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# MAR UX Design Principles for Vocational Training

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**Abstract.** Current scientific research on MAR UX design does not address all facets of user experience in a holistic manner. It only covers usability, value, and desirability of the fundamental elements of UX. No known current published research considers the adoptability design principles of UX in MAR. To address this need, this Paper proposed UX design principles for MAR vocational training application and apply it to the design and development of AR4Juan. AR4Juan is an android based MAR vocational skills training application for Senior High School students specializing in Computer System Servicing National Competency (CSS NC) 2. CSS NC2 is under Technical Vocational Livelihood (TVL) track of the K12 education program in the Philippines. The researchers used MAR UX design principles research process to formulate the proposed UX Design principles. The study found out that other literature's design principles only focus on usefulness, usability, and desirability of UX elements and does not consider the adoptability element. Adoptability principles are essential in ensuring the application's natural users usage increase. Thus, drives business success. AR4Juan is still in its prototype stage and needs to be evaluated in every key UX element to determine the degree of its usefulness, ease of use, user enjoyment and engagement and ease of access. Other researchers could adopt the proposed UX designed principles and improve it iteratively after every evaluation of the MAR application.

## 1. Introduction

Mobile Augmented Reality (MAR) is an idea developed around the mid-1990s incorporating Augmented Reality (AR) in a portable mobile device such as smartphones. It merges different technology like camera, location-based computing services (LBS), wireless communication and AR to create an interactive environment that allows users to experience an enhanced interactive virtual and physical world [1][2]. When the user aims the camera to the object or a marker, the virtual information is directly superimposed and displayed on the user's screen, and the user can interact with the system through its user interface [3]. MAR is growing rapidly and becoming more mature due to the continued enhancement of the smartphone's embedded technology [4]. In the study, a systematic review of 10 years of AR usability studies 2005 – 2014, nine different AR application area are identified [5] namely collaboration, education, and training, entertainment, and gaming, industrial, interaction, medical, navigation and driving, perception and tourism and exploration.

Vocational Training provides job-specific technical training for work in the industry. This training provides students with hands-on instruction that can lead to certification or diploma. Research on AR in education and training has reported that one of the most important advantages of AR is the increase of



student motivation, achievement and improve the skill and efficiency in assembly and maintenance tasks [6][7].

MAR applications can create more realistic and innovative experiences. However, when mobile applications and AR technology are being used and developed extensively, the focus is often on technological development, and the UX is not considered [4]. Moreover, Current scientific research on MAR UX design does not address all facets of user experience in a holistic manner. It only covers usability, value, and desirability of the fundamental elements of UX. No known current published research considers the adoptability design principles of UX in MAR. According to Frank Gou [8], adoptability has often neglected aspect of UX strategy. If users do not install the application, all of the product's good features become irrelevant. The main objective of this study is to propose a holistic MAR UX design principles for vocational training application and create an application prototype that applies the proposed design principles.

## 2. Background of the study

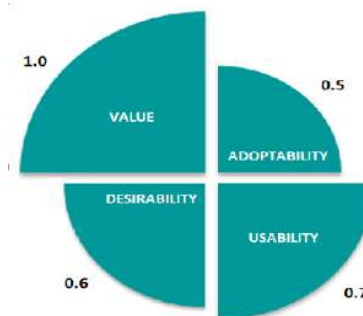
### 2.1. What is User Experience

UX professionals use the term user experience much more broadly that covers completely ranging from ease of use to user engagement to visual appeal, and it better captures all of the psychological and behavioral aspects of users' interactions with products [8].

### 2.2. Elements of User Experience



**Figure 1.** Frank Gou's four elements of UX



**Figure 2.** The relative importance of UX elements for MAR Vocational Training Application

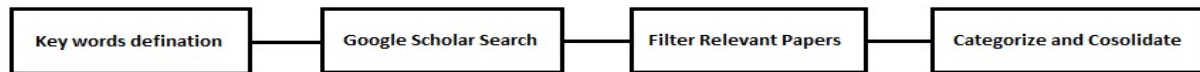
In attempting to achieve conceptual simplicity, Frank Gou reduced the many aspects of user experience to the four elements that are the most fundamental namely Value, Usability, Adoptability, and Desirability as shown in figure 1. Usability is about how easily users can complete their intended tasks using a product. Value refers to the usefulness of a product such as software application to the users. Adoptability relates to users' buying, downloading, installing and start to use a product. It should be considered as an integral component of an application design. Desirability relates to user's emotional appeal where the application allows the user to feel fun and encourage interactive engagement in using it [8].

### 2.3. UX Elements Relative Importance

The four elements of UX do not always have the same importance. Each element's relative importance is identified by the developers based on the type of application being developed and its target users. Understanding the relative importance is critical to correctly prioritizing product design and development efforts. Numeric weightings such .1 to 1.0 are assigned to a particular UX element wherein .1 is the lowest priority while 1.0 is the highest priority. These numeric weightings are used by the developers in assessing which UX element is more or less important in driving great user experience and prioritize the appropriate UX elements when allocating the resources that are available.

### 3. Research Process

As shown in figure 3, this paper presents the research process that is used in this study.



**Figure 3.** MAR UX Design principles research process

#### 3.1. Keywords definition

Before starting the search, the keywords are first defined, which are necessary for the research in online databases. The researcher used the keywords “*User Experience in Mobile Augmented Reality*”, “*Mobile Augmented Reality in vocational training*” and “*Augmented Reality Design Principles*” for the research.

#### 3.2. Google Scholar Search

Google scholar is the online databased used to search the defined keywords. We used the defined keywords in Google Scholar Search Engine and produced a combined 45 papers.

#### 3.3. Filter Relevant Papers

In the next step, the researchers read all the documents and decided if the paper is relevant to the present study. The paper interest is to discover the holistic MAR UX design guidelines that could be used for vocational training because this is still an unexplored area. Scientific research under medicine, tourism and gaming domain is excluded because this is beyond the scope of this study. The researchers identified six relevant papers, as shown in Table1, focusing on UX in MAR, MAR in Vocational Training and MAR dynamic interactions.

#### 3.4. Categorize and Consolidate

After identifying the relevant papers, the researchers categorize the current work according to holistic UX design elements and consolidate similar principles in the same category into a set of MAR UX design principles for vocational training as shown in Table 2. Design principles whose category belongs to two UX elements are recategorized based on UX elements weights. The final category of the design principle will be in the UX element having the higher weights. For example, the design principle “virtual objects should be aligned appropriately with physical objects and should display continuously over time” is categorized under Value and Desirability elements. In this study, Value elements weight is 1.0 and Desirability only weight 0.6, since Value element has a higher weight than Desirability element, the design principle is finally categorized under Value element.

Since this study is related to produce MAR Vocational Training application prototype, Value element weighs the highest, followed by Usability, then Desirability and lastly Adoptability. Figure 2 shows the researchers assigned weight for every UX element used in the study. Value element weighs the highest because, in the study, MAR vocational training application’s usefulness to its intended users is given top priority. Therefore, design principles under this element are prioritized to be applied first and allotted more resources such as time and budget in the design and development of MAR application. Usability element weighs second to the highest because MAR application must be user-friendly in the sense that users need to be able to complete their tasks with efficiency and accuracy. Otherwise, MAR application simply fails to deliver its value. Desirability element weighs third to the highest because the researchers want to ensure that MAR vocational training application must be useful and user-friendly first before making the application fun and encourage interactive user engagement. Finally, Adoptability weighs last because this element provides less effect in delivering effective vocational training but essential in driving MAR application and business success. The researchers of this study make the call in identifying the weigh of each UX elements. The weigh is intended to identify the UX element that will be given

higher priority in the design and development and resource allocation of MAR Vocational training application.

Recent research work does not consider adoptability design approach in MAR application design, the researchers looked into the practice of mobile applications in the industry, acquire the adoptability component of it and consolidate it in the proposed MAR UX design principles in this study. These proposed principles could be applied during the development process of MAR application for Vocational Training. This paper aims to propose a holistic UX design principles in designing MAR application for Vocational Training.

#### 4. Recent UX, MAR and AR design principles

**Table 1.** Recent study on MAR application design principle

Source	Investigation Approach	Key Design Findings
[1]	Literature review on the interaction design of MAR	1) Use the context for providing content, 2) Deliver relevant-to-the-task content, 3) Inform about content privacy, 4) Provide feedback about the infrastructure's behavior and 5) Support procedural and semantic memory
[9]	Interaction Design Evaluation using AR for Assembly and Training Task	1) Simple Design, 2) Feedback, 3) Pre-knowledge, 4) Consistency, 5) User Mode, 6) User Control, 7) Help, Error prevention, Individualization and 8) Help & Documentation:
[7]	Study on Design and Development of MAR in Vocational Education and Training based on Co-creation process and UDL	1) Provide multiple means of presentation, 2) Provide multiple means of expression and 3) Provide multiple means of engagement
[10]	Heuristic evaluation of usability principles on dynamic interaction in MAR	1) Fit with user environment and task, 2) Form communicates function, 3) Minimize distraction and overload, 4) Adaptation to user position and motion, 5) Alignment of physical and virtual worlds, 6) Fit with user's physical abilities, 7) Fit with user's perceptual abilities, 8) Accessibility of off-screen objects and 9) Accounting for hardware capabilities
[4]	Study on demonstrated usability for MAR application	1) User-information, 2) User-cognition, 3) User-support, 4) User-interaction and 5) User-usage
[11]	Study on UX in MAR focusing on Emotions, Challenges, opportunities and proposed best practice	1) Spatial correspondence, 2) Tolerance to movement, 3) Object detail, 4) Object Correspondence, 5) Natural Interaction, 6) Personalized Experience and 7) Emotion-evoking avatar

As shown in Table 1, recent research work on MAR is focused on addressing usability, value and desirability issue of MAR UX design. Thorough evaluation of different area of MAR application and interaction design studies produced generic MAR design approach [1]; MAR application in industry skills training provides design recommendations to strengthen the trainee's procedural skill that is essential for assembly and maintenance task [9]; education and vocational setting designed and developed a MAR application for skills training utilizing co-creation and UDL design approach [7]; Heuristic evaluation of usability principles on dynamic interaction in MAR are performed [10]; usability for MAR application is demonstrated [4]; and in addition best practice in UX MAR design approach is proposed [11]. The recent study does not apply the holistic MAR UX application design approach which constitutes an opportunity for the researcher to discover its deficiency.

#### 5. Proposed MAR UX design principles for vocational training application

The proposed MAR UX design principles for vocational training application are categorized based on four fundamental UX elements namely Value, Adoptability, Desirability, and Usability. Each element has a set of proposed design principles, description and indicative design practice that are consolidated

from previous MAR/AR, UX, MAR vocational training related studies and the common practice of mobile applications in the industry.

### 5.1. Value

Value UX element is given the highest relative importance in driving UX success for this study. The reason is that in Vocational Training, the usefulness of MAR application in complementing the delivery of skills development is given top priority. To help MAR application developer come-up with a useful MAR application training tools, the following seven design principles are proposed: 1) *Collaborative creation process*, MAR developer should apply collaborative creation process (Co-Creation) and Universal Design for Learning (UDL) to identify the requirements needed in producing effective training MAR application. Its indicative practice is to design the MAR Vocational training application with experts in the Vocational Education and Training domain (teachers), software developers, graphic designers, and educational technology experts with an extensive background in UDL; 2) *Mental Model Building*, MAR training application should provide a mental model of an assembly task that describes the internal representation of an entire task. Its indicative design practice is a training task progress bar; 3) *Visual Aids*, MAR training application should present items of illustrative matter, such as a 2d/3d models, videos, images, and text, designed to supplement training written information so that it can be understood more easily. Its indicative design practice is display images and other multimedia objects related to training activity; 4) *Passive Learning*, MAR training application should have an option in the training that trainee is not active and only receives information about the task. Its indicative design practice is video demonstration in assembly training task; 5) *Haptic hints*, MAR training application should trigger the vibratory component of the smartphone or a vibrotactile bracelet that allows giving feedback about current actions and can help to prevent errors. Its indicative design practice is during training MAR application trigger the vibrator in the smartphone when the user commits a mistake; 6) *Fit with user's perceptual abilities*, MAR experience should be within the user's capacity to understand and handle training task. Its indicative design practice is during training; task procedures are displayed one at a time; and 7) *Alignment of physical and virtual objects*, MAR training application's virtual objects should be aligned appropriately with physical objects and should display continuously over time. Its indicative design practice is when the camera is pointed to the target physical object its corresponding virtual object should display next to it accordingly and continuous over time.

### 5.2. Usability

Value design principles could make Vocational training application useful. To deliver its usefulness, users need to be able to complete their task with ease of use, efficiency, and accuracy. MAR application developer could accomplish the delivery of application's ease of use using the following six proposed Usability design principles: 1) *Match between MAR System and the real world*, MAR application should speak the users' language, with words, phrases, symbols and concepts familiar to the user. One of its indicative design practice is during practical skills training, MAR application training control button resembles the images or icons of a multimedia player such as forward, back, play and pause icon; 2) *Simple Design*, MAR application should have all the required functionalities, not more and not less. Its indicative design practice is MAR system Menu should only contain needed options design to its intended purpose; 3) *Fit with user's physical abilities*, MAR application should allow the user to perform any action easy to perform. Its indicative design practice is when the user's simple hand gesture or voice command, MAR application seamlessly hide or display MAR objects; 4) *Accessibility of off-screen objects*, MAR application's UI control should allow users to easily recall those objects when outside of the field of view. The indicative design practice is a visual hint in MAR application such as an icon showing hidden active training activity objects; 5) *Consistency*, MAR application should use standards and be consistent in its user interaction while in operation. Its indicative design practice is MAR application produce consistent short tick sound every time the user selects any system controls; and 6) *User Control*, MAR application should allow the user to go back, forward and to the starting point at

any time in performing training task. Its indicative design practice is MAR application shows visible back, forward, go to begin and go to end button during the training mode.

### 5.3. *Desirability*

In general, MAR application is designed to be desirable and engaging. It allows the user to experience fun and encourage interactive engagement in using it. To realize this positivity, eight Desirability principles are proposed for this study. These principles are 1) Accounting for hardware capabilities, MAR experiences should be designed to accommodate for the capabilities & limitations of the hardware platform. Its indicative design practice is MAR Application contains a mechanism to identify smartphones hardware capability and load its settings ideal to the optimal systems operation on application's start-up; 2) System Feedback, MAR application should inform the user about the current user's action status. Its indicative design practice is MAR application provides visual emphasis such as control buttons glows every time user is using it; 3) User Mode, MAR application should have different modes (beginner, intermediate, advanced) to allow advanced users to work faster. Its indicative practice is MAR application provides a different user mode; 4) Error prevention, MAR application should prevent errors. Its indicative design practice is when user attempt or accidental initiate close MAR application, the system display notice that there is unfinished work and ask confirmation to save and exit the current work; 5) System user support, MAR application should give easily understandable help at the right time. Its indicative design practice is straightforward application Help and Documentation option; 6) Good object details, details of MAR objects should be sufficiently high (within the limits of the target hardware) to make them recognizable and appealing. Its indicative design practice is good quality icons, images, animations, and video presentation; 7) Inform about content privacy, MAR application system users information should not go out in the public media without consent. Its indicative design practice is to inform and seek user consent when publishing their skills progress or accomplishment in social media; and 8) Personalize Experience, Making MAR experience personal to each user increases the likelihood for emotional engagement. Its indicative design practice is user has an option to choose and personalized Avatar to assist in training.

### 5.4. *Adoptability*

Providing easy access to a product is a design consideration that every MAR application developer should consider. It allows the application to potentially increase the number of its users that could benefit from its features and create good business value. To improve MAR applications adoptability, two Adoptability design principles are proposed: 1) Sharing of MAR training task and accomplishments, MAR applications should allow the user to share task and accomplishments experience to friend's social media, email, IM, and SMS. Its indicative design practice is in every successful training task, the user is asked to share their accomplishments in their Facebook post. Included in the post is the recommendation to download and use the MAR Vocational Training Application; and 2) Share MAR training application, MAR application before closing should provide the user an option to share the application to social media friends. Its indicative design practice is when the user initiates the application's closing; the application encourages the user to share the MAR Vocational Training Application to social media friends.

## 6. **Application of Proposed MAR UX Design principle for AR4Juan application**

AR4Juan as shown in Figure 4, is an android based MAR vocational skill training application for Senior High School students specializing in Computer System Servicing National Competency (CSS NC) 2. CSS NC2 is under Technical Vocational Livelihood (TVL) track of the K12 education program in the Philippines. This paper is intended to apply the proposed UX principles in practice and later identify the degree of its usefulness, ease of use, user enjoyment and engagement and ease of access. The application is focused on providing training delivery on Set-up Computer Networks competency particularly in installing network cable of CSS NC2 specialization. The researchers apply the proposed design principles that are group into 4 UX key elements namely Value, makes the system use-full by ensuring



that all requirement needed in training are meet through Co-creation process; Usability, make the system user friendly through easy to recall and use system training controls; Desirability, makes the system fun and engaging through personalized avatar and good system to user interaction; and Adoptability, makes the application reach more its potential system user through social media. The following table summarizes the proposed UX design principles practice used in AR4Juan.

**Table 2.** Proposed UX design principles practice for AR4Juan.

UX Elements	Design Practice
Value	Co-Creation and UDL (perform during MAR Application Pre-Development) 1) Progress Bar 2) images and other multimedia objects related to training activity 3) Only display instructions one at time 4) Physical object's corresponding virtual object should display next to it accordingly and continuous over time
Usability	MAR object could be hidden and reveal easily thru gesture and voice control (incorporated in MAR application), Produce consistent short tick sound every time the user selects any system controls (incorporated in the application) 5) Activity Control Buttons resembles real-world multimedia symbols 6) Display only needed option control and information. 7) Shows visible back, forward, go to begin and go to end button during the training mode
Desirability	Ask the user to confirm current action while ending the training or application (incorporated in the application) 8) good quality icons, images, animations, and video presentation 9) personalized trainer Avatar
Adoptability	MAR user training activity, performance, experience, and application information could be shared using user's social media accounts (incorporated in the application, shows at the end of every training activity)



**Legend:**

- 1) Progress Bar
- 2) Images and other multimedia objects related to training activity
- 3) Only display instructions one at time
- 4) Physical object's corresponding virtual object should display next to it accordingly and continuous over time
- 5) Activity Control Buttons resembles real-world multimedia symbols
- 6) Display only needed option control and information
- 7) Shows visible back, forward, go to begin and go to end button during the training mode
- 8) Good quality icons, images, animations, and video presentation
- 9) Personalized trainer Avatar

**Figure 4.** AR4Juan Application Prototype

## 7. Conclusion & future works

The main contributions of this paper are as follows: 1) We proposed wholistic UX design principles for MAR application in vocational training, and 2) Design and Develop AR4Juan MAR application prototype applying the proposed UX design principles. This study is different from other studies reported in the literature regarding the design principle presentation. We classify the proposed design principles based on its corresponding UX key elements. This classification is done to determine the design principles that will confirm each UX element. We also found out that other literature's design principles only focus on usefulness, usability, and desirability of UX elements and does not consider the adoptability element. Adoptability principles are essential in ensuring the application's natural users usage increase. Thus, drives business success. AR4Juan is still in its prototype stage and needs to be evaluated in every key UX element to determine the degree of its usefulness, ease of use, user enjoyment



and engagement and ease of access. Other researchers could adopt the proposed UX designed principles and improve it iteratively after every evaluation of MAR application.

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