was removed because the information was redundant and was distracting the users. Therefore, the removal of the information did not reduce any intended message to be conveyed by the prototype.
The users were amazed by the ‘zoom’ ability available in the geographical map mode (Figure 4-14). They found it fascinating when the information layer was enlarged.
The spacing of the image selection buttons (Figure 4-15) was too close for the users’ finger touch. Frequently, there were two buttons touched with a finger. In order to ease the users’ manipulation of the buttons, the distance between buttons was increased.

Figure 4-15 Image selections feature for more than one image category

There was not much alteration made on the geographical map mode. Most of the design components were recognisable by users. The scrollbar thumb in the second layer’s
interface design was removed to prevent the user’s confusion between scrolling the content and moving the layer’s position (Figure 4-16).

The finalised interface design for the two points of access was developed into other two languages as below.

Figure 4-16 Final geographical map mode interface design (in English)

Figure 4-17 Final chronological mode interface design (in Chinese)
Figure 4-18 Final geographical map mode interface design (in Chinese)

Figure 4-19 Final chronological mode interface design (in Bahasa Malaysia)
The introduction page design had no amendment and was also developed in three languages as below.

Figure 4-20 Final geographical map mode interface design (in Bahasa Malaysia)

Figure 4-21 Final introduction page (in English)
4.4. Summary of Chapter

This chapter discussed the overall process of designing and developing the interactive exhibit prototype for the Sarawak Museum. The process started with the translation of visitors’ expectations into the prototype requirements. The current exhibitions lack personalisation, collaborative support, attraction, contextualisation, information organisation, physical interactivity, and active engagement.
The essential design requirements for the interactive exhibit prototype are to apply narrative context, multiple points of access to the application, layering of information, multi-lingual, aesthetic content that stimulates emotions, to support collaborative learning and physical interaction. These requirements are possible by embracing the use of digital technology into the exhibit design. There are two main factors taken into the considerations when designing the interactive exhibit prototype, which are minimalist and artifact-centered.

This study proposed to design and develop an interactive exhibit prototype delivered via multi-touch tabletop display technology that functions as a foundation for understanding the related Archaeology artifacts available in the Sarawak Museum. In this way, the interactive exhibit prototype will work in line with the conventional exhibitions to achieve the museum’s educational role. The interactive exhibit prototype is designed for information presentation-based for visitors’ exploration, providing contextual information for the Archaeology theme. The application provides multiple points of access and supports multi-lingual which is accessible for various visitors.

The prototype development process involved a formative evaluation to assess the usability and application design of the prototype before the installation at the Sarawak Museum. The evaluation reveals positive responses from the users. Some minor improvements are remarked in terms of the design rationales, such as the colours, information organisation and interface design. Formative evaluation is significant for this study to prevent any major problems occurring during the implementation of the interactive exhibit prototype.

This chapter concludes the prototyping process (Stage 3). The final product of the interactive exhibit prototype will be installed and implemented at the Sarawak Museum for user evaluation. The final stage of the study will be presented in the next chapter (Chapter 5), discussing the summative evaluation process to investigate the effectiveness of the interactive exhibit prototype in enhancing the current conventional exhibitions and visitors’ learning experiences.
Chapter 5. Summative Evaluation

The prototyping discussed in the previous chapter (Chapter 4) has produced an interactive exhibit prototype for Archaeology theme at the Sarawak Museum. The prototype has opted for multi-touch screen tabletop as the display technology to allow for multi-users input and interactivity on a large display. The application design provided two points of access (chronological mode and geographical map mode) and multi-lingual feature to allow flexibility in visitors’ learning. The information was organised and presented in narrative context to provide consistency and usable structure with two layers of information to facilitate for visitors’ exploration. The interactive exhibit prototype design is expected to enhance the current conventional exhibitions and visitors’ learning experiences.

Summative evaluation is carried out at the end of the study to identify the effectiveness of interactive exhibit prototype implementation in achieving its goal. This chapter discusses the process of summative evaluation, involving the questionnaire survey design and the results derived.

5.1. Methodology

The evaluation was carried out after the design and development of the interactive exhibit prototype. The finalised interactive exhibit prototype was installed at the Sarawak Museum and was placed at the entrance of the Archaeology gallery exhibits that was noticeable by the museum visitors upon entering the gallery. The interactive exhibit prototype acted as a foundation for understanding the related Archaeology artifacts available in the Sarawak Museum. Therefore, by placing the prototype at the gallery entrance served its purpose. The prototype was deployed temporarily at the Sarawak Museum until the completion of user evaluation.

Summative evaluation aims to address the last research question RQ7: “How is the effectiveness of the prototype in enhancing the current conventional exhibitions and visitors’ learning experiences?” Four objectives are to be assessed to answer the research question, as follows:

1. To find out whether the interactive exhibit improves the dissemination of information
2. To find out whether the interactive exhibit facilitates knowledge (intellect)
3. To find out whether the interactive exhibit facilitates enjoyment (emotion)
4. To find out whether the interactive exhibit offers more satisfaction

The methodology used in the summative evaluation was based on mixed methods, by using both quantitative and qualitative methods. The qualitative approach involved field studies by observing user interaction on the prototype. The quantitative data was obtained through paper-
based questionnaire survey to find out the visitors’ reactions towards the interactive exhibit. The evaluation was conducted at the Sarawak Museum (Dewan Tun Abdul Razak) during the opening hours, in July 2012.

5.1.1. Participants

The participants for the summative evaluation were randomly selected from museum visitors at the Sarawak Museum, who would interact with the interactive exhibit in their natural setting. This evaluation was targeted (but not limited to) 100 respondents. Male or female participants above 12 years old with different level of educational experience and personalities were preferred for the evaluation. It was important that the participants must not be constrained in time to give their full attention on the activities involved during the assessment.

5.1.2. Instruments

The paper-questionnaire survey was adopted by this study to gather visitors’ learning experiences on the interactive exhibit prototype at the Sarawak Museum.

The questionnaire (can be found in Appendix 5) comprised both open-ended and close-ended questions, separated into two sections. The questionnaire design integrated the three contextual frameworks (personal, social, physical) (Falk & Dierking 1992) as discussed in Chapter 2 to assess visitors’ learning experiences on the interactive exhibit prototype.

The first section of the questionnaire survey collected more information on personal context, which is visitors’ general demographics information. The second section of the questionnaire comprised questions and sets of statements to evaluate visitors’ knowledge and experience, usability of the interactive exhibit prototype (to determine the social and physical contexts), and visitors’ overall satisfaction on the prototype. Some questions in the survey came with a single choice or multiple choices or open-ended answer.

Details of each section are discussed below:

1. Visitors’ demographics

Participants’ background information was collected in the first section to recognise who the visitors are, in general. The variables investigated were:

- gender (two possible values: male, female)
- age group (six possible values: under 18, 18-24, 25-34, 35-44, 45-54, over 55)
- nationality
- language (two possible values: English, other)
- education level (four possible values: high school or equivalent, college/university, postgraduate, other)
• profession (seven possible values: professional, self-employed, trader/proprietor, educator, student, retiree, other)

2. Participants’ learning experiences and interactive exhibit’s performance

This section consisted of two sub-sections to assess the participants’ learning and experience at the Sarawak Museum and the usability of the interactive exhibit prototype. The questions related to learning experiences and exhibitions’ usability were converted into statements and followed with agree-or-disagree choices. The opinions of the participants were measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree).

Fifteen statements were incorporated in “Learning and Experience” attempted to assess visitors’ learning experience through the types of engagement on the interactive exhibit prototype; cognitive and affective engagement. Ten statements were similar to as found in the front-end evaluation. The additional five statements were related to interactive exhibit and the topic, Archaeology. The fifteen statements involves cognitive aspect (item no: 1,2,3,4,5,6,7,9,10) and affective aspect (item no: 8,11,12,13,14,15) as follows:

1. I discovered things I didn’t know.
2. I learned more about things I already knew.
3. I gained knowledge about the Archaeology in Sarawak.
4. I shared knowledge and experience with other people.
5. I can understand the information conveyed by the display system.
6. I learnt through interaction with the display system.
7. I can recall the information from the display system.
8. I became interested in the topic.
9. I found the display system informative.
10. I found the display system as a learning resource.
11. I found the display system emotionally engaging.
12. I found the display system entertaining.
13. I got curious about finding out more.
14. I had a lot of fun.
15. It was a worthwhile visit in exchange for my time.

Thirteen statements incorporated in “Display System Usability” attempted to evaluate the effectiveness of the interactive exhibit components towards visitors’ learning experiences. This sub-section would determine the motivational aspects (e.g. social and physical) for visitors’ learning experience. The statements were focusing on the interface design (item no: 1,2,5,6), information design (item no: 7,8,9,10,11) and multimedia interactivity (item no: 3,4,12,13) as follows:

1. The display system is easy to use and to navigate.
2. The interface of the display system is clear and consistent.
3. The interface of the display system is intuitive.
4. The interactive display is more attractive than the traditional display.
5. The interactive display is more effective than the traditional display.
6. The display system arouses interest.
7. The content appeals to hold attention.
8. The display system makes the searching of information easier.
9. The display system presents the information in a comprehensive way.
10. The information on the display system is well-organised.
11. The information presented on the display system is easier to absorb compare to the traditional display.
12. The display system makes use of multimedia technology to enhance my understanding on the exhibit topic.
13. Overall, the interactive display system is better than the traditional display.

- The participants’ overall satisfaction towards the interactive exhibit prototype was asked in rating questions from (1) dissatisfied to (5) satisfied. Then, an open-ended question was asked to identify what the users have learned through the interactive exhibit prototype. The responses on this question allowed for triangulation and were very useful to identify visitors’ understanding of the interactive exhibit.

- The level of user acceptance on the interactive display was also evaluated and measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree). Suggestions for improvement were requested in the finishing part to determine the limitation of the interactive exhibit and the possible resolutions for future exhibition development.

5.1.3. Procedure

The researcher would introduce the interactive exhibit prototype to the visitors who attended the exhibit. They would be invited to use the interactive exhibit on their own to discover the information they looked for. Most often, visitors’ interactions on the interactive exhibit would raise conversation with the researcher to ask questions about the subject being displayed. The researcher would take note on significant comments retrieved from the observation on visitors’ experience towards the interactive exhibit prototype.

When the visitors completed their information exploration on the interactive exhibit prototype, the researcher would introduce the study on the prototype and invited them to take part in the questionnaire survey. The questionnaires’ relevance and protections of confidentiality or anonymity were also clarified to motivate visitors for taking part in the study comfortably. The questionnaire form was designed anonymously and the participant’s personal identity would not be recorded in any form. Hence, the corresponded participant in the questionnaire form could not be recognised.
The questionnaire form was distributed to the participant after getting his/her agreement to participate. Participants were left alone to complete their questions. However, the researcher was nearby to provide any assistance related to the survey, if needed. At times, indirect interview followed when the participants returned the questionnaire form to get direct feedback on their experience.

5.1.4. Data Collection

This evaluation used both qualitative and quantitative method to collect comprehensive data. Qualitative data through the observation was gathered to assess participants’ personal experiences, while data from the questionnaire survey was collected to measure the quality of the interactive exhibit prototype (Screven 1990). The qualitative data were used to enhance the quantitative result. In this way, the quantitative outcome can be explored further and explained in more detail through the qualitative data to validate the findings.

There were 106 copies valid responses collected and used for the analysis. The acceptable questionnaires were reformulated from hard-copy form (the questionnaire form) into computerised data file. The data were keyed in and entered into the computer system and was checked two times to prevent any typing error. The statistical responses were tabulated and analysed using SPSS version 17.0 software. The qualitative data gathered was analysed through reading and exploring the data.

5.2. Results and Discussion

5.2.1. Demographics

The survey collected 106 respondents, consisting of 60 males and 46 females. Predominantly, as shown in (Table 5-1), the participants fall under 18 to 24 years old (46.2%), follow with the group of 25 to 34 years old (35%), 45 to 54 years old (8.5%), 35 – 44 years old (4.7%), over 55 years old (3.8%) and under 18 years old (1.9%). The participants were predominantly college / university educated (67%) who are students (52 people) and professionals (26 people). Majority of the participants are Malaysian (73 persons) and the survey result identifies that English, Bahasa Malaysia and Chinese are the three predominant languages, which is supported by the interactive exhibit prototype. The participants’ demographics in summative evaluation are almost identical as found in the front-end evaluation, in terms of the participants’ age, education background and their professions (refer to 3.2.1).
### Table 5-1 Statistics of respondents' demographics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>60</td>
<td>56.6</td>
</tr>
<tr>
<td>Female</td>
<td>46</td>
<td>43.4</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 18</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>18 – 24</td>
<td>49</td>
<td>46.2</td>
</tr>
<tr>
<td>25 – 34</td>
<td>37</td>
<td>34.9</td>
</tr>
<tr>
<td>35 – 44</td>
<td>5</td>
<td>4.7</td>
</tr>
<tr>
<td>45 – 54</td>
<td>9</td>
<td>8.5</td>
</tr>
<tr>
<td>Over 55</td>
<td>4</td>
<td>3.8</td>
</tr>
<tr>
<td>Nationality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>73</td>
<td>68.9</td>
</tr>
<tr>
<td>Australia</td>
<td>15</td>
<td>14.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>British</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>Spain</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Indonesia</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>China</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>USA</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Belgium</td>
<td>2</td>
<td>1.9</td>
</tr>
<tr>
<td>Singapore</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>UK</td>
<td>3</td>
<td>2.8</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>India</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or equivalent</td>
<td>17</td>
<td>16.0</td>
</tr>
<tr>
<td>College / University</td>
<td>67</td>
<td>63.2</td>
</tr>
<tr>
<td>Post graduate</td>
<td>19</td>
<td>17.9</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>2.8</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional</td>
<td>26</td>
<td>24.5</td>
</tr>
<tr>
<td>Self-employed</td>
<td>9</td>
<td>8.5</td>
</tr>
<tr>
<td>Trader/proprietor</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Educator</td>
<td>8</td>
<td>7.5</td>
</tr>
<tr>
<td>Student</td>
<td>52</td>
<td>49.1</td>
</tr>
<tr>
<td>Retiree</td>
<td>3</td>
<td>2.8</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>6.6</td>
</tr>
</tbody>
</table>

### 5.2.2. Learning Experiences and Interactive Exhibit's Performance

1. **Visitors' learning preference**

Visitors' learning experiences on the interactive exhibit prototype are evaluated on the two aspects related to the educational experiences, which are cognitive and affective aspects. The statistical summary of visitors' learning and experience can be found in Table 5-2. The statements are measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree). The statistical study (Table 5-2) reveals that majority of the statements received **satisfactory visitors' feedback** as the average mean values appears to be about 4 (Agree).
Table 5-2 Statistical result of respondents’ learning experiences in the Sarawak Museum

<table>
<thead>
<tr>
<th>No.</th>
<th>Statements</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Cognitive Aspects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>I discovered things I didn’t know</td>
<td>4.25</td>
<td>.673</td>
</tr>
<tr>
<td>2.</td>
<td>I learned more about things I already know</td>
<td>3.89</td>
<td>.887</td>
</tr>
<tr>
<td>3.</td>
<td>I gained knowledge about the Archaeology in Sarawak</td>
<td>4.13</td>
<td>.718</td>
</tr>
<tr>
<td>4.</td>
<td>I shared knowledge and experience with other people</td>
<td>3.68</td>
<td>1.01</td>
</tr>
<tr>
<td>5.</td>
<td>I can understand the information conveyed by the display system</td>
<td>4.31</td>
<td>.735</td>
</tr>
<tr>
<td>6.</td>
<td>I learnt through interaction with the display system</td>
<td>4.21</td>
<td>.813</td>
</tr>
<tr>
<td>7.</td>
<td>I can recall the information from the display system</td>
<td>3.89</td>
<td>.832</td>
</tr>
<tr>
<td>8.</td>
<td>I found the display system informative</td>
<td>4.25</td>
<td>.718</td>
</tr>
<tr>
<td>9.</td>
<td>I found the display system as a learning resource</td>
<td>4.29</td>
<td>.804</td>
</tr>
<tr>
<td></td>
<td><strong>Affective Aspects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>I became interested in the topic</td>
<td>4.01</td>
<td>.822</td>
</tr>
<tr>
<td>2.</td>
<td>I found the display system emotionally engaging</td>
<td>3.84</td>
<td>.830</td>
</tr>
<tr>
<td>3.</td>
<td>I found the display system entertaining</td>
<td>4.01</td>
<td>.910</td>
</tr>
<tr>
<td>4.</td>
<td>I got curious about finding out more</td>
<td>4.08</td>
<td>.859</td>
</tr>
<tr>
<td>5.</td>
<td>I had a lot of fun</td>
<td>3.92</td>
<td>.933</td>
</tr>
<tr>
<td>6.</td>
<td>It was a worthwhile visit in exchange for my time</td>
<td>4.23</td>
<td>.808</td>
</tr>
</tbody>
</table>

- **Cognitive aspect**
  Visitors agreed that they have discovered new things (mean=4.25) and have received contextual information (mean=3.89) about the Archaeology of Sarawak (mean=4.13) from the interactive exhibit prototype. Visitors can comprehend the information conveyed (mean=4.31) and able to learn through interaction with other people (mean=3.68) and the interactive exhibit (mean=4.21). Visitors can recall the information from the interactive exhibit prototype (mean=3.89). They found the interactive exhibit informative (mean=4.25) as a source to enhance their knowledge (mean=4.29).

- **Affective aspect**
  Visitors gained interest in the exhibit topic (mean=4.01). They found the interactive exhibit was fun (mean=3.92), emotionally engaging (mean=3.84), entertaining (mean=4.01) and able to increase curiosity to learn more about the topic (mean=4.08). Visitors agreed that the experience was worthwhile (mean=4.23).
2. **Interactive exhibit usability**

Usability of the interactive exhibit design is evaluated from the interface design, information design and multimedia interactivity. The statistical summary can be found on Table 5-3. The statements are measured by five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree). The statistical result of the statements indicate **satisfactory** responses from visitors as all statements achieved the average of 4 (Agree).

**Table 5-3 Statistical result of the interactive exhibit prototype**

<table>
<thead>
<tr>
<th>No.</th>
<th>Statements</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Interface Design</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>The display system is easy to use and to navigate</td>
<td>4.25</td>
<td>.826</td>
</tr>
<tr>
<td>2.</td>
<td>The interface of the display system is clear and consistent</td>
<td>4.07</td>
<td>.939</td>
</tr>
<tr>
<td>3.</td>
<td>The interactive display is more effective than the traditional display</td>
<td>4.08</td>
<td>.885</td>
</tr>
<tr>
<td>4.</td>
<td>The display system arouses interest</td>
<td>4.06</td>
<td>.741</td>
</tr>
<tr>
<td></td>
<td><strong>Information Design</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>The content appeals to hold attention</td>
<td>3.95</td>
<td>.855</td>
</tr>
<tr>
<td>2.</td>
<td>The display system makes the searching of information easier</td>
<td>4.23</td>
<td>.854</td>
</tr>
<tr>
<td>3.</td>
<td>The display system presents the information in a comprehensive way</td>
<td>4.13</td>
<td>.782</td>
</tr>
<tr>
<td>4.</td>
<td>The information on the display system is well-organised</td>
<td>4.26</td>
<td>.772</td>
</tr>
<tr>
<td></td>
<td><strong>Multimedia Interactivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>The interface of the display system is intuitive</td>
<td>4.10</td>
<td>.780</td>
</tr>
<tr>
<td>2.</td>
<td>The interactive display is more attractive than the traditional display</td>
<td>4.14</td>
<td>.970</td>
</tr>
<tr>
<td>3.</td>
<td>The information presented on the display system is easier to absorb</td>
<td>3.98</td>
<td>.926</td>
</tr>
<tr>
<td></td>
<td>compare to the traditional display</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>The display system makes use of multimedia technology to enhance</td>
<td>4.15</td>
<td>.848</td>
</tr>
<tr>
<td></td>
<td>my understanding on the exhibit topic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Overall, the interactive display system is better than the traditional</td>
<td>4.00</td>
<td>1.042</td>
</tr>
<tr>
<td></td>
<td>display</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• **Interface design**
The interface system was easy to use and to navigate by the visitors (mean=4.25). The design provides clear, consistent (mean=4.07) and intuitive interface (mean=4.10) that arouses visitors’ interest (mean=4.06).

• **Information design**
The interactive exhibit content appears to hold visitors’ attention (mean=3.95). The narrative context and the layering of information have presented the information in a more organised (mean=4.26) and comprehensive way (mean=4.13). The points of access in the application allowed easier exploration (mean=4.23).

• **Multimedia interactivity**
Through the use of multimedia interactivity, the interactive exhibit prototype is more attractive (mean=4.14), more effective (mean=4.08), easier to absorb (mean=3.98) and easier to comprehend the information (mean=4.15). Overall, it was believed that the interactive exhibit enhanced the traditional display (mean=4.00).

Ranged from 1 (Dissatisfied) to 5 (Satisfied), the level of visitors’ satisfaction towards the interactive exhibit prototype has obtained 4.30 in average which reveals that visitors are satisfied with the prototype. It was seen as a promising communication tool as visitors also agreed to employ this interactive exhibit in the museum (Mean = 4.62).

5.2.3. Further Discussion

Summative evaluation aims to address the last research question RQ7: “How is the effectiveness of the prototype in enhancing the current conventional exhibitions and visitors’ learning experiences?”.

This study assumed that if the interactive exhibit prototype were designed effectively, it would be an effective interactive exhibit for the Sarawak Museum to convey the Archaeology theme by providing conceptual and visual framework for understanding the related Archaeology artifacts. Four objectives established earlier will be used as a measurement to assess the prototype’s effectiveness. The discussion below is reflected from the users’ observation in the summative evaluation.

1. **To find out whether the interactive exhibit improves the dissemination of information**
The current Archaeology exhibits presented in the Sarawak Museum were the array of artifacts placed in display cases with printed labels around them. The early preliminary study revealed that the objects display was found unsystematic and unexciting which could demotivate visitors to attend further. The quality of some labels was becoming poor as it had been on the displayed for some time. Additionally, the contextual information was
deficient for museum to convey the whole message of the exhibition. Thus, the understanding of the context was difficult to achieve.

The additional significant manuscripts and mesmerising visual that were missing in the common printed labels were solved by the use of multimedia application. The use of two points of access (a timeline and a map) on the interactive exhibit, with the narrative concept, was perceived as a benefit for visitors. An anonymous international tourist said: “I was attracted by the timeline which is something difficult to be done by the traditional display, especially when the history needs a good summary. This is a good job.” He was very satisfied with how the information was being displayed and how he was able to understand the Archaeology in Sarawak in a minimum of time without difficulty. Most visitors who interacted with the exhibit agreed that the application has made their exploration on their desired information easier through its comprehensiveness.

Visitors usually avoid lengthy explanations (Stephen Bitgood 2000; Stephen Bitgood 1994; Hein 1998) in their museum learning because of memory load and time constrains. This problem is faced by most of the conventional exhibition as supported by the front-end study evaluation (Chapter 3). The information selection, organisation, and presentation play a role in this context. The use of timeline to narrate the chronology of Archaeology in Sarawak was an effective concept in communicating such large amount of information to visitors. Also, the use of geographical map in conveying information has made it easier for visitors to understand the significant objects by places. The observation disclosed that most visitors actually enjoyed reading the chronology information from the start until the end. They pointed out that the timeline had well-narrated the topic of Archaeology which led them to understand the overall context. It also helped them to recall the information easily as they could think of the pictures or artifacts presented on the interface.

The use of technology allows easy upgrading on the quality as well as the quantity of the content, which might not be effective through the conventional labels presentation. The object and information available in the museum gallery were reinforced by the use of multimedia presentation in terms of its learning content and display quality. A visitor came by after his visit in the museum gallery and pointed out that he could spend most of his visit time on the content presented on the interactive exhibit due to the additional information that were not accessible in the gallery.

The interactive exhibit required visitors to manipulate and explore their desired information by themselves which could not be offered in the traditional object displays. The interactive exhibit offered active engagement in constructing knowledge based on their prior knowledge and interest, such as free choice and self-directed exploration to select their
preferred content to view by choosing the point of access that they like. Visitors would understand the information better when they made it personal (Falk & Dierking 1992; Caban et al. 2000) as their attention was focused. The interactive exhibit facilitated for visitors to select and filter information without spending too much time. Thus, it minimised museum fatigue. First-time visitors usually take longer time to figure out where to start the exploration (Falk & Dierking 1992). The interactive exhibit, which served as an introductory for the museum gallery, was useful for them. From the observation, the first-time visitors spent some time on the interactive exhibit before exploring the objects display and were able to recognise their target objects in the gallery. As a result, they did not end up with the jumbled discovery in museum gallery and it saved their orientation time. They were satisfied that the interactive exhibit assisted their visiting path in the gallery.

A visitor said this to his mother, “We travelled here to here. Let’s see. What can we find here, Mom?” A visitor told her friend, “Wow. I have never seen something like this before.” Another visitor was fascinated and noted “I gain enthusiasm for the gallery upstairs prior to entering.” Initially, some visitors were just following the crowd to take a look at the tabletop. It was observable that they attempted to skip the exhibit as they were uninterested about the topic. When one of their companions voiced up a doubt regarding the content, they were naturally involved in the conversation and turned out interacting with the display to find that particular information. When curiosity aroused, visitors discussed with their companions; and social interaction developed. Curiosity develops a visitors’ need to learn (Rounds 2004) and social interaction is one of the ways to facilitate learning (Falk & Dierking 1992; Litwak 1993; Vygotsky 1978; Hein 1998). Hence, the information presentation method has provoked visitors’ interest in the topic.

2. **To find out whether the interactive exhibit facilitates knowledge (intellect)**

Effective learning exists when visitors are motivated and engaged in the learning process (Boyd 2001; Hein 1998; Falk & Dierking 1992). The interactive exhibit was designed aesthetically for usability and exploration; to evoke visitors’ curiosity and keep them attentive on the display.

Usability of the interactive exhibit prototype has been achieved through the ease of use, efficiency, usefulness, learnability, and memorability. Visitors could search for information easily and without many mistakes. They also found it comfortable to go through and to retrace steps while interacting with the interactive exhibit prototype. The amount of content displayed was accepted (neither too long nor too short) and the content was perceived simple and concise, thus, it was a good source for learning. The interactivity offered by the interactive exhibit prototype was not sophisticated; therefore, it did not divert visitors’ attention from the information on the screen and kept them focused.
Some visitors were captivated by the technology, especially visitors who had no prior experience with interactive exhibits. In the beginning, they would just stand near the tabletop and observed how other visitors were manipulating the interface. They attempted to manipulate it themselves and are finally familiarised with the interaction method after few time inaccuracies. They learned by “modelling” other visitors in order to learn (Falk & Dierking 1992). By having this experience, visitors will be acquainted with the advanced technology and be able to handle other multi-touch devices. When they were asked about what they have learnt through the interactive exhibit, some of their answers were actually unrelated to the intended message delivered through the interactive exhibit, such as: “I learnt how to use the touch screen”, “I know how to zoom in and out in multi-touch screen” and “I get familiar with the display technology now.” This indicates that the novelty of multi-touch display technology applied in the prototype was educative for visitors, especially those who were non-technology persons.

Learning is subjective (Moscardo & Pearce 1986) and there is no definite measurement to confirm the level of acquisition. However, visitors’ understanding of the Archaeology theme may perhaps verify their learning outcome. This study evaluated visitors learning by asking a question of what they have learned from the interactive exhibit. Their answers were most likely the information that they could recall after interacting with the prototype. Some of the responses given were as follows.

- “I learned different time and different findings of archaeology in Sarawak.”
- “The age of some artifacts and paintings found in the caves. It was great, sometimes funny.”
- “Introduction to places in Sarawak.”
- “I learned about local ancient history and culture from different areas in Sarawak at different time periods.”
- “The amazing artifacts found in Sarawak.”
- “The places to see the archaeological evidences.”
- “History about Sarawak archaeology.”
- “Prehistory of the era.”
- “Ceramics.”
- “History of Sarawak that I had no idea about.”
- “I learned about the burial boats and the old skull.”
- “I discovered historical areas that I never know earlier.”
- “Niah Caves.”
- “I found out about Gua Sireh today.”
- “I learn from the timeline and understand where artifacts were found.”
The answers abovementioned could not confirm that visitors had successfully grasped the whole intended message. Their responses were short and precise; therefore, it was difficult to validate. Nevertheless, the answers given were closed to the anticipated outcome and associated with the exhibit topic, the Archaeology in Sarawak. Hence, it can be resolved that visitors had an effective exploration of the interactive exhibit which effectively enhanced their knowledge.

Table 5-4 A comparison of respondents’ cognitive experience in pre-digital exhibition and digital exhibition.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Statements</th>
<th>Mean1</th>
<th>Mean2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning and Experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>I discovered things I didn’t know</td>
<td>4.04</td>
<td>4.25</td>
</tr>
<tr>
<td>2.</td>
<td>I learned more about things I already know</td>
<td>3.78</td>
<td>3.89</td>
</tr>
<tr>
<td>3.</td>
<td>I shared knowledge and experience with other people</td>
<td>3.54</td>
<td>3.68</td>
</tr>
<tr>
<td>4.</td>
<td>I can understand the information conveyed by the exhibit</td>
<td>3.60</td>
<td>4.31</td>
</tr>
<tr>
<td>5.</td>
<td>I learned through interaction with the exhibit</td>
<td>3.38</td>
<td>4.21</td>
</tr>
<tr>
<td>6.</td>
<td>I can recall the information from the exhibit</td>
<td>3.52</td>
<td>3.89</td>
</tr>
</tbody>
</table>

The statistics in Table 5-4 reveals the comparison of evaluation results in front-end evaluation (Mean1) and in the summative evaluation (Mean2) which was measured in five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree). The use of interactive exhibit prototype appears to increase the visitors’ cognitive engagement that results in intellectual experience.

3. To find out whether the interactive exhibit facilitate enjoyment (emotion)

There were two youngest participants (age between 12 to 14 years old) who recognised the multi-touch tabletop and explored it together at the same time, as a sharable media. One of them said “It was very interesting, not boring at all. I can play and learn at the same time. It’s just like surfing the internet for free on a larger screen.” While the other commented: “Compare to the traditional display, this kind of display is more futuristic. I will come for another visit if I am free. I want to search more about the archaeology in Sarawak.” From this discussion, it is demonstrated that interactive technology has made their learning enjoyable and has increased the holding power on the exhibit. The two of them enjoyed the exhibit as both learning and entertainment tool.

The visual and physical aspects of the interactive exhibit prototype have attracted visitors to be responsive towards the display. Some visitors mentioned that they did not like reading in nature. When they looked at the interactive exhibit, they could not just skip but were moved to touch on the screen. They surprised themselves that they in fact ended up more reading
and had more understanding on the topic. It was interesting to find out that visitors’ affection precedes cognition in learning. The exhibit for learning is effective when it evokes visitors’ affection (Stephen Bitgood 1994). From the observation, visitors engaged with the exhibit in positive attitude and emotion. As a result, it motivated them to act more to satisfy their cognitive needs. There were no more comments such as “It was boring”, but the received comments were:

- “That’s beautiful.”
- “It’s cool.”
- “Wow! I can enlarge it.”
- “I can zoom in and out like this. Oh, yeah!”
- “This is an interesting way to learn history.”
- “Amazing! The map is colourful.”

It is understandable that many teenagers and adults are used to using technology applications, especially with the entertainment platforms. The interactive exhibit was designed to allow visitors to have more access to the information and more control over their museum experience. Visitors were able to explore their preferred information at their own pace and in their own way, which made the interactive exhibit more personalised. They would be able to construct their own meaningful and enjoyable experience in the museum visit. In this manner, the interactive exhibit facilitated visitors’ enjoyment in learning.

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Statements</th>
<th>Mean1</th>
<th>Mean2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I got curious about finding out more</td>
<td>3.86</td>
<td>4.08</td>
</tr>
<tr>
<td>2.</td>
<td>I found the exhibit emotionally engaging</td>
<td>3.60</td>
<td>3.84</td>
</tr>
<tr>
<td>2.</td>
<td>I had a lot of fun during my visit</td>
<td>3.38</td>
<td>3.92</td>
</tr>
<tr>
<td>4.</td>
<td>It was a worthwhile visit in exchange for my time</td>
<td>3.52</td>
<td>4.23</td>
</tr>
</tbody>
</table>

The statistics in Table 5-5 reveals the comparison of evaluation results in front-end evaluation (Mean1) and in the summative evaluation (Mean2) which was measured in five-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Not sure, 4-Agree, 5-Strongly Agree). The use of interactive exhibit prototype appears to increase the visitors’ affective engagement that results in enjoyable experience.

4. To find out whether the interactive exhibit offer more satisfaction

The level of visitors’ satisfaction towards the conventional exhibit (in the front-end evaluation), ranged from 1 (Dissatisfied) to 5 (Satisfied), achieved 3.42 on average. While,
the level of visitors’ satisfaction towards the interactive exhibit prototype, has obtained 4.30 in average which confirmed that the interactive exhibit was seen as a promising exhibition design as visitors agreed to employ this exhibit in the museum (Mean = 4.62).

![Respondent's satisfaction level](image)

**5.3. Summary of Chapter**

This chapter discussed the summative evaluation that was conducted at the last stage of the exhibition development process. The interactive exhibit prototype was installed and implemented at the Sarawak Museum for user evaluation to identify the effectiveness for enhancing the current conventional exhibitions and visitors’ learning experiences.

The interactive exhibit prototype allows for both cognitive and affective engagement, which is essential for museum educational experiences. Based on the evaluation result, the interactive exhibit prototype is believed to be a more attractive and effective approach in disseminating information compared to the conventional displays. Visitors’ knowledge and experience in museum learning is positively facilitated through the interactive exhibit prototype.

The interactive exhibit prototype design has provided deeper and contextual learning through the narrative context and the layering of information. The prototype provides flexibility in learning through the availability of two points of access. Personalised learning is achieved and allows visitors to control their own learning interest and to explore at their own pace. The collaborative learning is facilitated through the multi-touch tabletop display which invokes visitors’ discussion to share information. The simplicity and appealing interface design increase visitors’ enjoyment in their learning process. Visitors’ learning experiences is also enhanced through the intuitive
and consistent interface design, well-organised and educative content, narrative context and the effective use of display technology that is collaborative, interactive and engaging.

The chapter concludes that the interactive exhibit improves the information dissemination method, facilitates visitors’ knowledge and enjoyment as well as offers more satisfaction to the museum visitors. The result was further supported by the metrics indicated from the users’ satisfaction survey collection where the average score obtained was 4.30 out of 5.00. The summary evaluation results will be used analysed as the directions for further study, which will be presented on the following chapter.
Chapter 6. Conclusion

This final chapter summarises the findings throughout the study and suggests potential improvements for future work to address the limitations found in the current study.

6.1. Conclusion of the Study

This study aims to design and develop an interactive exhibit in the Sarawak Museum in order to enhance the current conventional exhibitions and visitors’ learning experiences through a multidisciplinary approach by incorporating the theories of learning in museums, relevant display technology, and application design requirements based on visitors’ perspectives on the Sarawak Museum’s current exhibitions. This study has raised seven research questions in Chapter 1 and all questions have been discussed in the different chapters of this dissertation. The following is a summary and conclusion of those discussions.

What is the role of museums today? (RQ1). As a public institution, museums bear significant missions for the people. The earlier studies revealed that, over the years, the role of museums has shifted from documenting collections of object to having an educational responsibility. Even though the role of object documentation and research in museums are important, the primary objective lies on the museum education (Hein 1998; Hooper-Greenhill 1999). Functioning on this role, museums are expected to educate their visitors on the documented objects. This responsibility is executed through the museum exhibitions that serve as the communication tool to convey knowledge behind the objects to the museum visitors. Museums not only need to disseminate knowledge actively, but also to offer enjoyable experience for visitors in their museum visit. This implies that museum education needs to stimulate both cognitive (intellect) and affective (emotion) experience of visitors. The educational mission of museums is achieved when visitors are able to construct meaning and experience from their visit. Therefore, the fact that museum becomes popular in the society today requires improvement to be done on the physical setting, particularly on the exhibitions, to give visitors an informative and memorable experience.

What are the learning theories in museums that aid their role today? (RQ2). As suggested by Hein (1998), “learning in the museum and understanding visitors’ learning has become a matter of survival for museums”. The focus of museums has shifted from objects to be exhibited to visitors in their learning. Many studies have discussed the theory of constructivist learning and its relevance in museum education. The constructivist learning focuses on learners to construct their own knowledge based on their prior knowledge, experience, and interest (Hein 1998). Hein (1998) described learning in constructivist museum is an active process of constructing meaning that engages learners’ action and mind, underpinned by prior knowledge and experience to contextualise the meaning, mediated by social interaction, motivated (intrinsically and
extrinsically), and takes time. The educational environment in museums provides “open-ended” learning that responds to the needs and interest of visitors. This suggests that learning in museums is personal, self-directed and free choice that leads to changes in visitors’ personalities, such as perceptions, attitudes and behaviour. Visitors “can learn at their own pace, in their own way, or not at all if they choose” (Dean 1996). Thus, the constructivist learning theory is applicable to the museum education where visitors have full control on their knowledge acquirement.

Museum learning experience is contextual and motivated by different factors. As argued by Falk and Dierking (1992), visitors’ learning experience is constructed within the interaction of the three contexts, consisting of personal context, social context, and physical context. The framework of the Interactive Experience Model discusses the importance of the three contexts (personal, social, physical) in the practice of constructivist learning and suggests that these contexts are inseparable, intertwined and are essential for the success of museum learning (Falk & Dierking 1992). Museum visitors comprises of different individuals with different background and behaviour. Even though learning in museum setting is self-driven, however, in some way; learning setting plays a role in facilitating the process, such as the social and physical setting. Therefore, the museum exhibition must be designed effectively to allow for these variations and to provide opportunity for visitors to actively construct their own knowledge that leads to a contextual meaning.

What is the role and implication of using various display technologies in interactive exhibits? (RQ3). It is revealed that the technology has introduced a high level of interest and engagement through its visualisation and interactive capability. In addition, the use of interactive technology in the exhibit allows flexibility for the users to construct their own learning. In this way, interactive technology plays a vital role in enhancing the construction of knowledge and experience. To summarise, the use of display technology in interactive exhibits allow for cognitive engagement as well as affective engagement. It is reminded that the use of technology in museum exhibition must not distract and draw visitors’ attention away from the original aim, which is to convey the knowledge of artifacts (Stogner 2009; A. Griffiths 2003; Morgan 2012; Damala 2007). The use of interactive technology in museum exhibitions should augment the conventional displays (artifacts and labels) to facilitate visitors’ learning opportunity for contextual education.

What are the factors to be considered when designing an interactive exhibit? (RQ4). The significant factors include the information organisation, the selection of the display technology, and the aesthetics. The choice of display technology is significant as it influences the visibility, input possibilities, and interaction with the display (Hinrichs et al. 2008; Damala 2007). Hein (1998) argued that the arrangement of learning content influences the construction of
knowledge as the visitors learn based on their prior knowledge and experience. Therefore, the interactive exhibit prototype must be designed under the visitors’ familiarity to assist their learning process.

What is the learning preference of visitors at the Sarawak Museum? What are the problems of the current exhibitions at the Sarawak Museum and what are the solutions? (RQ5). The study on museum visitors’ perspective was integrated to the theoretical findings from RQ1 to RQ4 to determine the museum visitors in general. The present study was localised to the learning preferences of visitors at the Sarawak Museum to design and develop the interactive exhibit prototype. A preliminary survey was conducted to identify the preferences of visitors at the Sarawak Museums and to assess the limitations of current Sarawak Museum exhibitions as well as to suggest possible solution to enhance the museum displays. The survey result reveals that visitors are looking for both the intellectual and emotional experiences in the museum visit. Based on the evaluation, the characteristics of the Sarawak Museum visitors are similar to constructivist learners who are actively constructing knowledge based on their prior knowledge and interest. The visitors learn through different kinds of sensorial modalities, include visual, auditory, read, and kinesthetic. Nevertheless, the visual-related activity is still preferred in the museum visit. Most of visitors are interested in the Archaeology theme at the Sarawak Museum and this subject received more visitors’ attention. Therefore, this study selected the Archaeology as the exhibit topic. The general problems of the Sarawak Museum exhibitions are related to the information organisation and contextualisation, the visualisation and attractiveness as well as the engagement capability. The survey result also reveals there is a need to provide multi-lingual feature in museum exhibit to allow for different culture of visitors. The proposed solution that fits into the problems is to embrace technology into the museum exhibition, which is the interactive exhibit.

After understanding and gathering basic information in the previous sections, the study continued to design and develop the interactive exhibit prototype. The visitors’ preferences and the limitations on the Sarawak Museum exhibition were translated into the prototype design requirements. The constructivist learning theory and the three contexts (personal, social, and physical) involved were also incorporated. These design requirements determine the applicable display technology and application design for the prototype. What is the relevant and applicable display technology and application design suitable for the prototype in order to be effective? (RQ6). The prototype design concept is required to fill the gap of current conventional exhibitions at the Sarawak Museum, which is to provide the opportunity for visitors to construct their own knowledge actively through multiple points of access and layering of information for contextual knowledge and to enable collaborative learning as well as physical engagement on the display. The study opts for multi-touch screen tabletop as the prototype’s display technology with the considerations of the high level of interactive capability, large display area for visibility
and multi-user input functionality as well as the intuitive interface that is accessible by all age group of visitors. A drawback from this display technology is the high cost. Therefore, the multi-touch table for this study is created in an alternative way, supported by open source application and DIY construction technique. The application is designed to present information for a single exhibit theme (Archaeology), in the context of different times (chronological) and different locations (geographical). The prototype focuses on the use of narrative concept to organise the information in form of timeline and a map. The information displayed on these narrative platforms consists of two layers that allow visitors to explore for information that is more detailed. As a result, the prototype produces two points of access on the application (chronological mode and geographical map mode) to allow flexibility in visitors’ learning. Finally, the multi-lingual feature provides three different languages, English, Bahasa Malaysia, and Chinese. The study conducted an evaluation on the prototype design before the final implementation at the Sarawak Museum to identify the potential problems on the prototype design and to assess the usability in facilitating visitors’ learning experiences. The evaluation results revealed positive responses from the users and only minor modification applied for the interface design.

How is the effectiveness of the prototype in enhancing the current conventional exhibitions and visitors’ learning experiences? (RQ7). The finalised interactive exhibit prototype was installed and implemented at the Sarawak Museum to study the effectiveness of the prototype design in achieving its goal. Chapter 5 outlined the result of the summative evaluation. Overall, the survey result reveals that the interactive exhibit prototype is an effective communication tool to present the Archaeology theme at the Sarawak Museum with strong user acceptance of 4.62 (Mean). This is resulted from the effective use of narrative concept that depicts the information contextually and is presented in an attractive manner. The result concludes that the interactive exhibit prototype improved the dissemination of information at the Sarawak Museum, facilitates visitors’ knowledge and enjoyment as well as provides more satisfaction to the visitors. The overall user satisfaction obtained 4.30 (Mean) in average and this reveals that visitors are satisfied with the interactive exhibit prototype.

This study concludes that the multi-disciplinary approach implemented to design and development of interactive exhibit at the Sarawak Museum is effective in enhancing the current conventional museum exhibitions and visitors’ learning experiences. There have been noteworthy improvements in the visitors’ attitude and satisfaction after engaging through the interactive exhibit prototype. Therefore, the prototype design requirements have been achieved and justified to be positively motivating visitors’ learning in Archaeology, cognitively and affectively. From the result of this study (in Section 5.2.), the acceptable important factors for designing and developing an effective interactive exhibit lie in the information design and the display technology:
• The simplicity and consistency of the interface design enhances the attractiveness on the display. Simple and consistent design in the prototype also motivates the visitors’ exploration, assists them to use with ease, and minimises mistakes.

• The use of narration in the information design improves the visualisation and information organisation. The prototype focuses on the use of narrative concept to organise the information in form of timeline and a map. The narrative concept increases the contextual information in the prototype that facilitates visitors’ understanding of the topic.

• The prototype offers flexibility in learning through the two access points and the multi-lingual feature, and allows for deeper exploration through the two layers of information that facilitates the visitors to create their own meaning.

• The intuitive interface and usable interaction system through the multi-touch screen tabletop facilitates own learning through exploration and provides a more enjoyable experience to the visitors.

• The interactive capability of the multi-touch screen tabletop increases the emotional engagement of visitors on the museum exhibition as it provides the opportunity for social interaction and collaborative learning.

The interactive exhibit is effective when it motivates visitors to engage and to experience with the exhibit. There are a variety of factors that can influence the effectiveness of the interactive exhibit in engaging visitors’ learning experience. Eight general guidelines to consider when designing the interactive exhibit are as follows:

1. **Provide a familiar theme**
   The visitors will tend to be more actively involved with the exhibit content that is familiar to them. The title for the exhibit can help visitors to make connections with the exhibit content.

2. **Design for an attractive and engaging environment**
   As visitors are active participants, they will spend more time on the exhibit that attracts and motivates them. An interactive exhibit will improve the museum environment to be more attractive to reinforce the visitors’ intrinsic motivation. Exhibit that allows for physical interaction can evoke visitors’ emotion. However, the interactive exhibit design must not draw the visitors’ attention away and distract the exhibitions environment.

3. **Offer personalisation**
   Visitors can personalise their museum experience if the exhibit provides choices and controls in their engagement. The interactive exhibit design can provide multiple points of access and layering on information for self-exploration. Multi-lingual exhibit can also help to cater for different cultures of visitors.

4. **Support collaborative learning**
Most visitors go to the museum in groups. Designing an exhibit that supports social activities can help to increase the social experience among the visitors, such as an interactive exhibit that allows for multi-user and social interactivity.

5. **Design for contextualisation**
   The exhibit requires a consistency in the information design. Narrative context can help to organise the information to provide a better visualisation and more contextual information for visitors' learning experience.

6. **Design for accessibility and usability**
   An effective interactive exhibit design allows the visitors to learn and to use it without difficulty. Identifying the appropriate interactive device (technology) and interface design is necessary to meet the visitors' expectations. The exhibit must be designed for visibility and simplicity to be accessible by the visitors.

7. **Design for artifacts-related content**
   Many visitors like to see the real artifacts displayed in the museum exhibit. Therefore, the interactive exhibit design needs to augment the value and meaning of the available displayed artifacts to facilitate visitors’ experience.

8. **User evaluation**
   Evaluation on the developed interactive exhibit can improve the functionality and effectiveness of the design. Three levels of evaluations that are necessary for the exhibition design (Screven 1990) are (1) front-end evaluation (before the design process), (2) formative evaluation (during the design process), and (3) summative evaluation (after the design process).

The interactive exhibit prototype has taken advantage of the potential of technology in its design. The major concern in museum studies on the use of interactive exhibit is the balancing between the conventional display and the digital technology exhibit. The interactive exhibits must not dominate the original displays (artifacts and labels). The prototype developed in this study is not a standalone display, but is a complementary communication tool that is presented along with the artifact displays. The prototype functions as the foundation for understanding the related artifacts available in the Sarawak Museum, specifically the Archaeology artifacts. The survey result reveals that the interactive exhibit prototype has been successful in motivating visitors to experience the original artifacts with a better knowledge created through the prototype. Hence, this study also concludes that the integration strategy of the conventional display (artifacts and labels) and the digital exhibit has been achieved. In addition, the interactive exhibit prototype is effective to facilitate for contextual museum learning.

Although the interactive exhibit prototype is not novel in terms of the technology as interactive tabletop display system has been available in the digital exhibitions practice, it offers low cost alternative as the proof of concept for this study. On top of that, the application and design is
novel within the context of the Sarawak Museum. Hopefully, as a starting point to introduce this seed or idea of utilising technology not only help to provide contextual understanding to visitors and to make it a more enjoyable experience, but the technology can also aid in faster dissemination of information as museums lack of time, stuffing and space to display everything. The technology not only facilitates the visitors’ learning experience, but also helps the museums in achieving its educational role.

This study has contributed to the growing research on museum exhibitions, especially for the Sarawak Museum, through the prototype application design and the creation of an entertaining museum learning experience. The proposed design and evaluation of the study can be used to assist the museum exhibition designers in planning for future interactive exhibitions. The technology and design approach from this study are suitable for other museums in Sarawak or Malaysia because of the similarity in many aspects, such as visitors’ demographics, behaviours, and museum experience. The methodology from this study can be applied to other museums in order to improve the information dissemination process for museum education.

This study believes that digital technology plays an active and significant role in aiding the museum education and bears this role in the future. Therefore, designing an “open-ended” learning functionality through the effective use of technology that integrates with the artifacts is the effective strategy to allow for visitors who come from all walks of life.

6.2. Directions for Further Study

The suggested potential areas to be studied in the future addresses the current limitations of this study as follows:

1. The interactive exhibit content for future studies can be improved by involving more multimedia elements (e.g. audio, video, animation) to allow more access points and cross referencing information.
2. As the current study is targeted to general visitors, future studies can be carried out to design an interactive exhibit that tailors to a specific target user, such as for children or family groups.
3. It is interesting to see if the approach used in this study can be applied into other display systems, such as mobile devices or Augmented Reality, and how the result would be different with the interactive tabletop.
4. Social learning in this study can be further explored, such as to allow social networking system that brings museums into public sphere to engage a world audience and to encourage their participation to create own meaning, that is not limited to physical space.
5. In future, an interactive exhibit that is not only museum-centred, but also visitor-centred can be developed to encourage public’s participation directly on the exhibit content,
such as a system that is connected and allows users to build and contribute their own history and common shared history in communities.
References


Hornecker, E., 2008. “I don’t understand it either, but it is cool” - visitor interactions with a multi-touch table in a museum. 3rd *IEEE International Workshop on Horizontal Interactive Human Computer Systems*, pp.113–120.

[Accessed January 17, 2013].


Richards, J.D., 2010. Digital applications for cultural and heritage institutions; Digital technologies and the museum experience: handheld guides and other media; Museum informatics: people, information and technology in museums. *International Journal of Heritage Studies*, 16(6), pp.527–529.


List of Publication

Appendices

Appendix 1. Ethic Clearance
Appendix 2. Consent Letter

Swinburne University of Technology (Sarawak Campus)
Tingkat 1, Kompleks Negeri
Jalan Simpang Tiga
93576 Kuching
Sarawak Malaysia

Tel: +60 82 416353
Fax: +60 82 423594
Website: www.swinburne.edu.my

TO WHOM IT MAY CONCERN

Introduction

You are invited to participate in a study that is being conducted by Dian Valeria Ng (the researcher), with Mr. Gregory Wee and Mr. Wilson Suai as her research supervisors. This survey is done as part of her Master studies with Swinburne University of Technology Sarawak Campus (SUTS) which focuses on the implementation of an interactive display system for museum exhibits in the Sarawak Museum in order to improve visitors’ sensorial experience and the dissemination of information.

Project title: Design and Development of Interactive Display for Museums in Sarawak

Aim of the Study

The aim of this study is to design and develop an interactive display system for museum exhibits in the Sarawak Museum in order to enhance visitors’ sensorial experience and the dissemination of information.

This survey is carried out in order to collect responses from visitors about their perceived experience and perception of the effectiveness of the current museum displays in the Sarawak Museum. The data collected will be analysed for developing an interactive display system for museum exhibits in the Sarawak Museum.

Free Consent & Withdrawal from Participation

This survey will be done by filling the answers on the questionnaire papers and returning it to the researcher. It will take approximately 30 minutes to complete. Participation in this study is entirely voluntary. You may choose not to take part or not to finish the questionnaire without penalty.

Privacy & Confidentiality

Your willingness to participate in this survey indicates consent to the publication of the data. The participant’s identity will not be recorded and will remain anonymous. There will be no way to link the data to your personal identity.
Research Output

The data gathered in this survey will be analysed and used as part of my Master thesis. This information will also be published in academic conferences and journals. Your participation will remain anonymous.

This project has been approved by or on behalf of Swinburne’s Human Research Ethics Committee (SUHREC) in line with the National Statement on Ethical Conduct in Human Research. If you have any concerns or complaints about the conduct of this project, you can contact:

Research Ethics Officer, Swinburne Research (H68)
Swinburne University of Technology
P O Box 218, HAWTHORN VIC 3122
Tel:   (03) 9214 5218 or +61 3 9214 5218
Email:   resethics@swin.edu.au

If you would like more information about this study, please contact the researcher.
Thank you for taking your time to participate in this survey.

Yours sincerely,

__________________________
Dian Valeria Ng
Postgraduate Research Student
School of Business and Design
Swinburne University of Technology (Sarawak Campus)
Email: dvng@swinburne.edu.my
Appendix 3. Front-End Evaluation

Design and Development of Interactive Display for Sarawak Museum

This survey is carried out in order to collect responses from visitors about their perceived experience and perception of the effectiveness of the current museum displays in the Sarawak Museum. The data collected will be analysed for developing an interactive display system in the museum to enhance visitors’ experience. We would like your cooperation to help us in providing information by filling in the following questions.

We appreciate your cooperation and time spent for participating on this survey.

The data collected through this questionnaire will be analysed and published in academic conferences and publications such as journals. Your identity will not be recorded nor revealed in any form or association.

Please place an X or √ next to the most appropriate choice and fill in all the answers.

Section A: Personal & Demographic Information

1. What is your gender?
   □ Male         □ Female

2. What age group do you fall into?
   □ under 18    □ 18 – 24
   □ 25 – 34     □ 35 – 44
   □ 45 – 54     □ over 55

3. Which country are you from? ______________________________

4. What language do you generally use?
   □ English      □ Other (please specify)_____________________

5. What is the highest level of education you have completed?
   □ High school or equivalent □ College / University
   □ Post graduate            □ Other (please specify)_____________________

6. What is your current profession?
   □ Professional       □ Self-employed
   □ Trader / proprietor □ Educator
   □ Student             □ Retiree
   □ Other (please specify)___________________________
Section B: General Information on Visitor's Behaviour

7. Is this your first visit to this museum?
   ☐ Yes          ☐ No

8. Who are you coming to this museum with?
   ☐ Alone            ☐ Family
   ☐ Friends / Relatives ☐ Organised group
   ☐ Other (please specify)___________________________

9. Why do you visit this museum? Please select all that apply.
   ☐ For my leisure activity
   ☐ For personal interests
   ☐ To experience something new
   ☐ To expand knowledge
   ☐ For entertainment
   ☐ Other (please specify)___________________________

10. How long do you usually stay in the museum?
    ☐ 1 hour or less        ☐ 2 hours
    ☐ 3 hours               ☐ Other (please specify)___________________

11. What would you do during the visit to museums? Please select all that apply.
    ☐ Look at things       ☐ Touch things
    ☐ Play                ☐ Read and learn
    ☐ Talk with friends   ☐ Other (please specify)___________________

Section C: General Information on Visitor's Preference

12. Name one of the categories of exhibits that you are interested in.
    ____________________________________________________________

    a. What was interesting and attractive about it?
       ___________________________________________________________

    b. What would you like to suggest for improvement?
       ___________________________________________________________

13. Name one of the categories of exhibits that you are not interested in.
    ____________________________________________________________

    a. Which part of it was not interesting and attractive?
       ___________________________________________________________
b. What would you like to suggest for improvement?

__________________________________________________________________
__________________________________________________________________

14. How do you personally like to learn things in museums? Please select all that apply.

☐ Through touching & physically interacting with the display
☐ Through reading the text labels & printout
☐ Through images / photo stills
☐ Through audio or video shows
☐ Through multimedia and interactive application
☐ Through interaction with friends or tour guide
☐ Other (please specify)___________________________________________________
Please state your reason(s)
__________________________________________________________________

Section D: Evaluation of Visitor’s Experience and Perception towards Current Exhibitions’ Performance

Please circle your most applicable answer to the statements below.
1 – Strongly Disagree  2 – Disagree  3 – Not Sure  4 – Agree  5 – Strongly Agree

<table>
<thead>
<tr>
<th>Statements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>I discovered things I didn’t know</td>
<td>1</td>
<td>2</td>
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<td>4</td>
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</tr>
<tr>
<td>I learned more about things I already knew</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I shared knowledge and experience with other people</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I got curious about finding out more</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I can understand the information conveyed by the exhibit</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I learnt through interaction with the exhibit</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I can recall the information from the exhibit</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I found the exhibit emotionally engaging</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I had a lot of fun during my visit</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>It was a worthwhile visit in exchange for my time</td>
<td>1</td>
<td>2</td>
<td>3</td>
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</thead>
<tbody>
<tr>
<td>The sign posting and directions for the exhibits is visible</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The overall exhibition is attractive</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The content appeals to hold attention</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The exhibition provides up to date information</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The overall information of the displays is accurate and comprehensive</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The written materials encourage creative thinking</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The information can easily be comprehended</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The information takes less time to absorb</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</tbody>
</table>
15. Please rate your **overall expectation** for this museum after you visit by circling the appropriate number.

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<th>5</th>
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</thead>
<tbody>
<tr>
<td>Dissatisfied</td>
<td>Satisfied</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

16. Please rate your **overall satisfaction** for this museum after you visit by circling the appropriate number.

<table>
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<th>1</th>
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<th>5</th>
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</thead>
<tbody>
<tr>
<td>Dissatisfied</td>
<td>Satisfied</td>
<td></td>
<td></td>
<td></td>
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</table>

17. Of all the displays you saw, did any catch your eyes? What was it? Is there any reason you favoured this display?

_____________________________________________________________________
_____________________________________________________________________

18. Do you have any other comments about the written materials of the displays? Are they clear? Any suggestions for improvement?

_____________________________________________________________________
_____________________________________________________________________

19. Do you have any other comments about the communication techniques? Any suggestions for improvement?

_____________________________________________________________________
_____________________________________________________________________

20. Would you prefer to have multimedia interactivity in the museum display? Please circle your most applicable answer.

<table>
<thead>
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<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Strongly Agree</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please state your reason(s)
_____________________________________________________________________
_____________________________________________________________________

21. What kind of multimedia interactivity would you like to suggest to be implemented in the museum to enhance your experience?

_____________________________________________________________________

Thank you for your time in completing this survey
Appendix 4. Font and Colour

Sans-serif font types are used for the interface as it is clean and easier to read, which is also appropriate for museum labels (Weiner 1963). The Century Gothic font is applied for the title and the main menu, while the Calibri font is used for the main content. Large font size is utilised for the texts to facilitate the users’ readability of the display.

CENTURY GOTHIC          CALIBRI

The colour theme used for the interface design is the earth tone which matches the exhibit theme. Earth tones are the natural colours of rocks, trees, dirt, etc. The related colour tone used emphasises the theme of the exhibit. Black and white colours are applied to the texts. Bright and eye-catching colours were used as the highlighter.

![Figure: Colours applied in the interactive exhibit prototype](image-url)
Appendix 5. Summative Evaluation

The Evaluation of an Interactive Display System in Sarawak Museum

This survey is carried out to collect responses from visitors about their perceived experience and perception towards the interactive display system in the Sarawak Museum. The data collected will be analysed to evaluate the effectiveness of the interactive display system for Sarawak Museum exhibits in enhancing the information dissemination and visitors’ learning experience. We would like to have your cooperation to help us in providing information by filling the following questions.

We appreciate your cooperation and time spent for participating on this survey.

The data collected through this questionnaire will be analysed and published in academic conferences and publications such as journals. Your identity will not be recorded nor revealed in any form or association.

Please place a √ next to the most appropriate choice and fill in all the answers.

Section A: Personal & Demographic Information

1. What is your gender?
   □ Male    □ Female

2. What age group do you fall into?
   □ under 18    □ 18 – 24
   □ 25 – 34    □ 35 – 44
   □ 45 – 54    □ over 55

3. Which country are you from? ____________________________

4. What language do you generally use?
   □ English    Other (please specify)_______________________

5. What is the highest level of education you have completed?
   □ High school or equivalent    □ College / University
   □ Post graduate    Other (please specify)_______________________

6. What is your current profession?
   □ Professional    □ Self-employed
   □ Trader / proprietor    □ Educator
   □ Student    □ Retiree
   Other (please specify)____________________________________
Section B: Evaluation of Visitor’s Experience and Perception towards the Interactive Display System Performance

Please circle your most applicable answer to the statements below.
1 – Strongly Disagree  2 – Disagree  3 – Not Sure  4 – Agree  5 – Strongly Agree

<table>
<thead>
<tr>
<th>Statements</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Learning and Experience</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I discovered things I did not know</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I learned more about things I already knew</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I gained information/ knowledge about the Archaeology in Sarawak</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I shared knowledge and experience with other people</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I can understand the information conveyed by the display system</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I learnt through interaction with the display system</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I can recall the information from the display system</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I become interested in the topic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I found the display system informative</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I found the display system as a learning resources</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I found the display system emotionally engaging</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I found the display system entertaining</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I got curious about finding out more</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I had a lot of fun</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>It was a worthwhile visit in exchange for my time</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td><strong>Display System Usability</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The display system is easy to use and to navigate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The interface of the display system is clear and consistent</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The interface of the display system is intuitive</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The interactive display is more attractive than the traditional display</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The interactive display is more effective than the traditional display</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The display system arouses interest</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The content appeals to hold attention</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The display system makes the searching of information easier</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The display system presents the information in a comprehensive way</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The information on the display system is well-organised</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The information presented on the display system is easier to absorb compared to the traditional display</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The display system makes use of multimedia technology to enhance my understanding on the exhibit topic</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Overall, the interactive display system is better than the traditional display</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
7. Please rate your overall satisfaction for this interactive exhibit after experiencing it by circling the appropriate number.

1  2  3  4  5
Dissatisfied  Satisfied

8. What did you learn from the interactive display?
_____________________________________________________________________
_____________________________________________________________________

9. Any comments or suggestions for improvements of this interactive exhibit?
_____________________________________________________________________
_____________________________________________________________________

10. Would you prefer to have this kind of multimedia interactivity in the museum display? Please circle your most applicable answer

1  2  3  4  5
Strongly Disagree  Strongly Agree

Please state your reason(s)
_____________________________________________________________________
_____________________________________________________________________

11. What kind of interactive multimedia technology would you like to suggest to be implemented in the museum to enhance your knowledge and experience?
_____________________________________________________________________
_____________________________________________________________________

Thank you for your time in completing this survey