Conceptual Model of Augmented Reality Mobile Application Design (ARMAD) to Enhance user Experience: An Expert Review

Nik Azlina Nik Ahmad[1], Ahmad Iqbal Hakim Suhaimi[2], Anitawati Mohd Lokman[3]*
Universiti Kuala Lumpur, Software Engineering Section
Malaysian Institute of Information Technology, Kuala Lumpur, Malaysia[1]
Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia[2, 3]

***Abstract*—Rapid technological advancement has altered the demands of user experience (UX) in product design. However, research has shown that there is a gap and paucity of conceptual and practical models in this research field that may serve as guidelines for the design of immersive technologies such as augmented reality (AR) applications. Identifying the variables and components that influence the enhancement of AR design is critical for creating a great UX. The literature indicated that emotion is the primary driver of the UX. Therefore, this study proposed a conceptual design model for AR mobile application that incorporates user interface, interaction, and content design elements while taking their emotions into consideration in order to improve the UX. The focus of this study is to evaluate the proposed conceptual design model of augmented reality mobile application design (ARMAD) through expert reviews. Feedbacks from the expert reviewers are compiled and illustrated in order to refine the initial ARMAD model. The findings showed that majority of the expert reviewers agreed that the conceptual design model is suitable to be used as guideline in designing AR applications that enhances the UX through emotional elicitation. Accordingly, ARMAD model has been refined according to the feedback and suggestions from the expert reviewers. This model will provide researchers and practitioners insight into the essence of AR design that influence the user experience.**

Keywords*—Augmented reality; conceptual design model; emotional UX; Kansei Engineering; mobile application; user experience

I. Introduction

Augmented reality (AR) has received increased attention over the last few years and has shaped a new way people interact with technologies. With the advent of smartphones, mobile augmented reality (MAR) has brought new opportunities and experiences, leading to MAR's exponential growth in recent years, with 1.1 billion AR users in 2022 [1]. The report also showed that around 83.1 million individuals will use AR application at least once in a month [1]. The emergence of AR technology has significantly improved the usability and experience of smartphone users. MAR has increased the accessibility to products and services in various sectors including retail [2]–[4], transportation [5]–[7], tourism [8], [9], games [10], [11], health [12], [13], and education [14]–[16].

The advancement in this AR immersive technology has altered the way people interact with devices and information, hence provide new opportunities for investigating how to design in immersive environments. To leverage AR in improving the user experience (UX), the AR application must be meticulously designed to captivate the user's attention and satisfaction. Based on the literatures, there is a clear need for research that considers the user emotions in AR design to enhance UX [17]–[19] since user demand has expanded beyond functionality to also include emotional satisfaction [20]. Similarly, [21] argued that application design should addresses the whole UX rather than the concept of usability alone. However, the user may experience various design challenges when using such immersive technologies [22], [23]. As AR technology becomes more prevalent, the requirement to grasp the intricacies of MAR interface design to satisfy its users grows [24]. To deliver a positive UX design, designers must address the user challenges by comprehending the factor and components of AR design.

Although the usage of this persuasive technology is on the rise, there is a scarcity of conceptual and practical models to serve as a guide when designing AR applications for UX. Most of the existing models focused only on the AR application development [25], [26], games development [27], [28], or AR for learning [29]. Although there exist models on AR UX, their emphasis has been on overall system development [30] and researching user acceptability on AR applications [31], rather than investigating the relationship between AR design components, emotions, and UX. Therefore, what are the significant components for designing an emotional UX for AR mobile application? This study aims to find out the answer to this question by obtaining and incorporating expert opinions. For that purpose, this study proposed a conceptual model for augmented reality mobile application design (ARMAD) through a combination of user interface (UI), interaction and content design components to better understand the influence of those components on the user's emotional experience. The main concern of the expert validation is to verify the following research questions (RQ):

RQ1) What are the significant components that are required in designing the AR mobile application?

RQ2) Does the design components able to elicit the user's emotion?

*Corresponding Author.

This study employed *Kansei* Engineering (KE) [32]; a widely used method for emotional design research [33]. KE suggested using specimens to identify the relationship between emotion and product design [34]. Therefore, in this study, the specimens were provided to the expert reviewers throughout the validation procedure so that they could experience the AR product samples and evaluate whether the specimens could elicit their emotions. This study is motivated by the advanced technological research and trends in UX and AR. Since the past literatures demonstrated that UX is a phenomenon that contributes to the success of technological products [35]–[37], therefore investigating the potential of emotional UX in the field of AR technology is warranted.

II. Related Works

A. Emotional user Experience Design

The landscape of UX demand has significantly changed as a result of rapid advancements in information technology. UX is a field in which emotions play a significant role [21], [38]. According to [39], UX design is concerned with the emotional state of the user during, before, and after using a particular technological product. This emotional experience influences the user's proclivity to remain involved with the product in the future. UX design is the practice of designing products with users in mind in order to provide meaningful, relevant, and engaging experiences to the intended users. UX is crucial in technological product design because it has the ability to enhance the user's satisfaction and loyalty [17], [19]. The most crucial factor in deciding how successful a product is how widely it is accepted and adopted by its users [40]. While the user acceptance is often influenced by their user experience, therefore a user's perception and emotions of a product also rely on the quality of their interaction with the product. Unfortunately, the human factor is often disregarded in most product development, as argued by [41], [42]. This is also supported by [43], who advocated for early user involvement in the product design phase. [44] argued that it is extremely important to comprehend how a user feels about the design's aesthetics and other visual elements. In line with this, [19] also argued that incorporating the user's emotions into the design leads in a more satisfying and engaging experience for the user. But how can the user's emotions be incorporated into the product's design? There is a popular method in emotional design research known as Kansei Engineering that may address human affect by translating their emotions into design components [34]. KE often entails evaluating product samples or specimens to identify how the design components influence the user's emotional experiences.

B. User Experience in the Augmented Reality Context

AR is a technology that substantially enhances the UX by superimposing audio or visual content [45]–[47]. In another word, AR enables mobile devices to create engaging user experiences by layering digital contents on physical environments [48], [49]. This way, AR application may captivate the user's attention through its immersive environment. It has been argued by [50] that not only it is able to improve the UX, but AR has also elevated the user interface (UI) to a new level. According to [50], AR is capable of facilitating emotionally engaging experiences. Nevertheless, [51] argued that without careful design, AR application might result in user dissatisfaction and confusion, besides being difficult to comprehend and adapt. As reported by [51], the AR UI that is supplemented with unnecessary information has confused the users and has caused them to have problems to understand the features. This is also supported by [52] who conducted a study on graphical user interface, which found that some of the users have reported funny or negative feelings when using the AR mobile applications, and the design may give users confusion with the unsuitable visual cues displayed on the mobile screen. The limited screen size of a mobile devices also plays a role in triggering user negative emotions, if the screen is cluttered or improperly designed [31], [47]. Hence, [51], [52] has suggested to use proper and only necessary visual design elements in AR design. Therefore, there is a need to explore the possible design components for the AR-based mobile application design that can foster positive emotions and user experience.

Although the literatures asserted that AR mobile applications are capable of delivering a new level of interaction via their virtual UI [47], [50], however there is a lack of models that emphasize on AR mobile application design for the UX. The summary of the existing AR models is presented in Table I.

As depicted in Table I, most of the existing models focused on the overall AR product development [25], [26], [53], [58], user engagement [28], AR learning [29], [55], [56], games development [27], [28], [57], and user acceptance or adoption of the MAR applications [31], [40]. However, none of these models put an emphasis on the AR design components that may elicit a positive emotional UX, thus need further research [59], [60]. Therefore, it is important to have a model that explores the user emotions and investigate how they are influenced by AR design elements in order to design a positive AR user experience.

C. The Importance of Expert Review in Model Development

An expert is someone who can provide a professional and useful opinion based on their knowledge, experience, and reputation in their field of expertise [61]. In research, field experts are the valuable source of information in providing empirical input and judgment in evaluation [62]. Expert opinion is valuable in reviewing a certain model and framework, or when verifying a phrase, method, or approach in research, because in order to acquire relevant and concrete results, a research needs to obtain necessary feedback from the expert knowledge [61]. According to the literature, model validation can be performed by reviewing and enlisting experts in evaluating the suitability and completeness of all variables or components involved, and should be pertinent to the research objective [63]. The procedure of expert review is conducted to ensure that the model is acceptable and that each of its component is pertinent to the research [64]. Therefore, in this study, experts play a significant role in reviewing and verifying the model's suitability for the research at hand.

TABLE I. EXISTING AUGMENTED REALITY APPLICATION MODELS

Source	Model Context	Aspects Discussed	Research Focus
[30]	Conceptual model for AR application design and development for user experience	Design and Implementation of User Experience Model for AR Systems	AR Application development
[26]	Conceptual model for M-learning application development	Enriching learning in architectural classroom with MAR	
[53]	Conceptual model for AR application development (hardware, software) with enjoyable aspect	MAR for cultural heritage towards enjoyable informal learning	
[54]	Conceptual model of MAR for hearing impaired museum visitors' engagement	Design and development of AR application that focus on museum visitor's engagement.	AR user engagement
[40]	Conceptual model for AR adoption	Factors Affecting AR adoption in retail industry	AR acceptance or adoption
[31]	Conceptual Framework for user acceptance	Encourage UX, satisfaction and willingness in E-commerce purchase	
[29]	Conceptual model for AR learning	AR technologies with adaptive learning systems	AR learning
[55]	Conceptual model for designing MAR application to learn basic numbers	AR application development for teaching and learning	
[56]	Conceptual design model for learning	MAR for Geography Fieldwork Learning	
[28]	Conceptual model for user engagement in MAR games	MAR games user engagement	AR Games development
[57]	Conceptual design model for audio-based interaction technique in MAR Games	MAR games	
[27]	Conceptual model for mobile games	MAR games	

III. METHODOLOGY

A. Description of the Proposed Model (ARMAD)

In this section, the proposed model is described in detail. The model is a conceptual design model for AR mobile application. A conceptual design model is a representation of a system that illustrates its components' interdependencies [65]. It serves as a base prior to the product design and requires understanding with design concepts in their entirety [66]. Examining the conceptual design model may provide insight into how well the variables are related in light of the research objective [65]. The purpose of this model is to identify the design components that are able to elicit the user's emotion. As a reflection of the two research questions stated in Section I, the formation of this conceptual design model attempts to achieve two research objectives; 1) To identify the significant components required in designing an AR mobile application, and 2) To determine whether the design components can evoke the emotions of the user. The expert review procedure was designed to ensure that the ARMAD model was constructed in accordance with the study's objectives. Therefore, the expert review process will focus on these two main concerns of the model.

Generally, the proposed conceptual design model for AR mobile application consists of five main components which are user interface design, interaction design, content design, context of the system, as well as emotion. The method used to construct the ARMAD model is based on [67]. The model is presented in Fig. 1 and each of the model's component is further elaborated below.

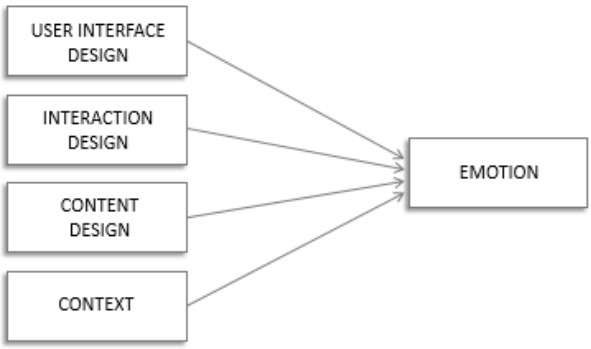


Fig. 1. The Initial Conceptual Model of Augmented Reality Mobile Application Design

The following Table II presents the components of the ARMAD model. Their descriptions are provided in order to explain why each of the components is relevant to this study.

TABLE II. THE MODEL COMPONENTS OF AUGMENTED REALITY MOBILE APPLICATION DESIGN

Components	Description of Significance	Source
User interface	An application's interface is the first station where the user will land on a system. The user interface (UI) will serve as the user's point of contact with the system, allowing them to view, access, or manipulate the information or visual elements on the screen.	[30], [48], [68], [69]
Interaction	To increase individual's involvement with the system so that person in the virtual world may engage naturally and feel in control. By providing users with timely feedback and the means to manipulate the visual elements, the system can provide a realistic simulation to the users.	[21], [30], [70]–[72]
Content	The virtual content is intended to aid users in adapting to their new surroundings and engaging with the system's activities in an immersive environment.	[73]–[76]
Context	The environment in which AR technology being designed will function or be incorporated.	[77]–[79]
Emotion	The perceptions and feelings that develop in the mind of a person as a result of that person's unique set of experiences.	[80]–[82]

B. Procedures for Expert Review

Evaluation strategies based on expert review have proven to be very effective [64]. Therefore, in this study, an expert review procedure was conducted in two main phases to validate the proposed model. As illustrated in Fig. 2, several steps were carried out in order to achieve the review objective; 1) to finalize the list of expert reviewers and 2) to acquire the experts' review findings.

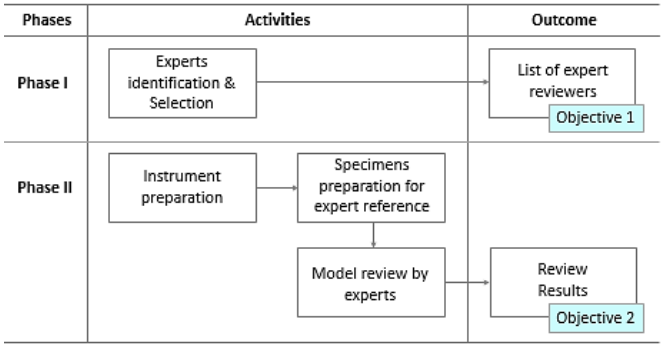


Fig. 2. Phases Involved in Expert Review Procedure

C. Phase I – Experts Identification and Selection

The objective of the first phase is to finalize the list of expert reviewers. According to [63], expert selection is very important in the validation process. This entailed identifying the requirements for expert reviewers, which were set in accordance with the following criteria:

1) Possess at least five years of work experience in the relevant fields of this study.

2) Have at least practical, teaching, or research experience pertaining to UX design, augmented reality, mobile application design, or Human Computer Interaction (HCI).

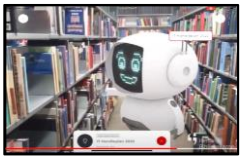
All of the selected experts have more than five years of experience in their respective disciplines and have expertise in the relevant domains of UI/UX design, mobile application design, AR, or HCI. According to [83], the ideal number of involvement should be three to five experts in the process of gathering knowledge or making recommendations. Therefore, five experts were chosen to participate in this study and the summary of expert demographics is displayed in Table IV.

D. Phase II – Instrument and Procedures

The second phase involved model validation by the experts. However, before the validation procedure begins, a set of questionnaire has been prepared as the review instrument. This study employed *Kansei* Engineering (KE) approach to guide the review process due to its applicability in emotional design research. KE procedures entail delivering product specimens for evaluation in order to elicit an emotional response [34]. The specimens are also used to identify whether a particular product design can evoke emotions when using the AR-based products. Therefore, the experts were supplied with six specimens, as depicted in Table III. All specimens are provided in video format with specific links to AR-based products to enhance expert understanding of the relationship between emotions and AR mobile application design. All experts are required to fill out the questionnaire when evaluating the model, and use the specimens as a reference. The choices of specimens were made based on the relevant market-available products, as suggested by [34]. Since the conceptual design model proposed in this study focused on designing AR mobile application, therefore, the samples of its type were provided as reference to the reviewers, as represented in Table III.

After all the instruments and materials were prepared, the experts were provided with the review form which comprised of five parts: 1) demographic information and research description, 2) consent form, 3) the proposed ARMAD model for their review, 4) list of specimens with working link, and 5) questionnaire. The questionnaire was designed in accordance with the research questions pertaining to why the model was constructed, as stated in Section 1. Since the main concern of the model development was to identify the relevant components for AR mobile application design and to assess if the design components presented in the model are appropriate for emotion elicitation, therefore the questionnaire has been tailored to address these questions. The questionnaire was divided into three sections, which are, 5A) the model's primary components, along with their descriptions, 5B) the relevance of each component to the augmented reality mobile application, 5C) expert's overall opinion which include the model's logical connections and flow, appropriateness of each component, the overall design readability, their agreement with the proposed model, and whether all of the components are suitable for eliciting users' emotions. In addition, they were encouraged to further comment in the provided sections, particularly for the overall opinion part. Since some of the experts are based on international company, therefore the review processes were conducted through email and some though physical meeting. Experts were given two weeks to review the model and complete the questionnaire. In the final step, the review forms were analyzed in order to determine the applicability of the model to be incorporated in the design of AR mobile application that enhances UX via emotions.

TABLE III. LIST OF PROVIDED SPECIMENS FOR EXPERT USE

Specimen UI	Specimen ID & Link	Specimen UI	Specimen ID & Link
	SR001 Specimen Link		SR004 Specimen Link
	SR002 Specimen Link		SR005 Specimen Link

	SR003 Specimen Link		SR006 Specimen Link

IV. Findings and Analysis

A. Expert Review Identification

As previously stated, the purpose of this study is to validate the proposed model through expert review. Following identification process, five experts were selected to participate in this study based on their expertise and specialized knowledge in the fields. This number is adequate according to [83], who suggested that the number of reviewers could range from three to five experts. Table IV displays the demographic information of the experts.

TABLE IV. The Expert Demographics

Expert	Gender	Field of Expertise	Experience
E1	Male	AR, UI/UX Design, Mobile App Design	9
E2	Male	UX Design	7
E3	Male	AR, UI/UX Design	8
E4	Female	UX Design, HCI	21
E5	Female	AR, HCI	17

B. Analysis of Expert Review

The review results are presented in Table V to Table VII, and in Fig. 3. For part 5A of the questionnaire, all of the experts agreed that the descriptions of the model's components as presented in Table II are correct and should be maintained. While in 5B, the relevance of each component to AR mobile application was rated by the experts, as shown in Table V.

The results of part 5B are depicted in Table V, which indicated that majority of experts are in agreement that the proposed conceptual design model is applicable to the research focus and has pertinent relationship among the components. However, there is an exception for the 'context' component, which according to one of the experts, although relevant to this study, context may not be grouped with other design components. According to the expert, the context however, remains significant in this research to ensure that all design components are designed within a particular system context.

Part 5C sought expert opinions on the model's readability, relationship, and appropriateness, and the findings are shown in Fig. 3. The findings showed that all of the experts agreed that the conceptual design model is readable and understandable, the relationship between each and every component is appropriate and sensible, and the proposed model is practical for the affective design of AR-based mobile applications.

TABLE V. Experts Feedback on the Relevance of Each Model Component

No.	Proposed Components	(No. of experts = 5)		
		Relevant	**Maybe Irrelevant**	**Not Relevant**
1	User Interface Design	5	0	0
2	Interaction Design	5	0	0
3	Content Design	5	0	0
4	Context	4	1	0
5	Emotion	5	0	0

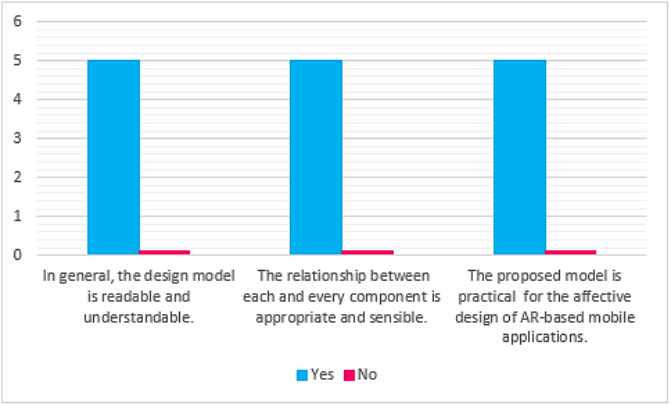


Fig. 3. Expert Opinion on the Model Readability, Relationship, and Appropriateness.

TABLE VI. Experts Response on Their Agreement with the Proposed Model

Expert	Summary of Response
E1	Yes, the model is applicable and relevant to various types of AR mobile applications. The model consists of all the important components for augmented reality and has covered the most influential AR parts such as user interface. The UI, as the user's first station, plays a very important role, to allow users interact through it, and to boost user's interest to explore further.
E2	The proposed model meets my agreement. The UX design needs to have sufficient, relevant contents that are customised to particular system context in order for interactions to take place. Since the goal is to enhance the user's experience, this approach is a good fit.
E3	Overall, the model looks good and workable as it emphasis on the UI/UX design. However, I would like to suggest that the context may not be grouped together with other design components, rather, it may stand by itself to support the entire system design in a particular system context.
E4	Yes. The model is well-defined, and its constituent parts are well-suited to the study of emotional design as intended by the researcher.
E5	Agree. Each of the proposed components is vital to the design of a system. The UI, is the core component in system design since it supports communication between user and the system. The interaction component is able to support various kinds of interaction in AR system context, it could be the way the touch the screen to manipulate the digital elements, etc. in addition, the AR system should be supplied with the right contents in order to get the system works. Well, all of the components presented in the model are the essence of a system design. However, since designers have to design AR systems according to a specific AR environment, it is good to consider the inclusion of context as well.

In addition, experts were also asked about the acceptability of the design model. Table VI presents the feedback and comments of experts in response to the question, "Overall, do you agree with the proposed model? Please state reasons for your response". As shown in the table, experts agreed with each component proposed to be associated with any mobile augmented reality application. According to their feedback, the UI, interaction, and content are the essence of AR application design, which should be built within a particular system context or environment, and the user's emotions will play a major role in shaping the user experience.

TABLE VII. EXPERTS FEEDBACK WHETHER THE PROPOSED MODEL COULD ELICIT EMOTION

Expert	Comments
E1	In my view, the user's degree of satisfaction with a product may be impacted by their emotions, at least in part. Designers may achieve user pleasure via thoughtful creation of the UI, interactions, and content. However, for anything to be helpful and satisfying to its intended audience, the design must be appropriate to its context of usage. As demonstrated in specimen 004, design aesthetics have the power to make us feel good.
E2	The UX design cares about the user experience, and it is influenced by the user's emotions. These components appear to meet the design requirements, and as UI/UX designers, we are always thinking about how to improve the user experience and for that reason, we carry out user research on a regular basis.
E3	I've accessed all the specimens supplied to get a feel for the product. Having handled a wide variety of specimens, I've had a wide range of experiences, each of which has influenced my feelings. Some specimens made me feel happy because I found them entertaining, while others made me feel confused.
E4	After reviewing all the specimens, SR006 caught my interest because of its well-designed interface and interactivity it provides. I am very certain that this specimen will be useful for augmented reality type of applications.
E5	The combination of these components is able to stir the user's emotions, and I have personally experienced this after evaluating all of the provided specimens. It is also important that the user interface give clear and concise instructions for user friendliness and understanding.

Table VII presents the experts' response to the question, "Are the components of this conceptual design model (user interface, interaction, content, and context) suitable for eliciting users' emotions?". For this question, experts are required to refer to the provided specimens. The experts found that the specimens have evoked a range of emotions from positive to negative, which led them to agree with the question.

Overall, the findings of the expert review indicated that most of the experts agreed with the proposed conceptual design model with minor modification required, and they considered that the combination of the model's components is capable of eliciting user emotions and is suitable to this research.

C. The Revised Conceptual Design Model

As can be seen in Table V to Table VII and Fig. 3, the majority of experts agreed that the proposed conceptual design model exhibits appropriate components and relationship for the study. However, the goal of this expert review was to obtain complete agreement from all experts in all sections; if at least one expert disagrees with or is unsure about a model or component, the model should be revised accordingly. Based on the recommendations of the experts, the initial version of the model was refined for better comprehension and to fit the context. The expert E3 has suggested that the 'context' component may not be appropriate to be grouped with other design components since it is not a design component but rather serves to support the design process on a particular system context. Therefore, the expert suggested to remain the context in the model but keeping it separate from other design components. The AR conceptual design model has been revised and redesigned based on the expert's feedback and recommendations. The revised ARMAD model is presented in Fig. 4.

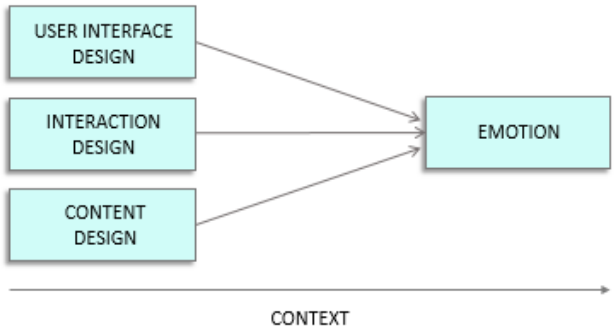


Fig. 4. Augmented Reality Mobile Application Design (ARMAD) Model.

ARMAD model suggested that all the design components; UI, interaction, as well as content should be designed within AR system context in order to make it purposeful. The UI design in this model suggested that the AR mobile application should be designed with interface-environment harmony using suitable visual cues in order to let the user feel presence in the virtual world. In order to enhance positive user experience, the interaction of AR application should be designed with lively interaction that able to provide instantaneous feedback while the users engage with the application. In addition, the design of AR applications needs to take into account the form of virtual content in order to provide insightful information and instructions to users in an immersive environment. The main idea of this model is to understand the influence of the user interface, interaction, as well as content design on the users' emotional experience with augmented reality mobile application.

V. CONCLUSION

Motivated by the advanced technology research and trends in UX and AR, as well as the absence of models in the research area, this study proposed a conceptual model for AR mobile application design (ARMAD) that caters to the users' emotional experiences. The proposed conceptual design model intends to fill the gap of previous AR models that did not address the user emotions in improving the UX. This study sought consultation from experts to validate the initial ARMAD model. In light of this, the expert review methods and procedures involved in this study are outlined in depth. Findings of the expert review are collected and presented in order to improve the ARMAD model. Overall, findings showed that the majority of experts agreed that the conceptual

design model proposed in this study is a useful guide and practical for use in designing the AR mobile application. All of the expert reviewers agreed that the proposed model is suitable for eliciting users' emotions and that the relationship between the model's components are comprehensible, sensible and practical to the research focus. The final step involved refining the model based on reviewers' recommendations. Objectively, this model contributes to defining design elements towards enhancing the emotional UX of AR mobile applications. Understanding user emotions is crucial because it influences the user satisfaction and most importantly, establishes a baseline for designing for a positive UX. This study concludes that the objective of validating the ARMAD model has been met.

The limitation of this research involved the difficulty in obtaining specimens for evaluation since the majority of accessible specimens are in video form. Therefore, only video samples were used as specimens for the reviewer.

Future work should entail creating an AR prototype that incorporates the design components and guidelines proposed in the ARMAD model. Kansei Engineering method may be employed to determine the influence of design elements on user emotions using a self-reporting quantitative approach. The outcomes of the research design may be used to verify the effectiveness of this model.

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