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Mobile Augmented Reality for Hearing Impaired Museum Engagement (MARHIME): A Conceptual Model

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Abstract. Most Mobile Augmented Reality (MAR) applications for museum are largely tailored for normal visitors while the disabled such as hearing-impaired (HI) visitors are not well supported. This makes them to go through unpalatable experiences and eventually dissatisfy with their visit to the museum. In order to attract HI museum visitors' interest, our study employs the concept of engagement through the use of the MAR application. Our recent finding revealed several MAR elements for museum HI visitors' engagement. These elements include aesthetics, curiosity, usability, interaction, motivation, satisfaction, self-efficacy, perceived control, enjoyment, focused attention and interest. These elements which were extracted from a comprehensive literature review are then validated through expert reviews. A total of eleven elements were sent for review by the experts and they have validated six elements of engagement. This paper proposes a conceptual model of MAR for HI museum engagement (MARHIME). This model is expected to provide guidelines for developers in developing MAR applications that are able to engage HI museum visitors and make them satisfy with the museum visit. Our future work will develop the MARHIME application which will be validated by HI museum visitors.

INTRODUCTION

Augmented reality (AR) involves the introduction of virtual objects into the real environment in order to obtain an augmented environment [1]. This augmented environment is the direct superimposition of physical objects with computer-reproduced objects. The knowledge of AR is influencing human-computer interaction greatly with the proliferation of MAR apps and the provision of social support within many domains ranging from education, healthcare to tourism [2], [3], [4], and [5]. MAR has been implemented in museums as evident in the works of [1], [6], [7], [8] and [9]. These apps serve as alternatives to the museums' conventional brochures and visiting information guides. MAR apps in museum can successfully help museums manage large crowds if the apps are easy to learn, easy to use and provide the visitor with an engaging and enjoyable experience. However, a number of researches focus on these MAR apps in museum for normal-hearing visitors and thus a decrease in awareness for hearing impaired (HI) visitors and tourists [10]. These HI visitors struggle with having an engaging experience during their visits. Therefore, the work of [11] explored the design elements of the MAR for engaging hearing impaired visitors at the museum site.

The study depicted eleven elements required to design MAR apps for engaging HI visitors using only literatures within the domain of engagement and MAR which are previously implemented in similar studies. These elements include Aesthetics [12], Curiosity [13], Usability [14], and [15], Interaction [16], Motivation [17], Satisfaction [18], Self-Efficacy [19], and [20], Perceived Control [13], Enjoyment [21], and [22], Focused Attention [15] and Interest [23]. Therefore, based on these elements, this study initially validates the suitable elements to achieve the second phase of the study which considers the development of a conceptual model of MAR for engaging hearing impaired museum visitors.

Related models investigating user engagement of MAR apps include the works of [24] in developing a conceptual model of user engagement for mobile-based augmented reality games, [25] in designing immersive experiences that maximize consumer engagement, [26] in introducing an integrated framework to support mobile based learning engagement, and [27] in considering an assessment of students' flow experiences during a MAR science game, where flow serves as a measure of engagement. However, these models have based their research on the majority populace which are normal hearing individuals and the areas of application of their models do not consider engagement in the museums. Therefore, this article considers the hearing impaired populace as visitors to the museums and thus proposes an MAR conceptual model to measure engagement during their visits.

RESEARCH DESIGN

A normal approach for evaluation is by asking for user feedbacks and expert reviews have been proven to be very effective [28]. Therefore, expert review was conducted to validate the elements to develop the MARHIME conceptual model. The experts were selected from the fields of Augmented Reality (AR), Mobile Augmented Reality (MAR), Human Computer Interaction (HCI), Hearing Impaired (HI) and Museum from several countries namely Malaysia, Romania, United States of America and Australia. A total of eight experts were chosen in line with the studies by [29], [30], and [31] which state that three to ten experts are the required minimum for expert validation. The experts are all PhD holders in their domains and they have over 5 years of working experience. Table 1 provides the profiles of the experts. The experts are assigned codes E1 to E8 to distinguish them when presenting their recommendations in the subsequent tables.

TABLE 1: Summary of Experts' Profiles

Expert Code	Gender	Field of Expertise	Experience
E1	Female	Museum, HCI	18
E2	Male	Museum, HCI	20
E3	Male	MAR, HI	11
E4	Female	Museum, MAR	6
E5	Male	MAR, HI	16
E6	Female	HI, HCI	14
E7	Male	HCI	17
E8	Female	HCI	>5

The review forms were either given by-hand or via email and also collected back via the same medium. The experts gave their opinions, suggestions, and recommendations in written format in the review form. The selected elements which have been identified to support the design and implementation of a mobile augmented reality application for hearing-impaired museum visitors were listed and the experts were requested to provide comments as well as necessary inputs to the basis of designing the conceptual model with its related elements. The choice by the experts involved assigning to each element the relevant scale as highlighted in the review forms. The results obtained from this review are discussed in the following section.

RESULTS AND DISCUSSION

The measurement adapted for the elements followed a three-point scale anchored by “Definitely not relevant (D)” (1), “Maybe not relevant (M)” (2) and “Relevant (R)” (3). The responses from the experts were then transcribed into quantitative data and analysed using descriptive analysis. The findings from the results of the expert review are shown in Table 2 and Figure 1.

From Table 2, the relevance of each element was displayed with respect to the expert review reports. It was observed that five out of eight experts chose self-efficacy as “Maybe Not Relevant”. This opinion of “Maybe Not Relevant” was also expressed by single experts for curiosity, perceived control, focused attention and interest. Focused attention was also chosen to be “Definitely Not Relevant” by expert E5. The details from Table 2 are displayed in the form of a bar chart as shown in Figure 1. The legend shows the different scales, while the x and y axes represent the elements and the frequency of relevance from the experts respectively.

TABLE 2: Relevance of Elements for MARHIME Conceptual Model

Element	Relevant (R)	Maybe Not Relevant (M)	Definitely not Relevant (D)	Mean
Aesthetics	E1, E2, E3, E4, E5, E6, E7, E8	-	-	3.00
Curiosity	E1, E2, E3, E4, E5, E6, E8	E7	-	2.63
Usability	E1, E2, E3, E4, E5, E6, E7, E8	-	-	3.00
Interaction	E1, E2, E3, E4, E5, E6, E7, E8	-	-	3.00
Motivation	E1, E2, E3, E4, E5, E6, E7, E8	-	-	3.00
Satisfaction	E1, E2, E3, E4, E5, E6, E7, E8	-	-	3.00
Self-Efficacy	E3, E5, E8	E1, E2, E4, E6, E7	-	1.13
Perceived Control	E1, E2, E3, E4, E5, E6, E8	E7	-	2.63
Enjoyment	E1, E2, E3, E4, E5, E6, E7, E8	-	-	3.00
Focused Attention	E1, E2, E3, E4, E6, E7	E8	E5	2.25
Interest	E1, E2, E3, E4, E5, E7, E8	E6	-	2.63

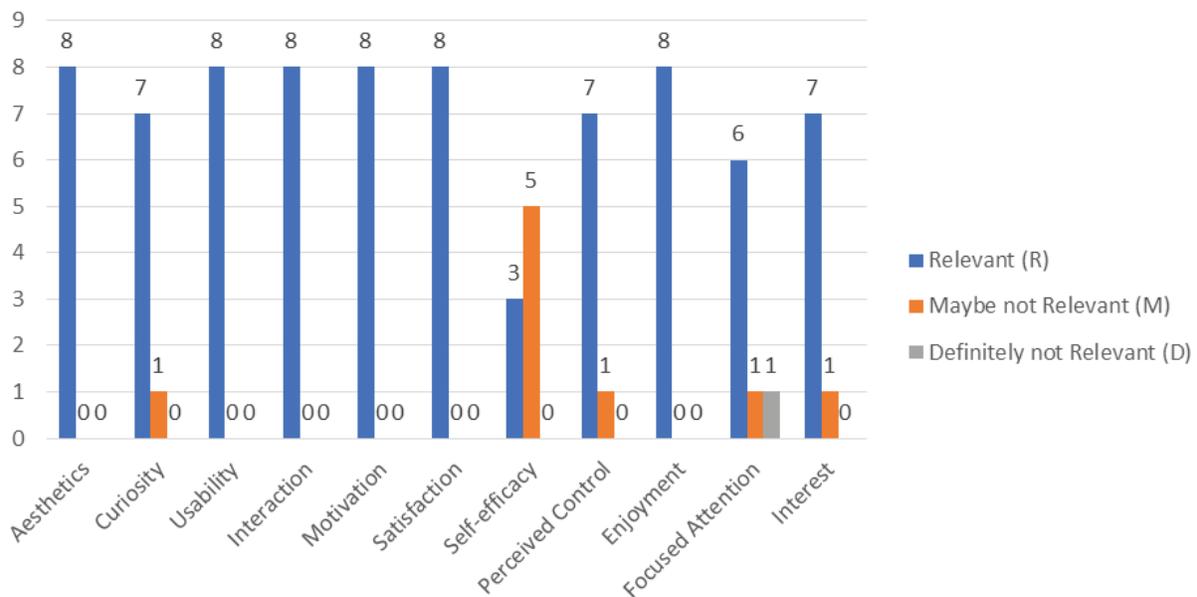


FIGURE 1. Relevancy of elements for MARHIME conceptual model

The criteria to choose the suitable elements for the MARHIME conceptual model was based on the choice of all the experts who agreed that the elements are relevant (see Figure 1) or the elements have mean of 3.00 (see Table 2). Therefore, the chosen elements are Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment.

The elements selected from the expert review are then utilized to construct the MARHIME conceptual model as shown in Figure 2. The conceptual model of MARHIME which is able to engage HI visitors and eventually enhances their learning during their museum visits. The study will explore engagement elements which will be used to design a conceptual model of engagement with MAR museum visit. Based on Figure 2, the four main components namely; Museum, MAR, HI, and Engagement together with the six elements that have been identified that include; Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment will form the MARHIME conceptual model.

The conceptual model depicts the element of satisfaction as pleasing moments with an app which will lead to users fulfilling their expectations on the usage. This element pinpoints that every users usually have predefined target or aim for exploring an app whereas if this target aim is not met then they will disengage with the app. On the other hand, if the target aim is met then they will become more engaged with the app. Also, the element of enjoyment implies the feeling of being benefiting to the conveying message of app. This concept involves users experiencing enjoyment, fun and entertainment with fulfilment based on their interaction with the app. The element of enjoyment is linked with the element of aesthetic which is the mixture of the nature of beauty, art, and taste and

with the creation and appreciation of the app. Aesthetic implies that the theory of beauty is introduced into the MAR so that mobile users can appreciate the expression and representation of the message that the MAR app is conveying.

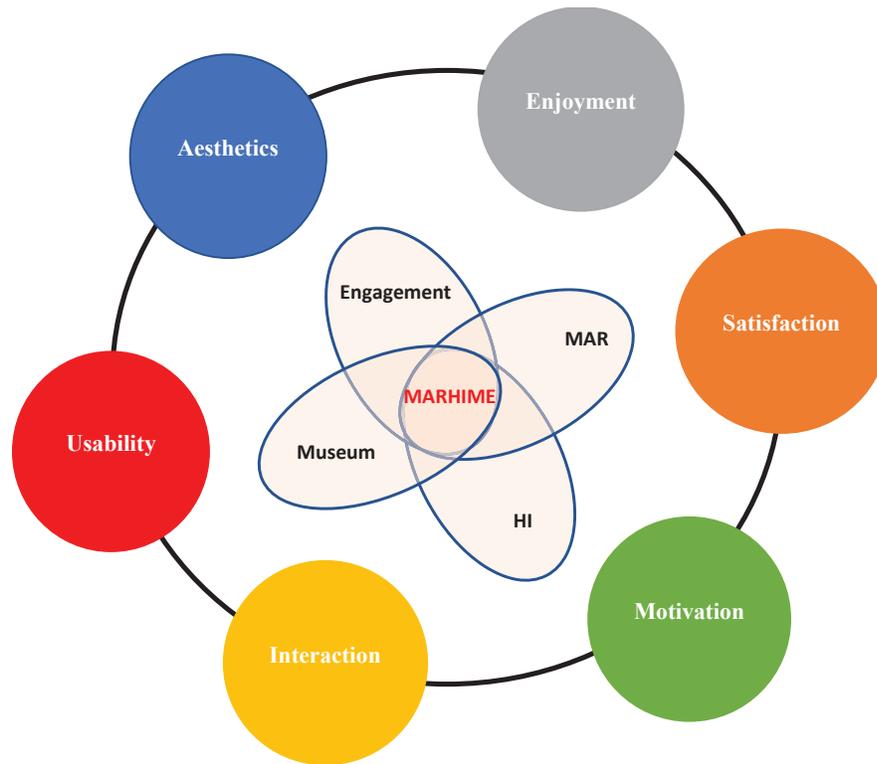


FIGURE 2. Conceptual Model of Mobile Augmented Reality for Hearing-Impaired Museum Engagement (MARHIME)

Furthermore, the element of motivation defines the ability for users to be willing and desire to accompany task which shows that users usually get engaged with the app that they perceived to inspire or motivate them towards achieving their target objectives and tasks. Likewise, the element of usability depicts flexibility, ease of use and learnability of the app. As mentioned by [32], ease of use of a system is one of the measuring tools for evaluating MAR app and the element promotes users engagement and satisfaction with an app. Also, the element of interaction reflects the way and manner that users and app connects. This is important because the platform and nature of the app communication will affect user engagement with the app. Hence, the ability to connect between users and application is critical to engagement.

CONCLUSION AND FUTURE WORK

This study has identified six elements for the construction of the proposed conceptual model of Mobile Augmented Reality for Hearing-Impaired Museum Engagement (MARHIME). These elements include Aesthetics, Usability, Interaction, Motivation, Satisfaction and Enjoyment which were validated through the expert review. These elements and their corresponding items shape the proposed conceptual model and will further serve as a guide for app developers to create a mobile AR for engaging the hearing impaired at the museums. Therefore, future research will proceed to design a prototype MARHIME app to incorporate the identified elements to further validate their relations to engagement of the hearing-impaired museum visitors.

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