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Design And Development Of An Augmented Reality Application To Learn Mandarin

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Abstract: This paper presents the design and development of an augmented reality (AR) app to enhance learning Mandarin among university students using a user-centered design life cycle (UCDL). A survey was conducted to investigate the difficulty of learning Mandarin and the thoughts of using technology to assist the students in learning the language. Forty-five students participated in the survey. The results show that participants have difficulty learning to speak, write, read, or listen in Mandarin, with writing was found to be the most difficult (M = 3.49, SD = .94). The majority of the participants (n = 39, 87%) reported having never seen or used an AR education app. However, most (n = 36, 80%) also said that they are interested in using an AR app to learn Mandarin. A low-fidelity prototype of an AR app to assist students in learning Mandarin was designed. An expert usability evaluation was conducted with three experts. Thirty-three usability problems were found, and further changes to the low-fi were designed. A usability evaluation of the low-fi with a group of students will be conducted followed by the app's development. A final round of usability testing of the final app will also be conducted.

Keywords: Internet of Thing (IoT), decision tree, minimax, room occupancy detection, subspace learning, SVD, SVM.

1. INTRODUCTION

Augmented Reality (AR) is a technology that creates a reality-based interface and travels from laboratories across the world to different industries and markets for customers. With virtual (computer-generated) objects that seem to coexist in the same space as the real world, AR supplements the real world. AR has been widely used in supporting navigations, tourism, and medicine. Furthermore, AR supports learning across multiple platforms through sound, image, writing, video and animation. These facilitative tools reduce the problems arising from individual differences and help build an effective learning environment by providing a richer context, particularly for interaction-based oral courses.

This paper is interested in reviewing the literature in regard to AR in education. The next section will describe this matter.

Augmented Reality (AR) In Education

Education is the process of receiving and gaining knowledge. Traditionally, education is

conducted face-to-face among the educator and students. From an educational perspective, augmented reality (AR) has a high potential and broad applicability in the future. It is user friendly and let interactions between people and digital device. AR bring people into the new era, which can learn anytime and everywhere, using a wide range and appropriate material. Currently, AR has been widely used in education.

Nechypurenko et al. [1] conducted a study to introduce AR in learning chemistry. They created an AR app with 3D visualization of the structure of atoms, molecules, and crystalline lattices. No evaluation has been made of the final version of the app. However, their preliminary results show significant demand for using the AR app in classes.

Mohd Azhar et. al [2] introduces AR in learning history. This study aim to investigate the effect of combining the AR with the traditional information about historical places to create excitement in learning history. Through the mobile application camera that points to the marker or picture target, users can view the 3D models in the real world. Additionally, by answering the quiz questions, users can also assess their knowledge based on what they have read in the book. For testing purposes, twenty users used the app. The findings indicate that users strongly believe that AR's presence leads to greater user satisfaction in learning history.

A study by Tanalol et. al [3] aimed to introduce Jawi letters and words to kindergarten children. An AR app that includes gamification features such as rewards and multiple levels of exercise, was developed. The authors conducted a testing evaluation of the app with 12 children. They investigated the learning interest of the children after introducing the app for 5 minutes. The result shows that the app's use was found to increase the children's interest in learning Jawi.

A study by Amirnuddin and Turner [4] has been using AR in teaching law to first-year students. For tutorials, a game-based AR environment was conducted. Posters with QR codes were posted in various locations in the campus. Students need to search for the posters and scan the QR code. A two-dimensional video relevant to the module will appear. Students will then need to search for the next QR code to complete the module. The result shows that incorporating AR in learning law enhances the learning experience compared to the traditional teaching method in the class.

AR app is accessible in two types, either marker-based or marker-less AR app. The next sub-section will briefly discuss the difference between these two types.

A. Marker-based AR Apps

Marker-based AR requests for a fixed picture also related to as a trigger photo that a person can scan using their mobile devices through an AR app. The mobile scan will trigger the extra content (video, animation, 3-D or other) set up in advance to show on top of the marker.

In a study by Gherghina et al. [5], mentioned that the marker for an AR app has to be extraordinary and avoid applying stock photos by all means as other apps may already use these. If the marker image is developed correctly, marker-based AR content gives quality experiences. The tracking is also very strong and fast, which makes the AR content does not shake. Katiyar et al. [6] stated that the marker recognition could be either local or cloud-based. This means that the marker databases can be saved on the device, and recognition also occurs on the device. The databases can also be saved on a cloud, and recognition occurs on a server. That said, phones are only sending point clouds to the server. Device-based recognition can occur straight away, but if cloud recognition is applied, it will require a longer time for the content to be downloaded from the server. Generally, it requires a couple of seconds before the user can view any AR experience.

B. Marker-less AR Apps

Marker-less AR refers to a software application that does not require prior knowledge of a user's world to superpose virtual 3D material onto a scene and keep it in space at a fixed point. [7]. Marker-less AR places virtual 3D objects in the physical environment depending on the environment's real features rather than identifying markers. In the field of augmented reality, the marker-less AR technique has been described as the most difficult and important technique, as it identifies and recognizes illumination, halfway overlapping, and directions based on the characteristics of an object and shows excellent performance [8].

Marker-less AR has been shown for camera pose estimation using natural features such as planes, corners, or corner points [9]. Computing a homography between frames provides an important tracking mechanism for registering augmentations with a scene with a planar scene [10]. Klein and Murray [11] demonstrated a more stable marker-less AR scheme by separating monitoring and map building activities instead of simultaneous localization and mapping. To provide initial metric scale information, these methods require manual calibration or a known-size item. To recover from cumulative errors or complete tracking failures to reach reliable tracking, landmark features are also used. The outcome showed that using a large number of multiple-scale image patches is useful in a small AR environment for robust camera tracking. Although it is possible to robustly detect more distinctive image features invariant to scale and orientation [12] for tracking over several frames, their complex computation makes the method inappropriate for real-time applications requiring around 30 frames per second [13].

Gamification

In early 2000, games were gradually implemented in many sectors for training, education, and persuasion purposes. The field of human-computer interaction started investigating the different aspects of user experience, and research topics became the design for pleasure, fun, and motivation. Games fascinate many individuals worldwide to spend countless hours and cash to unlock levels and duties [14].

Nowadays, the web industry has come out with a new term, which is gamification [15]. Gamification has been described as a process of improving motivational and affordable resources to evoke game interactions and more behavioral results [16]. Instead of making complete games, the gamification's driving principle is to use game design elements in non-game environments, items, and facilities to motivate desired behaviors. Gamification can enhance user experience and user interaction in non-game applications and services [17]. Based on the study carried out by Hamari et al. [16], gamification produces positive effects and benefits. The gamification effect may be triggered by a novelty effect instead of a long-term effect [18].

However, it also seems that the gamification removal could have adverse effects [19] on those users who are still engaged in gamification, probably due to lack of resistance to losing their badges and points [20]. If incentives are used to facilitate behavior that someone already has some intrinsic incentive to participate with and those rewards are withdrawn, compared to previously, the subject will be less likely to engage in the behavior [21]. Video games and game elements have also been studied to influence user behavior in the direction intended by the interface designer [21] or of integrating embedded values [22] into persuasive technology.

Vendors and consultants have tended to practically define the term gamification in terms of consumer benefits, such as the introduction of game technology and game design strategies outside the gaming industry, the approach of using game thinking and game mechanics to solve problems and attract users, and the incorporation of game dynamics into a website, service, group, content or campaign [17]. This shows that gamification is an important element in the

non-game industry to improve user experience.

The learning outcomes of gamification were mainly considered positive by all research in educational or learning contexts, such as improved motivation and participation in and enjoyment of learning activities. However, at the same time, the studies [e.g. 23] pointed to negative findings that need to be paid attention to, such as difficulties in task assessment and design features.

A. Rewards

Rewards for a target that has been accomplished are understood to be a form of gratification. These incentives include tangible rewards, such as a gold star, a pass that allows the user to move on to a successful grade or the next step of the curriculum. The Hallford & Hallford [24] design guide for computer role-playing games lists four types of rewards. There are rewards of glory (does not affect the game but brings enjoyment and pleasure to the player), sustenance (allows inventory accumulation, such as magic swords), access (rights of access to new parts of the game), and facilities (new abilities).

A study by Abdullah Sani and Petrie [25] created an app to assist older adults self-monitor their eating and drinking intake. The authors included some rewards elements into the app such as congratulatory messages and a trophy icon if the users have reached certain milestones in eating or drinking. They found that these rewards were positively encouraging the users to keep drinking and eating to reach their daily goals.

B. Levels

To increase the users' engagement in a certain application, levels with different difficulties should be implemented as many people are motivated by competition. For instance, levels can be distinguished from a basic, medium, difficult, and serious. Zagal et al. [26] define scores, levels, and leaderboards as target indicators, as all three are used to keep track of player success in games and provide feedback on them.

Farzan et al. [27] studied the impact of user engagement on a social networking website. The website is designed with a point and leveling system. The study aimed to investigate whether the point and leveling systems inspire employees to contribute more to the website. Results show that most users were motivated to move their point status up to the next status level on the site. Level-focused users will contribute more in order to gain more points and jump to a higher level.

Implementing levels can support the processes of learning. Gamification breaks down duties into separate subtasks and milestones. By trial and error, users can solve these subtasks and repeat them until the issue has been solved, and a certain ability level has been achieved [28]. Cognitive mechanisms for the internalization of learning material may also be systematically generated by creating increasingly challenging tasks [29].

In a study by Mekler et al. [30], the authors found that levels inspired participants to create substantially more tags in less time compared to points and leaderboards. In contrast with the points and leaderboards, introducing the leveling method motivated participants to improve their success for longer. Levels can be an easy, feasible, and productive way of driving user behaviour in the short term.

C. Showing Progress

Progress estimators are associated with specific goals and, when active, provide a metric of improvement relative to those goals. Progress estimators do not provide a complete oracle but only partial, goal-specific advice. In a learning environment, they are using targets from marking to ensure focused improvement. The benefits of showing progress are students know

their levels and know how to move their learning on.

It helps players know how far they have advanced in the game and how well they are doing by providing progression units such as levels, environments, quests, and achievement markers. Progress units may also function as reinforcements (e.g., to adjust the speed of an operation using time pressure). Progress markers such as high scores often make reputation scores, promoting competition, and increasing replay value in a social context.

D. Motivation

Another element of games is motivation. Our confidence in how successful users will be and our interest in the target and its meaning is influenced by our confidence. When users feel a personal attachment to the goal [32], users are more inspired. Some educational games are based on external encouragement, where students collect unique incentives to entice them to continue learning by playing the game. In the healthcare industry and with short-term content memorization, these types of games have had some success [33]. However, they appear to improve low-level content repetition memory instead of deep comprehension. However, students appear to be more intrinsically motivated if the game's goal and the learning outcomes are closely related, and the rewards are in overcoming the challenges of the game and learning.

This current study is interested in building a marker-based AR app and includes gamification features for learning purposes. The paper is organized as such: Section IV introduces the language of choice for the development of the AR app, Section V presents the methodology of the study, Section VI presents the results of the study and the low-fi prototype of the AR app, and Section VII concludes this paper.

Universiti Malaysia Sabah Bachelor's Degree Programs

Universiti Malaysia Sabah (UMS) bachelor's degree programs require its students to enroll in foreign language courses to graduate. A foreign language is any language that is not the first language of that student. For example, a Malay student can enroll in Mandarin Language courses, or an International student can enroll in Malay Language courses. The total credit hours needed to complete prior to graduating depends on which program the students are attached to. For Computer Science, students must complete eight credit hours (approximately four courses) to graduate from the university. A student is free to enroll in any foreign language as they like, and on which semester they plan to enroll in the subjects.

A. Motivation of current study

The first, fourth, and fifth authors are lecturers, researchers and, mentors in Faculty of Computing and Informatics, Universiti Malaysia Sabah (UMS). The authors encounter comments from the students that learning foreign languages is difficult. A successful work by previous researchers found that Augmented Reality (AR) brings positive outputs in education, such as in history [2], law [4] and jawi [3] classes. Reviewing the literature found that little work has been done in introducing a language that does not use the common Latin alphabet using AR.

The Mandarin Language is one of the most preferred foreign language courses to be enroll by the local students in UMS. A short interview study conducted by the first author was done with ten students to investigate this pattern. The result shows that most participants reported they mostly enrolled Mandaring Language as it is one of the most spoken language in Malaysia apart from Malay and English. The participants reported that they prefer to enroll in a course that can widely be beneficial for them to work in the future.

2. METHODOLOGY

A. Study Design

This study followed the user design lifecycle (UCDL) [34]. UCDL is an iterative process of product development that involves the users in each phase of the lifecycle. The user involvement includes by giving design ideas, suggestions, and concerns, and evaluating the end-product using various research and design techniques. Previous research has proofed that using UCDL, a highly acceptable and accessible end product, is usually developed [25, 35].

This current study involves three parts of investigations: 1) Initial Study, 2) Design and Formative Evaluation, and 3) Implementation and Summative Evaluation.

In Initial Study, a survey was conducted to investigate the current problem in learning Mandarin among university students. In Design and Formative Evaluation, a low-fi prototype of an augmented reality app to teach Mandarin hereafter "myHanyuApp" was designed. A formative usability evaluation was conducted of the low-fidelity prototype with a group of experts. Lastly, In Implementation and Summative Evaluation, an augmented reality (AR) app was developed, and a summative usability evaluation with a group of students will be conducted. The overall study design can be viewed in Figure 1, below.

This paper is interested in presenting the results of 1) Part 1: Initial Study and 2) Part 2: Design and Formative Evaluation. The detail output of these parts is described in Section VI, below.

B. Materials

A questionnaire was created using Google Form. The questionnaire was distributed by the first author and made available for ten days. The questionnaire included questions about demographics, the thoughts on the difficulty of learning Mandarin, and the thoughts on using technology in learning Mandarin.

Regarding the thoughts on the difficulty of learning Mandarin, a Likert scale (with 1 – very easy, 5 – very difficult) was used. The questions included the difficulty to speak, write, listen, and read in Mandarin.

C. Participants

The questionnaire was distributed to bachelor's degree students in Universiti Malaysia Sabah (UMS). The participation was voluntary. Forty-five students participated in the survey. Of these, 22 respondents were male, and 23 were female. 17 respondents reported having learned Mandarin in a year, 15 reported having learned Mandarin in 2 to 3 years, and 13 reported to have learned Mandarin for more than 3 years. Overall, 20 respondents reported using books or dictionary to learn Mandarin, 27 via online such as YouTube, nine via group discussions, 37 via attending lectures, and 26 via self-learn. Table 1 summarizes the participants' demographics.

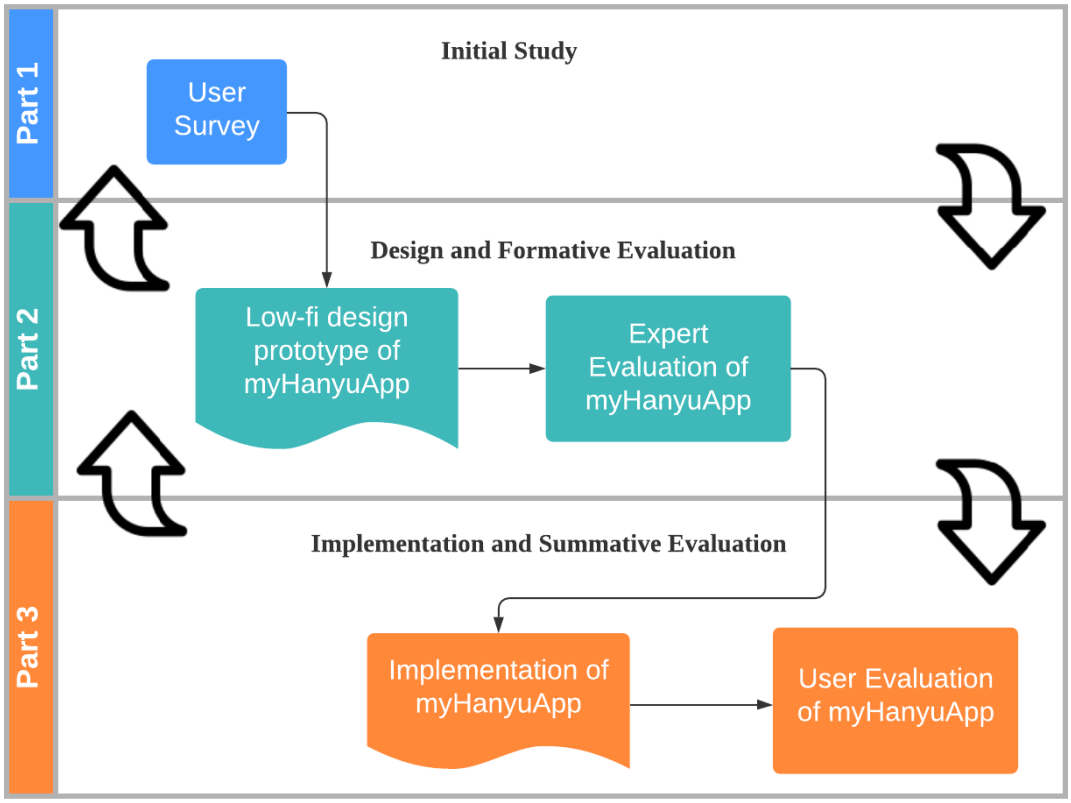

Figure 1: The study design using user development lifecycle

Table 1: Distribution of participant's gender and current method to learn Mandarin							
Learning Duration	Gender		Method to learn Mandarin				
	Male	Female	Book / Dictionary	Online	Group discussion	Lectures	Self-learn
1 year (n = 17)	7	10	7	12	4	10	9
2 – 3 years (n = 15)	7	8	11	11	5	15	11
> 3 years (n = 13)	8	5	2	4	0	12	6
Total	22	23	20	27	9	37	26

3. RESULTS AND DISCUSSIONS

A. Preliminary Results

A chi-square test of independent was performed to investigate the relation between the duration the participants have learned Mandarin and the thought learning Mandarin difficult. The result shows that the relation between these variables was significant, x2(2, N = 45) = 8.68, p = .01. Table 2 shows that most students in the first three years of learning Mandarin agree that the learning process is difficult. However, participants that have learned Mandarin for more than three years agree that learning Mandarin is not difficult. Overall, slightly more than half of the participants (n = 25 (55%)) agree that learning Mandarin is difficult.

Table 2: Distribution of participant's thought that if learning Mandarin is difficult

Learning Duration	Yes	No
1 year (n = 17)	13	4
2 – 3 years (n = 15)	9	6
> 3 years (n = 13)	3	10
Total	25	20

Table 3 shows the mean ratings for the difficulty level of speaking, writing, reading, and listening Mandarin across the three groups of participants. For learning to speak, participants who are new to learn to speak (M = 3.35, SD = 1.11) in Mandarin found it more difficult than the other two groups. For learning to write, the longer the duration the participants have learned to write in Mandarin, the less difficult they found the learning process. The participants who have learned to write for more than 3 years rated just slightly over the average of 3, (M = 3.08, SD = .86) compared to those who have just started to learn to write (M = 3.76, SD = 1.03). For learning to read, there is a small difference in the mean ratings among the participants who have just learn (M = 3.59, SD = .94) to read in Mandarin and the ones who have learn for more than 3 years (M = 3.54, SD = .97). For learning to listen, there is a huge difference between the participants who have just learned to listen (M = 3.47, SD = .94) in Mandarin compared to those who have learned to listen for more than three years (M = 3.08, SD = .76). In overall, writing (M = 3.49, SD = .94) was found most difficult across all groups, followed by reading (M = 3.4, SD = 1.04), listening (M = 3.1, SD = .91) and lastly speaking (M = 3.04, SD = 1.14). Table 3 shows the distribution of the means of difficulty in learning Mandarin across all three groups of the participants.

Table 3: Mean ratings of the difficulty to speak, write, read and listen in Mandarin across the group of participants

Learning Duration	Speaking	Writing	Reading	Listening
1 year (n = 17)	M = 3.35 SD = 1.11	M = 3.76 SD = 1.03	M = 3.59 SD = .94	M = 3.47 SD = .94
2 – 3 years (n = 15)	M = 2.80 SD = 1.15	M = 3.53 SD = .83	M = 3.07 SD = 1.22	M = 2.73 SD = .88
> 3 years (n = 13)	M = 2.92 SD = 1.19	M = 3.08 SD = .86	M = 3.54 SD = .97	M = 3.08 SD = .76
Overall	M = 3.04 SD = 1.14	M = 3.49 SD = .94	M = 3.4 SD = 1.05	M = 3.1 SD = .91

Table 4 shows whether the participants across the groups like to play games during their spare time. A chi-square test of independent was performed, and the results show that the relation between these variables was not significant, $x2(2, N = 45) = 3.16$, $p = .21$. The majority of the participants (n = 35 (78%)) across all groups reported like playing games during their spare time. Table 4 also shows whether the participants have seen or used any education AR app. A chi-square test of independent was performed and the results shows that the relation between these variables was not significant, $x2(2, N = 45) = 1.44$, $p = .49$. Majority of the participants (n = 36 (80%)) across all groups have never seen or used any augmented reality (AR) education app. Table 4 also shows whether the participants prefer to have an app to assist them in learning Mandarin. The result shows that the relation between these variables was also not significant, $x2(2, N = 45) = 1.42$, $p = .49$. All groups reported are highly interested (n = 36 (80%)) in having an AR app to assist them learn Mandarin.

Table 4: Distribution of participants like playing games and are interested in an app to assist learning Mandarin						
Learning Duration	Play Game		Have used / seen AR		Interested in AR app	
	Yes	No	Yes	No	Yes	No
1 year (n = 17)	12	5	1	16	14	3
2 – 3 years (n = 15)	14	1	3	12	13	2
> 3 years (n = 13)	9	4	2	11	9	4
Total	35	10	6	39	36	9

In summary, the preliminary result shows that participants have difficulty learning to speak, write, read or listen in Mandarin. Writing in Mandarin was found to be the most difficult part of learning Mandarin across all groups of participants. Although most students have never used or seen an AR education app, they are highly interested in having an AR app to assist them in learning Mandarin.

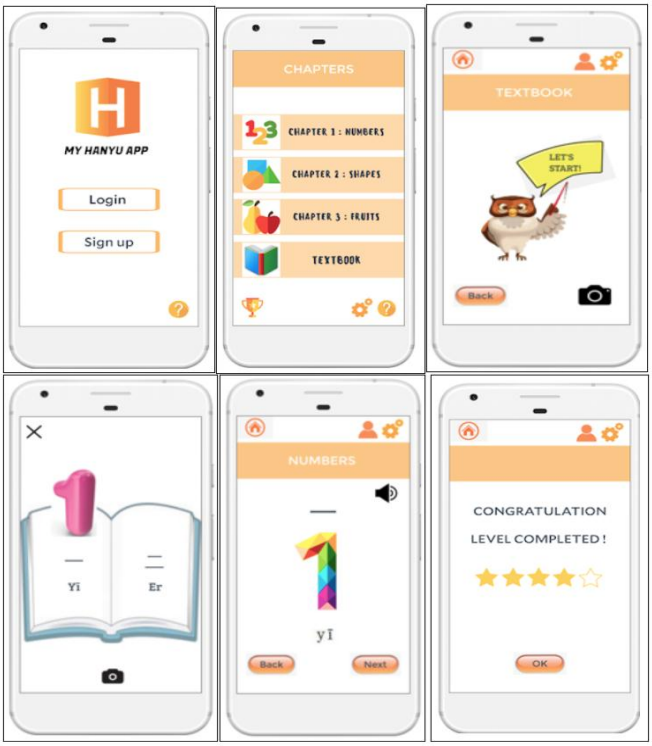

Figure 2(a-f, top-left to bottom-right): a) login / signup page, b) the chapter page using gamification element - leveling, c-e) some screens to learn numbers, f) congratulatory page after completing a level using gamification elements – rewards.

B. Low-fi Design Prototype of MyHanyuApp

The result of the preliminary study leads us to design a low – fidelity prototype of myHanyuApp. myHanyuApp is an AR app that assists students in learning Mandarin. Reviewing the literature, little work has been done in providing heuristic guidelines to develop an education AR app specifically for young adults. That said, the heuristic guidelines by Masmuzidin et. al [36], which proposed guidelines for learning in an AR environment, and Ko et. al [37], which proposed guidelines to develop AR app for smartphone users were followed.

The functionality of myHanyuApp includes what was found difficult by the participants

in the preliminary study. This includes incorporating the ability to learn to speak, write, read, or listen in Mandarin. As most of the preliminary study participants were also fond of playing games, gamification factors to eliminate alienation of using myHanyuApp were included. The gamification elements included providing levels, rewards, providing motivation messages, and showing progress. The approach to keep referring to the user needs and wants is part of the user-centered design lifecycle. This approach has been found successful by previous user experience study [25, 35].

myHanyuApp was designed using Marvel, a wireframing software. The design was kept simple and straightforward. Figure 2 shows some of the screens of myHanyuApp.

C. Formative Evaluation of MyHanyuApp

The formative usability evaluation [38] of myHanyuApp with three experts has been conducted. All experts have experience in usability testing between five to six years. Four evaluation tasks with multiple screens were given to the experts. The tasks include 1) log in, 2) update user profile, 3) read the first three numbers, and 4) listen to two types of shapes. A five-point scale of 0 = not a problem to 4 = catastrophic [38] was used. All experts conducted the evaluation separately at their own time. A one-week duration was given to the experts to complete the evaluation.

The experts found 33 usability problems. Of these, majority of the problems were about the inconsistent design interface between the screens, inconsistent fonts, confusing labels, and confusing instruction. Other problems that were found were the unsuitable location for the icons, confusing navigation between the screens, and lack of help feature. None of the usability problems were rated catastrophic. The experts also gave suggestions to improve the design.

4. CONCLUSION AND FUTURE WORK

This paper reports the initial study to investigate the need to develop an AR app to assist students learn Mandarin. A Google Survey with 45 participants was conducted to understand the most difficult element of learning Mandarin and their attitudes towards using technology to assist them in learning. The result shows that all four learning element, which are to learn to speak, write, read, and listen in Mandarin, were found difficult. Writing was found the most difficult element among these participants.

We further designed a low-fidelity prototype of myHanyuApp, an app to learn Mandarin. An expert usability evaluation was conducted and found 33 usability problems. Following the expert's usability evaluation, a hi-fi version of myHanyuApp have been developed. A usability evaluation test with a group of experts and users will be conducted. This is to fulfill the third stage of this overall study, 3) Implementation and Summative Evaluation, as stated above. These usability evaluations are in line with previous user-centered design lifecycle studies [e.g. 25] to ensure the system's usability developed useful for the targeted users.

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