

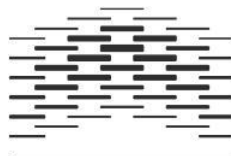
**MASTER THESIS**  
**in**  
**Universal Design of ICT**  
**May 2015**

How to develop a universally designed co-located Collaborative Mobile Learning game: The case of children and elderly users in China



Yang Xiangyang

**Department of Computer Science**  
**Faculty of Technology, Art and Design**



OSLO AND AKERSHUS  
UNIVERSITY COLLEGE  
OF APPLIED SCIENCES

## Acknowledgment

This project was done by Yang Xiangyang for his master thesis and supervised by Siri Kessel, Weiqin Chen.

I would like to thank the following for their contribution:

- Siri Kessel and Weiqin Chen for their supervision time as well as kindly guidance.
- The participants who were involved in the whole process of the application's development.
- The children's parents who signed the consent form to allow their children to participate in this research.
- The field expert who participated in interview at the early stage of the application's development.

## **Abstract**

This project is about applying Collaborative Mobile Learning for the special case of elderly people and children in China. Specifically, a co-located Collaborative Mobile Learning game prototype was designed and implemented for the purpose of improving English learning and socialization among users. The project work has been conducted according to User-Centered Design (UCD) research methodology. In order to make it universally designed, this project integrated accessibility into UCD. 10 representative participants were involved in this process. Interviews, observation, usability testing, and heuristic evaluation were used in this project. Several aspects associated with Universal Design were addressed, such as user diversity, situational variations, usability and accessibility. Based on user diversity, personalization was adopted to cope with different user requirements. Usability testing has been conducted in different stages with different focuses. For instance, formative testing was carried out at the very beginning of proposal to validate concept design. Summative testing has been conducted to reveal the majority usability issues of the viable prototypes. Heuristic evaluation was applied in order to address the accessibility issues of the prototype. The results of usability testing confirmed the majority of participants perceived the prototype was easily and effectively to use, and they were subjectively satisfied. Results of heuristic evaluation regarding accessibility indicated the tested prototype worked partially in terms of assistive technology and situational variations. Most importantly, communication and socialization were improved while using the prototype according to observation. These results indicate the benefits the co-located Collaborative Mobile learning game could offer for elderly people and children in China.

**Keywords:** Mobile Learning, Collaborative Learning, Universal Design, User-Centered Design

# Table of Contents

Acknowledgment .....	2
Abstract .....	3
Table of Contents.....	4
List of Figures .....	6
List of Tables.....	7
<b>1. Introduction .....</b>	<b>8</b>
<b>1.1. Background.....</b>	<b>9</b>
<b>1.2. Need of integration of Collaborative Learning (CL), Game-Based Learning (GBL) with Mobile Learning .....</b>	<b>11</b>
<b>1.3. Conceptual clarification.....</b>	<b>13</b>
<b>1.4. Research question.....</b>	<b>13</b>
<b>2. Literature review.....</b>	<b>14</b>
<b>2.1. English learning .....</b>	<b>14</b>
<b>2.2. Technology-supported education .....</b>	<b>15</b>
2.2.1. Computer-Mediated Learning .....	15
2.2.2. Mobile Learning.....	16
<b>2.3. Gamification .....</b>	<b>18</b>
<b>2.4. Collaborative Learning .....</b>	<b>20</b>
<b>2.5. Flow theory .....</b>	<b>23</b>
<b>2.6. Formative assessment.....</b>	<b>25</b>
<b>2.7. Universal Design (UD) for Mobile Learning .....</b>	<b>26</b>
<b>3. Design issues.....</b>	<b>29</b>
<b>3.1. Crucial elements for the application .....</b>	<b>30</b>
<b>3.2. Device.....</b>	<b>33</b>
<b>3.3. Graphical User Interface matters .....</b>	<b>34</b>
<b>3.4. Collaboration and individual learning .....</b>	<b>38</b>
<b>3.5. Technical features.....</b>	<b>39</b>
<b>4. Methodology .....</b>	<b>40</b>
<b>4.1. User-Centered Design (UCD).....</b>	<b>41</b>
4.1.1. Participants characteristic clarification .....	43
<b>4.2. Semi structured focus group interview.....</b>	<b>45</b>
<b>4.3. Usability Testing.....</b>	<b>46</b>
4.3.1. Formative Testing .....	47
4.3.2. Summative Testing .....	50
<b>4.4. Accessibility Testing .....</b>	<b>52</b>
<b>5. Data Collection and Results .....</b>	<b>54</b>
<b>5.1. Semi structured focus group interview.....</b>	<b>54</b>
<b>5.2. Usability Testing.....</b>	<b>55</b>
5.2.1. Formative Testing .....	56

5.2.2. Summative Testing .....	56
<b>5.3. Accessibility Testing .....</b>	<b>66</b>
<b>6. Discussion .....</b>	<b>69</b>
<b>7. Conclusion .....</b>	<b>73</b>
<b>8. Future work.....</b>	<b>75</b>
<b>Reference .....</b>	<b>78</b>
<b>Appendix.....</b>	<b>83</b>

## List of Figures

Figure 1: Over 65 aged people proportion globally and in China .....	10
Figure 2: A grandfather is teaching Chinese characters to his granddaughter .....	11
Figure 3: Flown as balance of challenge and ability. Source: (Chen, 2006) .....	24
Figure 4: Co-located Collaborative Mobile Learning application model in this research .....	29
Figure 5: Market share held by smartphone operating systems in China 2014, by share of the Internet traffic. Source: Statista .....	33
Figure 6: Google Android Developer Color Palette .....	36
Figure 7: Target groups' representatives in GUI implementation .....	37
Figure 8: Color contrast differences demonstration .....	37
Figure 9: User interface personalization on the same touch screen .....	39
Figure 11: A User-Centered Design model .....	42
Figure 12: Main interface of the low fidelity paper prototype .....	48
Figure 13: Theme-chosen interface of the low fidelity paper prototype .....	49
Figure 14: Main gaming scene of the low fidelity paper prototype .....	49
Figure 15: Main interface of improved prototype during milestone 1 .....	57
Figure 16: System settings interface of improved prototype during milestone 1 .....	57
Figure 17: Main gaming scene of improved prototype during milestone 1 .....	58
Figure 18: Screenshot of gaming scene .....	59
Figure 19: Main interface of the improved prototype during milestone 2 .....	60
Figure 20: System setting interface of the improved prototype during milestone 2 .....	61
Figure 21: Theme and difficulty level chosen interface of the improved prototype during milestone 2 .....	61
Figure 22: Main gaming scene of the improved prototype during milestone 2 .....	62
Figure 23: Participants group 4 and group 1 performing tasks during summative testing milestone 2 .....	64
Figure 24: Letter cards used in early functional prototype during milestone 1 .....	67
Figure 25: Screenshots of using Color Contrast Analyzer .....	67
Figure 26: Improved contrast ratio for main theme color using in prototypes .....	68
Figure 27: Improved contrast ratio for letter cards .....	68
Figure 30: Android built-in Accessibility features .....	73

## List of Tables

Table 1: Major differences between Computer-Mediated Learning and Mobile Learning.....	17
Table 2: Attributes associated with Collaborative Learning according to Dillenbourg.....	21
Table 3: Comparative study of typical educational applications regarding English learning.....	30
Table 4: Comparative study of common gaming implementations in mobile applications for elderly people and children.....	31
Table 5: List of most popular tablets on the market.....	34
Table 6: Set of guidelines regarding UCD approach according to ISO 9241.....	42
Table 7: 10 participants' characteristics.....	44
Table 8: Interview questions for 5 older participants (50-73) regarding Collaborative Learning while using digital devices.....	45
Table 9: Interview questions for 5 younger participants (2-5) regarding Collaborative Learning while using digital devices.....	46
Table 10: Definition of usability in the context of this research according to ISO 9241.....	46
Table 11: Summative testing tasks for milestone 1.....	51
Table 12: Summative testing tasks for milestone 2.....	51
Table 13: Interview questions regarding testers satisfaction of the prototype.....	52
Table 14: Relevant accessibility guidelines applied in this research.....	53
Table 15: Interview results regarding Collaborative Learning for 5 older participants.....	54
Table 16: Interview results regarding Collaborative Learning for 5 young participants.....	55
Table 17: Results of formative testing according to 5 older participants about the paper-based prototype.....	56
Table 18: Recommendations for user interfaces of the prototype according to 10 participants.....	58
Table 19: Recommendations for gaming mechanism applied for the prototype according to 10 participants.....	59
Table 20: Time required for completing tasks during summative testing milestone 2.....	63
Table 21: Interview results of user satisfaction and user acceptance.....	65
Table 22: Heuristic evaluation on Android Accessibility Testing Checklists.....	66

# 1. Introduction

In China, people have ingrained culture of having grandparents taking care of their children during their early youth, grandparents spend most of the time together during children's early childhood including pre-school education. It is the combination of population ageing and vastly progress of globalization that has caused national phenomena of millions of "empty nesters" and "left-behind children". Young parents move to big cities while leaving older grandparents and children behind due to the stressed urban life. Consequently, social isolation and loneliness have increased among them because of lack of companions and social interaction, which have huge impact on mental health of Children. Nevertheless, Cotten, Anderson & McCullough (2012) indicated Information Communication and Technology (ICT) usage might help people to maintain social ties, and generate positive impacts on their health. Particularly, mobile devices are considered as important tools for educational purposes by creating and maintaining social links. They are user-friendlier to users in terms of required ICT knowledge compared to computers, especially for those new ICT users. Therefore, based on the unique Chinese culture, this project proposed a co-located Collaborative Mobile Learning game for elderly users and children in China, for improving English learning and socialization among them.

From the perspective of Universal Design (UD), all products or environments shall be effectively used by all kinds of user groups to the greatest extent without specialized design or adaptation (Story, 1998). Vanderheiden & Tobias (2000) indicated UD was about making products, environments, devices that can be accessible by people with a wide range of abilities, and they can be operated with a wide range of situations in terms of environments, conditions, and circumstances. Thus, in order to create a universally designed co-located Collaborative Mobile Learning game in this research, it followed the theory suggested by (Henry, 2007). Henry suggested by integrating accessibility throughout User-Centered Design (UCD) could fairly address underlying usability and accessibility issues of products. UCD is a process of designing and evaluating usable prototype. Accessibility is related to usability, accessibility can be approached as the subset of usability (Henry, 2007). Integrating accessibility into UCD could help designers to include all kinds of users to the greatest extent and to make products to be usable and accessible in different situations. Henry gave a sample of how accessibility fits into UCD. 1): Understanding user characteristics, including users with different disabilities; 2): Environmental aspects that requires products work consistently under some circumstances; and 3) Usability testing. Therefore, based on this, three aspects associated with UD were addressed by taking an integrating UCD design approach in this research. They are User Diversity, Usability and Accessibility.

First of all, user diversity is important since the target groups in this research are elderly people and children. Iwarsson & Ståhl (2003) identified taking different user groups into account, allowed ICT products being more closely to Universal Design. Within user diversity, there must be diverse user requirements, even some conflicting requirements might occur. In this project, preliminary studies and literature studies were conducted in order to reveal basic users requirements, and personalization was used to cope with those conflicting user requirements. For example, it allowed users to configure system settings according to each individual's preferences or abilities.

Secondly, usability issues of the prototypes were emphasized via different research methods in this research, such as interviews, observation, usability testing. Iwarsson & Ståhl (2003) pointed out accessibility should partially replaced by usability in an activity component. Hence, usability testing has been conducted in different stages of the development process. Formative testing has been conducted at the proposal stage using a low fidelity paper-based prototype to validate the concept



design, qualitative data were collected by interview. Summative testing was divided into two milestones. During milestone 1, usability testing was mainly focused on qualitative data collected by after interviews and observation evaluations. There were a lot of major usability issues of the prototype since it was the first viable prototype, which users could interact with. During milestone 2, improved design has been implemented. Usability testing was carried out among 10 selected participants with more focuses on collecting quantitative data, such as time spent for performing tasks, and interview results regarding user satisfaction of the prototype.

According to (Henry, 2007), accessibility suggests ICT products can be usable by a wide range of users including people with disabilities in a wide range of situations including assistive technologies. Hence, due to time limitation, heuristic evaluation based on relevant accessibility guidelines has been conducted. Specifically, a short heuristic evaluation was carried out in order to test if the prototype worked consistently with Android integrating assistive technology: TalkBack by solely using Android Accessibility Testing Checklists. Finally, situational variations should be covered to ensure accessibility since everyone might face challenges under specific circumstances. In this research, situational variations were fairly addressed via adopting personalization. Personalization could reduce challenges one might face such as unstable physical environments, variations of individual's ability and etc. For example, personalization enables users to set up big icons or big font size, this could help user to pinpoint on the touch screen while traveling together on the bumpy roads so that the proposed Collaborative Mobile Learning game could work consistently under different circumstances.

Overall, the results of usability testing confirmed the majority of participants perceived the prototype was easily and effectively to use and they were subjectively satisfied with it. The results of heuristic evaluation indicated it worked partially in terms of assistive technology. Moreover, communication and socialization were evidently improved while using the prototype based on observation during user testing. These results indicate the benefits it has for elderly people and children in China.

## **1.1. Background**

Population ageing has become one of the most unprecedented, pervasive, enduring global phenomena, without parallels in human history, we will witness even more rapid ageing than ever before (United Nation, 2013). It affects almost every society across the entire world. By 2050, there will be 2 billion people aged 60 and over, comprising 22% of the world population (Banister, Bloom, & Rosenberg, 2010). The number of people aged 60 or over is project to grow to more than triple by 2100 globally, increasing from 841 million in 2013 to 2 billion in 2050 and close to 3 billion in 2100. Global population ageing has profound implications. China as one of the most populated countries in the world should take this problem even more seriously. Due to various reasons, for instance, economic growth, one-child policy and etc., maybe have advised raising standard of nationwide retirement ages currently 50 or 55 for women and 60 for men by five years each. It identified by 2050, the proportion of China's population over 65 is projected to grow to 24% from currently 9%. Figure 1 illustrates proportion of population aged over 65 people wordwidely and in China according to (United Nation, 2013).

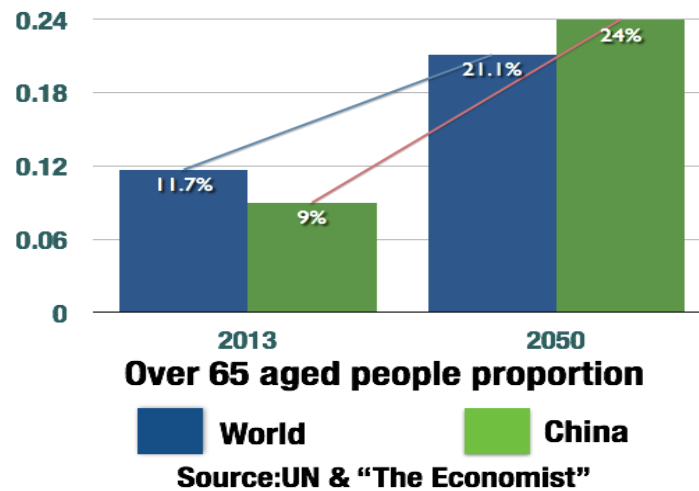


Figure 1: Over 65 aged people proportion globally and in China

It is quite common for grandparents to babysit their grandchildren in China. First fact is the ingrained traditional culture value in China, where people have a long history of living with elderly and having them participating in children's growth, especially during their early pre-school education. For example, as Figure 2 shows, a grandpa is teaching Chinese characters to his granddaughter. 90% of the city's young children are being looked after by at least one grandparent, and half of them provide exclusive babysitting on the basis of Shanghai Municipal Population and Family Planning Commission (TheAtlantic, 2013). Another fact is the due to the stressed urban life along with rapid development process of globalization, more and more young parents in the countryside move to big cities while left-behind children stay with their grandparents. This has caused huge concerns about the national phenomena "empty nester" and "left-behind children". Even for young parents who are live in big cities do not have enough time to accompany their parents and children because of the overloaded work. As a result, elderly people and children tend to lack of interaction with society or community, social isolation and loneliness have increased among them because of the intense feelings of emptiness and abandonment, which respectively refers to a subjective feeling state be alone or apart from others or an objective feeling which focus on the lack of interaction in community and separated by others according to (Tomaka, Thompson, & Palacios, 2006). Health concern regarding "empty nester" and "left-behind children" has become one of the most arguable national topics.

Solutions have been proposed by lots of previous researchers to deal with these issues. As with any other solutions, technologies are not the final answer, but a rather valuable tool for assisting contemporary users. ICT usage may help people to maintain contact with social ties as well as decrease social isolation and loneliness (Cotten, Anderson & McCullough 2012). They conducted interviews and survey in order to prove their hypothesis, and the collected data showed positive impacts of ICT products had in decreasing social isolation and loneliness. Within the popularity of mobile devices, they have been considered as important tools for creating and maintaining social links. For instance, nowadays elderly users are accustomed to use mobile devices for reading books or news, playing games, making phone calls or sending short message services (SMS). Kurniawan, Mahmud, & Nugroho (2006) conducted a quantitative research to find out mobile devices usage pattern among 100 representative participants in Mexico, and the majority of them were 60-65 years old (72%). The results indicated that a clearly majority (nearly 83%) thought mobile devices were interesting to use. In addition, the research done by Leme, Zaina, & Casadei (2014) surveyed the mobile usage pattern among 271 participants from Brazil, and it showed 149 participants (56%) had a

smartphone out of the 271 participants. The results presented the common usage pattern of mobile devices, 25% accessing social networks, 17% reading news, 12% playing games etc. However, even though the results only represent trends, experience, and behavior pattern associated with studied group, the results could be inferred to the elderly in the large communicat that is nowadays elderly people are interested in using mobile devices.

Besides, currently there are a number of labels to describe the young people studying at school, college and university, which include the digital natives, the net generation, the Google generation or gamer generation (Helsper & Eynon, 2010). Owing to the commonly use of these modern technologies, young people have grown up with computer games and other technologies that have changed their preferred leisure styles, their social interaction, and even their learning preferences (Bekebrede et al., 2011). All of these terms are being used to indicate the significance of modern technologies have in education such as computers, Internet, or mobile phones, and how they are associated with young people's daily life. Bekebrede, Warmelink, and Mayer (2011) pointed out in education the net generation or digital natives prefers active, collaborative and technology-rich learning process. Evidences showed clearly nowadays people at different age groups have interests in using modern technologies. Therefore, there is great potential of having these two groups of people learning together based on the unique Chinese culture by applying technology-supported education, which could potentially enhance learning and socialization among them.



Figure 2: A grandfather is teaching Chinese characters to his granddaughter

## ***1.2. Need of integration of Collaborative Learning (CL), Game-Based Learning (GBL) with Mobile Learning***

As with the vastly widespread ownership and flourishing development of mobile devices, they have been considered as valuable tools for supporting education. Although mobile devices have been widely preferred by users, the concern regarding learning efficiency as well as learning outcomes have been raised by previous researchers. Numbers of integrating features or applications of mobile devices could lead to severe problems in terms of decreasing of learning outcomes. Learning progress

could be interrupted by a lot external interferences such as sudden phones calls while learning, limited battery life, and not to forget relatively small screen size could lead to possibility of poor user experience. Game-Based learning was introduced in Mobile Learning systems as an effective way for promoting learners' motivation and engagement. There has been an emerging trend that integrates ML with GBL for the purpose of providing users with better learning experience. Shuler (2012) surveyed 200 top-selling education category applications for iPad or iPhone on App Store, and he found that 32% of game category applications made sort of educational claims. Nearly all of these applications were targeted to preschool children. Games are considered as precious tools for promoting learning motivation and engagement. They embody functional interactive elements by which is able to make learning process more interactive, consequently learning becomes more active. Newark-French (2012) surveyed time spent on different mobile applications categories across different platforms among mobile users in the US in 2012. Apparently, games and social networking applications captured the significant majority of consumers' time. Consumers nearly spent half of their time on playing games. This presented an emerging possibility of combining gaming with socialization for education paradigm when applying Mobile Learning systems. In such case, there is a possibility of integrating Collaborative Learning with GBL in this research when proposing Mobile Learning application for elderly people and children in China.

In this research, collaborative learning was adopted for the purpose of improving learning and socialization among elderly people and children. Certain aspects shall be addressed properly. Social activities might lead to distracting and decreasing in terms of learning efficiency while learning. By applying collaborative learning, this could enhance learning efficiency in which players are able to take control of learning process, and peer-regulation as well as communication is improved at the same time. However, based on the background of this study, older people and children in China usually live together, they spend most of the time together during early stage of children's daily lives, this would be potential of having these two different user groups learning together. So, this study proposed a co-located Collaborative Mobile Learning game. By requiring users to be co-located is helpful for promoting communication between them, which is also considered be helpful for decreasing social isolation and loneliness among them. Resta & Laferrière (2007) identified for future Computer Supported Collaborative Learning (CSCL) studies, instead of focusing attention on the question whether CSCL is better than face-to-face collaborative learning, but rather concentrate on what is feasible with new technologies, so in this research, users are co-located is more appropriate based on this scenario to apply mobile supported collaborative learning. Whether online communication is better than face-to-face was not the primary concerns in this research. In addition, this research implemented a collaborative Mobile Learning game instead of desktop-based education. The reason why it chose Mobile Learning is that generally desktop-based applications or computers are considered requiring users possess higher level of ICT knowledge in order to operate them, this could lead to exclude some of the users to some extent from the perspective of Universal Design. By contrast, modern mobile devices are well designed in terms user-friendly, they demand less computer literacy to operate them. This is particularly important for this research since it is the case of elderly people and children in China, children aged 2-5 years old are not able to user computers or desktop-based programs. In fact, most of elderly people in China have no experiences of using computers at all. This might not applicable for users from well-developed countries such as the US,

Germany, Norway and etc. So instead, mobile devices are considered easier to use and user-friendlier in this case, even for those completely new users who can use them without too much efforts (short instructions if needed) in order to operate them. Not to forget the learning mobility while applying Mobile Learning in education.

### **1.3. Conceptual clarification**

A lot of terminologies were used in this research. This section provides readers with conceptual clarification of those terminologies based on previous researchers. 1): Story (1998) defines **Universal Design** as all the environments or products shall be accessible by all kinds of users without adaptation and stigmatization. In this research, it followed the UD to make the proposed application more universally designed. 2): **Computer-Mediated Learning** (CML) refers to a new type of education in which learners practice and learn by using computer programs or applications without mandatory physically attending traditional classrooms (Prensk, 2005). 3): **Mobile Learning** (ML). The relatively new term: “Mobile Learning” might be confusing since it was introduced in education along with the development of modern mobile technologies. The term mobile itself illustrates the meaning of Mobile Learning, which literally means capable of moving or moving freely or easily according to (Oxford Dictionaries, n.d.). So, if mobile combined with learning, simply implies “learning while moving”. ML refers to a new type of education in which users are allowed to access educational contexts without geographic and time boundaries using modern mobile devices. Via Mobile Learning, educational paradigm is no longer restricted to taking place in formal contexts such as traditional classrooms, workplaces, private location and etc. (Laouris & Eteokleous, 2005).

### **1.4. Research question**

Universal Design is important for ensuring products that can be usable by all kinds of users, so it is important for this research to follow the concept of Universal Design when implementing the proposed co-located Collaborative Mobile Learning game for elderly and children in China. This lead to the main research question for this research as described below.

*How to develop a universally designed co-located collaborative mobile mediated game-based learning application for children and elderly users, for learning English and increasing socialization?*

In order to answer the research question, three aspects will be addressed in this research: 1): User diversity. Considering user diversity allows designers to properly understand users’ characteristics. In this research, since the target groups are elderly and children, there must be different users requirements within user diversity. Possibly, there must be some conflicting requirements in terms of the variations of individual’s preferences and abilities. Personalization will be adopted in this research

to fairly cope with different requirements. 2): Usability. According to International Organization for Standardization (ISO) 9241, usability is defined as the effectiveness, efficiency and satisfaction with which representative users achieve specified goals in specified environments. So it is important to address the effectiveness, efficiency and satisfaction of the prototype for the proposed application. Usability testing needs to be conducted in this research. 3) Accessibility. Accessibility ensures the application can be used for a wide range of users including people with disabilities in different situations. So, tests of accessibility need to be carried out.

## **2. Literature review**

In order to develop a universally designed co-located Collaborative Mobile Learning game for children and elderly users, literature reviews were conducted in this research among lists of papers mostly published between 2000-2014. Papers with regard to those evolving terminologies such as Mobile Learning, Collaborative Learning, Gamification, flow theory and formative assessment in game design, and Universal design for Mobile Learning were selected. The author started with searching papers that included one or more than more key words listed above. Selection criteria of these papers are: 1) applying mobile technologies or mobile devices for educational purposes; 2) adopting Game-Based learning in education to create better user-friendly environments or contexts; 3) Collaborative Learning in technology-supported education; and 4) Universal Design is crucial when apply technology-supported learning methods. Most of these papers were published on major international journals or conferences, such as Computer & Education, Association for Computing Machinery (ACM), Games Learning Society (GLS) and etc. This increased the reliability of literatures.

### **2.1. English learning**

During the past few decades, owing to the widespread of globalization, English has become the most commonly used international language across the entire world. It is the combination of British colonial power in the nineteenth and early twentieth centuries, and North America dominance of twentieth centuries that has made English as the most important language in the world (Cenoz & Jessner, 2000). According to "European Commission", there are significant statistics indicate a clear majority of pupils choose to study English. Learning English is mandatory both in primary school and secondary education in several countries in Europe including Spain, Italy, Austria and Greece. These countries have close to 100% of pupils learning English in their primary education. When it comes to language learning in upper secondary education, some 92.7 % of all EU-27 students at International standard of classification of education (ISCED) level 3 were studying English as a foreign language in year 2010 ("Foreign language learning statistics," European Commission.). In addition, English is used as a major foreign language in Asian countries such as China, Japan, and South Korean. In China, learning English is mandatory in elementary school, middle school and high school, and ability of speaking good English makes people more competitive in the employment market. Therefore, it is

crucial to highlight the importance of English learning. There has been an ongoing debate about how improve English learning among researchers. Numbers of previous researches have been done in this respect. For instance, Muñoz (2014) explored the younger learners' foreign language learning awareness, and indicated most of the participants were aware of the importance of English learning. Several difficulties in learning English were mentioned. For instance, problems regarding limited vocabulary and precise pronunciations, these problems can be fairly solved with the help of technologies at some point. White & Gillard (2011) gave an example of introducing a computer-assisted pronunciation training system for elementary children in Italy 2007. The results showed it could help children to improve pronunciations of English words. Based on the above elaboration, the main subject of this research was technology-supported education regarding English learning.

## ***2.2. Technology-supported education***

### **2.2.1. Computer-Mediated Learning**

In recent years, education is experiencing fast evolving along with the steady development of modern technologies. They have been constantly affecting our learning preferences. Technology-supported education systems have been widely implemented to support contemporary learners' preferences. The traditional teaching happens in the classrooms where teachers present learning materials to students, it heavily depends on mandatory physically participation of both teachers and students. In other words, they have to be physically present. However, the advent as well as evolution of modern technologies such as Internet, computers, has generated some profound effects on education. They have been continuously changing the way people used to learn and communicate. During the past several decades, Internet has stepped into a new phase in terms of its maturity. The rapid advancement of the Internet, arguably the fastest development of any technology in history, has caught attention of language learning, contemporary students are no longer required sitting in the traditional classrooms to access to educational contexts (Warschauer, 1997). Nowadays students present less interests in learning at school while immersing themselves in participatory culture out of school (Jenkins, 2009). Therefore, CML was introduced as an alternative to support learners accessing learning contexts. CML is a branch of E-learning that stands for the use of electronic media and Information and Communication Technology in education (Bates, 2004). Computer-Mediated Learning offers several advantages against traditional teaching, and it thereby became very common in educational paradigm. Those advantages are: 1): CML such as Distance Learning and the use of Computer-Mediated communication do not require physically participation of both students and teachers. Along with the rapid development of economic globalization, lots of employees need to travel around the world, thanks to the advent and prevalence of computer and the Internet, currently they can easily just hold meetings in offices or at home settings without those overloads traveling; 2): from the perspective of Universal Design, Computer-Mediated Learning and the Internet have a great deal of potential for improving accessibility to all kinds of users including

people with different kinds of disabilities such as motor-impairment, hearing-impairment, and visual-impairment. By integrating assistive technologies with CML such as Screen-Reader, Tactile feedbacks and etc., people with disabilities are no longer excluded from education. For example, the Electronic Networks for Interaction (ENFI) project at Gallaudet University generated some of the earliest examples of programs for CML (Marlatt, 1996), it is worth mentioning that students who attended Gallaudet were either deaf or had some sort of hearing impairment. In such cases, Mikołajewska & Mikołajewski (2011) pointed out that assistive technologies and appropriate adaptations are able to help compensate for functional limitations, enhance computer utilization and improve people's ability to compete for employment.

However, in a rush for promoting CML such as Web-based training (WBT), Internet-based training (IBT) and Distance Learning, and lack of universally guidelines (Motiwalla, 2007), designers usually fail to consider some of the most important critical factors for creating appropriate programs or applications for users. Consequently, the weaknesses of CML become more prominent. Foremost among these are teachers and students must possess a higher knowledge level in terms of computer literacy in order to operate these CML environments successfully. As in this project, the fact is that most of elderly people and younger children in China have no experiences in using computers (this is might not applicable to well-developed societies), So it will be difficult for them to use CML applications or programs. Besides, the excessive use of CML limits social interaction among students with teachers and their peers, which might lead to social isolation (Elearning-companion.com, 2013). In this study, it mainly focused on the major limitations of CML regarding learners' mobility, location and time boundaries as well as the premise in terms of required computer literacy. CML generally tend to be formal learning because it happens in formal settings such as classrooms, workplaces, educational or community premises. However, due to the widespread ownership of mobile devices, they have been used for supporting education. Via Mobile Learning, learners are allowed to access learning contexts at informal settings, such as on the bus, while walking and etc. Mobile Learning thereby was introduced as a supplement to bridge the gap between formal and informal learning.

### **2.2.2. Mobile Learning**

There is a growing belief that the modern devices have invaded every sector of our daily life. It seems as though we cannot go anywhere without seeing people using cell phones. We are accustomed to the daily use of cell phones not only for making phone calls, Short Message Service (SMS), but also checking social updates and even for educational purposes. ML enables users to access educational scenarios without being constrained to location and time according to Earnshaw (2011). On one hand, education is no longer constrained geographically. It can take place in specific informal contexts such as at home, on the bus or subway or even when users are walking. On the other hand, Mobile Learning enables learners to access the educational scenarios without being time restricted, in other words, learning progress takes place anytime without being schedule limited. In fact, it is the advancement of wireless communication and mobile technologies has made ML happens without being time, space, location constrained in parallel to other learning methods (Liu et al., 2003). Comparing with traditional classroom-based learning method and Computer-Mediated Learning, ML may take place anytime and anywhere. Assuredly, it benefits from the mobility of modern mobile



devices that contain cell phones, Personal Digital Assistant (PDA) devices, and handheld computing devices according to (Laouris & Eteokleous 2005). Learning thereby became more spontaneous and flexible. There were plenty of examples indicated mobile devices were used on educational purposes. For example, Duke University provided free iPods to over 1600 entering first-year students for the academic purpose in August 2004 (Belanger, 2005). Tan and Liu (2004) introduced a mobile-based interaction learning environment in order to aid elementary school students for English learning. In addition, there are a great diversity of mobile applications have been created with respect to English learning across different mobile Operating Systems (OSs), such as, iOS, Android, and WindowsPhone.

To provide better understanding of Mobile Learning, the research done by Laouris and Eteokleous (2005) have summarized the major differences between Mobile Learning and Computer-Mediated Learning regarding certain aspects such as terminology comparison, time and space boundaries, pedagogical changes. Table 1 lists out the major differences between Computer-Mediated Learning and Mobile Learning.

Table 1: Major differences between Computer-Mediated Learning and Mobile Learning

	Computer-mediated learning	Mobile Learning
Terminology comparison	Computer Bandwidth More formal	Mobile GPRS, WIFI, Bluetooth More Informal
Time and space boundaries	Private location Scheduled	No geographic boundaries Spontaneous
Pedagogical changes	More text and graphics based instructions Lectures in classroom or Internet labs	More audio, graphics, animation based instructions Learning occurring in the field of mobile devices

In essence, there are different definitions of Mobile Learning that have been proposed by previous active researchers, partially because definitions are varied from each other in terms of mobile technologies or the general notion of learner’s mobility. In order to properly discuss the definition of Mobile Learning on the context of this research, a short literature view based on empirical evidences from previous researches was conducted. Kukulska-Hulme (2009) pointed out there was no agreed definition of Mobile Learning, partly because the corresponding field is experiencing rapid evolution, and partly because of the ambiguity of the term ‘mobile’ self. He emphasized the concept of mobility which needs to be understood not only in terms of spatial movement, but also in such movements it may enable time-shifting and boundary-crossing. Earnshaw (2011) summarized all these definitions and divided them into four categories: 1) Technology-Oriented, 2) Electronic-Oriented, 3) Location-Oriented, and 4) Communication Interaction-Oriented. Each one of all these definitions has different focuses. Overall, this research tried to illustrate the significance of Mobile Learning, by referring to a new flexible educational paradigm that can be accessed in both formal and informal learning settings, which enables learners to access educational contexts by the practice of using mobile devices, such as cell phones, PDAs and handheld computing devices without space and time boundaries. It refined the definition of Mobile Learning in the context of the co-located Collaborative Mobile Learning game since the game requires players to be co-located. This violates the intention of Mobile Learning: “learning while moving”. It referred Mobile Learning as the practise of using mobile devices for educational purposes without emphasizing learner’s mobility in terms of time-shifting and boundaries-crossing. Although users are

allowed to play the co-located collaborative learning game without geographic restrictions, for instance, they could play it at home, in offices or even on the train when they are on travel. Because players are required to be co-located, they have to be face-to-face when conduct learning. This fails to enable time shifting and boundary crossing during learning while learning process has to be scheduled with a time and at a relatively stable space. They cannot use the game while they are physically moving. So, learning flexibility is decreased to some extent.

Mobile Learning is not all about technology, after all, it is about the learners. The learner is at the center of learning while mobile technology allows learner to access the education contexts without time and location boundaries. All in all, since the initiative of this project was to apply technology-supported educational system for both elderly and children in China to improve English learning and socialization. Mobile Learning is more appropriate in comparison to Computer-Mediated Learning for the following reasons. First of all, considering the general age for kids in China attending kindergarten is typically around 4 years old, in this case, children at this age cannot operate computers by themselves. On the contrary, mobile devices demand less ICT knowledge level to operate them. They are considered easier to use for elderly people and children since most of them do not have experiences in using any of computers or mobile devices before. For those completely new users to learn how to use mobile devices, less instructions required in comparison to computers. In addition, ML improves learning mobility and flexibility. Via ML, users are able to conduct learning without being limited by space and time. For example, they could conduct learning even when they are traveling on the train by using mobile devices. Another validate aspect of choosing ML instead of CML is that in comparison to computers or laptops, mobile devices assuredly require relatively less ICT knowledge level to operate, which promote the accessibility level of the proposed Mobile Learning game since most of the elderly and children do not have ICT knowledge.

### **2.3. Gamification**

As modern technologies stepping into a new level regarding their own maturity, they have been continuing in changing our learning preferences. Bekebrede, Warmelink, & Mayer (2011) presented in education the net generation or digital natives prefer active, collaborative and technology-rich learning process, for example, learning methods that involve extensive computer use and collaboration among students. Challenges pertaining to learning efficiency as well as motivation have caught field experts' attention while implementing technology-supported educational systems. Therefore, GBL thereby was introduced into education as a new effective learning method requiring players dealing with complex and difficult procedures. Games themselves fascinate millions of players spending countless time across different platforms, and they have ignited the enthusiasm of marketers, developers as well as researchers in Human Computer Interaction (HCI) field because of their potential of promoting engagement and motivation among users. According to (Connolly, Stansfield, & Hainey, 2007), GBL can be defined as "the use of game-based approach to deliver, support, enhance teaching, learning, assessment, and evaluation". Game itself accounts for the generally positive effects it has in education. Games are considered as considerable effective tools for promoting motivation and engagement not because of what they are, but because of what they embody and what learners are doing as they play a game. Kebritchi & Hirumi (2008) identified the following reasons that demonstrate GBL as an effective tool for learning, they are: 1): GBL uses action

instead of explanation; 2): GBL creates personal motivation and satisfaction; 3): GBL accommodates multiple learning styles and skills; 4): GBL reinforces mastery of skills; and 5): GBL provides an interactive and decision-making context.

O'Neil, Wainess, & Baker (2005) identified computer games are useful for instructional purposes and they also provide multiple benefits. Those benefits are: 1): Complex and diverse approaches to learning processes and outcomes; 2): Interactivity; 3): Ability to address cognitive as well as affective learning issues; and 4): Motivation for learning. In the light of the study of (Furio, Gonzalez-Gancedo, Juan, Segui, & Rando, 2013), they tried to evaluate the learning outcomes comparing with an iPhone educational game with traditional game, and the results indicated there was not significant statistic difference between them. So, GBL could be as an alternative to conduct educational purposes and promote learning motivation and engagement. However, most of the participants stated they preferred mobile educational game rather than traditional game and they would like to play again during interview session. During user testing session, the author mentioned they found out the participants were more engaging and motivated in mobile educational game other than traditional game. Since educational Game-Based learning provides new possibilities for teachers to motivate their students, this is extremely important because today's learners have a strong need for engagement and joyfulness with regard to learning (Prensky, 2002). It is commonly held acknowledgement that motivation is one of the most determining factors when it comes to learning efficiency. In other words, GBL is able to make learners more motivated and engaged during learning procedures. Thus, there has been a trend that integrates Game-Based Learning in educational paradigm. GBL is essential for this research, which could potentially motivate elderly people and children, and be helpful for decreasing social isolation and loneliness among them.

Along with the expansion and maturation of mobile technologies and mobile devices, there are lots of mobile games have been developed for educational purposes on the market. Although games are considered as effective tools for improving learning motivation and engagement, educational games might seem to be a promising approach, but without proper design, negative impacts might occur when adopting Game-Based Learning, such as poor learning outcomes, lack of socialization while one immerse in the world of gaming. Divergent views regarding learning efficiency when adopting GBL technology-supported education environments have been discussed over time. Some researchers advocate the idea of applying games into educational systems improves learners' motivation and engagement by simply embed regulation or evaluation system so that learning efficiency is enhanced. However, others hold different standpoint. They identify that even though games are considered as the potential means of promoting engagement and motivation of learners, certain elements of game pattern generally are considered as less attractive, for instance, scoring system that records how many tasks players have done or how much progress they have achieved. The term "Gamification" is then introduced by previous empirical researchers, which commonly refers to the using of game-design elements in non-gaming contexts, products, or services to motivated desired behaviors according to (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011). A great majority of games on different platforms have implemented gamification, for example, some of them adopt difficulty levels, scoring system which indicates personal achievements during play games, external rewards for encouraging users to finish further tasks and etc. (Deterding, 2012) identifies common implementation model of gamification is adopting simplest elements, such as points, levels, badges, and external rewards in relatively less attractive parts of gaming systems. However, due to lack of

sound frameworks and poorly understanding of gamification, resulting in most of them fail to engage players as they should be. Deterding points out that it is not gamification cannot work, but to be successful, it must include game design, not always just game elements, that implies meaningful gamification is always about game design, what game mechanisms adopted within games other than what kind of game elements shall be included. He emphasizes gamification means amplifying intrinsic value, in other words, underlying concept of gamification is properly understand what motivate users rather focus on game elements. Nicholson (2012) indicates one significant latent problem of adopting points, levels, badge is that external motivation might replace internal motivation, resulting in internal motivation reduces, which the user has for the activity.

Even though all of these researchers failed to propose an integral framework or guideline when applying gamification to technology-supported education, some of them still presented valuable points. In order to ensure the gamification of the proposed co-located collaborative learning game is meaningful, in this research, we abided to the concept of creating meaningful gamification through several theories presented in the paper done by (Nicholson, 2012). For example, self-determination theory is focused on what drives individual's to make choices without unrelated external rewards influence. In the context of the proposed co-located collaborative application, it should not apply external rewarding system, which could avoid reducing internal motivation of learners. "Situational relevance" concept indicates when designers create goals that are relevant to users. In such case, the score system applied in this research only indicates how much progress players have achieved which is related to users, for example, how many words they have finished within collaboration. Thirdly, he identifies in order to make gamification experiences that are meaningful are that allow users to set their own goals. In other words, give the users completely freedom without restricting them for given options. Therefore, based upon this, unlike general difficulty levels systems implementation, which requires players finishing beginning level in order to step next level, the proposed application applies difficult levels while allows users to choose freely without restricting them stick to levels by levels. For instance, users are allowed to choose difficulty level medium without finishing beginning level firstly. Players take whatever time they need while completing tasks without time limitations. It also provides users with system settings, where users could customize settings based upon their preferences. By this, older users and children can sit at a random cozy environments like at home or in the public area while play the game, learning thereby become be more spontaneous without too many restrictions. Another issue for creating meaningful gamification is to what extent of this given freedom. Researchers failed to provide to what extent freedom shall consent to the users while applying game-based collaborative learning. Too much freedom assuredly result in distraction and consequently the reduction regarding learning efficiency since generally younger users lack of self-regulation. Similarly, if users feel being over restricted, users' motivation and engagement will be affected.

## ***2.4. Collaborative Learning***

Bekebrede, Warmelink, & Mayer (2011) emphasized the net generation or digital natives prefers active, collaborative and technology-rich learning process in education. As mentioned earlier. Another

valuable point proposed by (O'Neil et al., 2005) is that collaboration or teamwork should be applied in the gaming context in order to make the learning process more interactive and engaging. Due to the field technology-supported collaborative learning is experiencing fast evolving, it is commonly acknowledged that there is no universally adopted definition of the complex concept: Collaborative Learning or Cooperative Learning, and agreement on precisely differences between those definitions. For example, Roschelle & Teasley (1995) defined collaboration as “the mutual engagement of participants in a coordinated effort to solve a problem together”. Mercer and Littleton (2007) describe the collaboration as:

*“Participants are engaged in a coordinated, continuing attempt to solve a problem or in some other way construct common knowledge... involving a coordinated joint commitment to a shared goal, reciprocity, mutuality and the continual (re)negotiation of meaning.”*

However, in order to properly understand Collaborative Learning, instead of defining the term “Collaborative Learning” in this research, it followed Dillenbourg (1999) recommendation and addressed the following four aspects regarding Collaborative Learning when apply the Collaborative Mobile Learning among elderly users and children.

Table 2: Attributes associated with Collaborative Learning according to Dillenbourg

Collaboration Learning attributes	Description
1. A situation can be characterised as more or less collaborative	Collaboration is more like to occurs between people with similar status than between a teacher and pupil. In this research, both older users and children were considered lack of companions and social interaction with society. Collaboration is more likely to occur since these two target group actually spend more time with each other in their daily life.
2. The interactions which do take place between group members can be more or less collaborative	Negotiation is considered to have a stronger collaboration flavour than giving instructions. In the context of this research, by requireing players are co-located, the proposed application encourages communication and negotiation between elderly users and children to complete tasks together, instead of simply giving instructions or having grandparents giving instructions or supervising children.
3. Some learning mechnisms are more intrinsically collaborative, learning mechnisms must be similar to those triggered in individual learning.	In this research, it should adopt gaming mechnisms that are appealing to both elderly users and children. For example, it shall embody attractive topics related to them.
4.The effects concerns of collaborative learning	It is important to address the learning efficiency when adopting collaborative learning, after all, it is learning-centered. Meanwhile, communication and socialization increase while using the proposed co-located Collaborative Learning game.

The experimental research done by (Hsu & Ching, 2013) reviewd a set of related peer-reviewed papers published between 2004-2011 regarding mobile technologies in supporting Collaborative Learning, and they concluded the four following major types of mobile computer-supported collaborative learning intervention that use mobile devices and technologies to support collaborative

learning. Below the list illustrates the actual meanings of these four main interventions on the basis of the proposed collaborative learning game in this research.

1. Presenting the individual portions of an assigned learning task and serving as the focal point of interaction. For example, the proposed application shall address each individual's contribution while complete tasks together.
2. Facilitating communication and interaction. For instance, by requiring players are co-located instead of online communication, promoting communication and social interaction between elderly users and children.
3. Providing feedback for group learning and instructor teaching. For example, for the proposed collaborative application, it shall provide feedbacks for the users after accomplish tasks together.
4. Managing and regulating interaction process.

When reviewing published papers were related to Collaborative Learning, there were a general pattern that they all emphasized the benefit of applying Collaborative Learning in technology-supported education as promoting communication and socialization between group members. Therefore, in this research, it defines Collaborative Learning as the grouping or the pairing elderly and younger children for the purpose of achieving academic goals using mobile devices. Collaboration was required and communication was improved among them. It proposed a Mobile Learning game between children and elderly users that embeded teamwork so as to trigger collaboration among them. The game required both older players and younger players completing tasks together. On one hand, by integrating teamwork into Mobile Learning applications in a more interactive manner helps not only to improve learning effectiveness, but also to strengthen social skills and relationship between children and elderly players to some extent. On the other hand, all of the above researchers emphasized the importance of facilitating social communication and interaction when applying Collaborative Learning. In the context of this research, by restricting the players to be co-located for the proposed Collaborative Mobile Learning game helps to improve communication and social interaction with each other. They have to be face-to-face in order to play it. In addition, Collaborative Learning enhances critical thinking as well as teamwork skills which are fine characters that comtemporaty students should posess (Gokhale, 1995). Collaborative Learning encourages learners to take ownership of their own learning. Even more, it helps learners to foster the ability in terms of self-regulation as well as problem-solving.

Along with the flourishing advancement of modern technologies, they have been used to support Collaborative Learning to achieve various academic goals for decades in which learners are divided into groups and are mutually engaged in the learning activities (Kreijns, Kirschner & Jochems, 2003). In Collaborative Learning, with its theoretical base in social culture, students are divided into pairs, groups or even communities of learning so that they could work with each other to form questions, discuss ideas and solutions, solve problems, complete tasks and reflect each individual's thinkings or experiences (Hsu & Ching, 2013). The recent interests in applying Computer-Supported Collaborative Learning (CSCL) represent a confluence of trend. There have been many successful examples for applying CL Computer-Mediated Learning systems over decades. For instance, the ENFI Project launched a collborative computer program to encourage students writing in a new way: introducing them with the idea of writing with a "voice" and writing with an audience in mind by providing fictional instructor. De Lucia, Francese, Passero, & Tortora (2009) conducted an experiment involving university students using the proposed CL environment, aimed at evaluating synchronous distance lectures. The results revealed synchronous communication and social interactions were enhanced by virtual environment. During observation session the tutors and the teachers noted that the students

were really motivated by adopting CL. These researchers have demonstrated the benefits of applying CL into learning process so as to promote learning efficiency and engagement. Similarly, along with the steady advancement of ML, it is also possible for introducing CL mechanism to ML applications. A set of researchers have analysed Collaborative Mobile Learning systems to find out if collaboration manages to promote successful learning. For example, S. Lewis, Pea, & Rosen (2010) proposed a social mobile application called “Mobltz”, which supported collaboration via mobile media in order to force a shift from the popular “participation” to “Co-creation”. Keeping this perspective, this research proposed a co-located Collaborative Mobile Learning game between elderly and children users. The game is based on the unique Chinese culture and requires collaborative between them. Co-located in this context stands for “face-to-face”. In other words, they have to be face-to-face to play the game. The reasons why it requires them are co-located are as follow. First fact is grandparents spend more time with grandchildren compared to their parents in China during their early childhood. They spend most of the spare time together, so there is no need for applying online communication for Collaborative Learning. Another fact is that it aims at not only improving English learning among them, but also encouraging communication between them. Potentially it will be helpful for decreasing social isolation and loneliness among them. In theory, it potentially offers several advantages when integrating Collaborative Learning, Game-Based Learning, and Mobile Learning, those advantages are: 1): bridge the gap between formal and informal learning by means of adopting Mobile Learning, making learning process more flexible; 2): Collaborative Learning makes learning process more interactive; 3): rich their daily life as well as strengthening the relationship between them; For example, elderly and children could play the game together in a long term, and 4): help users maintain brain active in order to stay healthy.

However, few crucial aspects must be addressed. First of all, what kind of collaboration mechanism would fascinate both children and elderly users. Culture differences should be taken into account. Just like Dillenbourg (1999) identified, learning mechanisms should be more intrinsically collaborative and not to be difficult to collaborate with. In other words, both elderly users and children would subjectively love to play the game with each other instead of forcing them. Secondly, all of these papers failed to mention that the way people interact with each other might affect the learning outcomes of Collaborative Learning. For example, because elderly people’s ability of fuctional senses generally tend to be inflexible and insensitive compared to children, so this study must keep a good trade-off in terms of conflicting requirements of both sides. For example, by adopting personalization with the co-located Collaborative Mobile Learning game, it should allow users to customize system settings, they could adjust system settings based on their preferences accordingly.

## **2.5. Flow theory**

Flow is one of the main reasons that people play games (Murphy, 2011), according to Csikszentmihalyi, Kolo, & Baur (2004), Flow is the mental state of operation in which a person performing an activity is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process of the activity. In essence, flow is characterized by complete absorption in what one does (Csikszentmihalyi, Kolo, & Baur, 2004). It is true since the primary goal of games is to create entertainment through intrinsic motivation, which is related to flow. Through the balance of skill and challenge the player’s brain is aroused, with attention engaged and motivation high (Rutledge). It is a commonly held belief that motivation plays an important role in education. Therefore, this study proposed an co-located collaborative Mobile Learning game for the purpose of

prompt motivation, engagement as well as communication among elderly users and children. Chen (2007) argued the use of flow in games helps foster an enjoyable experience that in return increases motivation and draws players to continue playing. As such, game designers strive to integrate flow principles into their projects, this research with no exception.

In order to prove adequately that collaborative Mobile Learning game does have influence with respect to motivation, this study adopted Malone's Motivation theory to measure the proposed collaborative Mobile Learning game may or may not motivate learners to learn. More accurately, it investigated whether the proposed collaborative game is able to contain intrinsic motivation, which Malone defined as including the following four primary components, those components are: challenge, fantasy, curiosity and control in accordance with (Alessi & Trollip, 2000). Furthermore, the research done by Goodnough (2012) discussed to what degree do educational games incorporate aspects of challenge, fantasy, curiosity and control pertaining to Malone's Motivation theory. Goodnough (2012) indicated challenge is arguably the most important of the elements associated with intrinsic motivation, it is also one of the most difficult to develop for. Adequate challenge is a critical component of motivation in education. If the challenge is too little, students will quickly get bored and become inattentive. By contrast, if the challenge is too great, the students will get frustrated or overwhelmed consequently they might give up. So Goodnough suggested find an reasonable balance between challenge and ability illustrates in Figure 3.

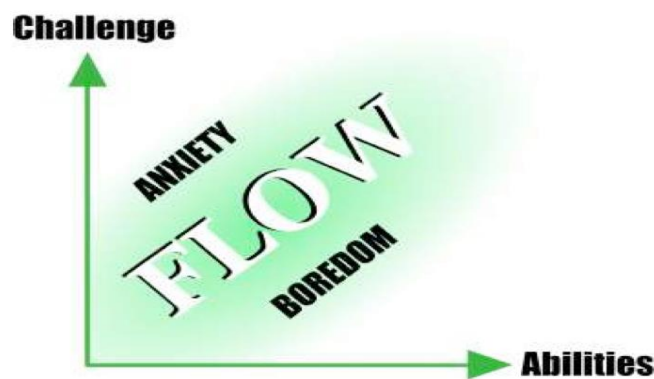


Figure 3: Flown as balance of challenge and ability. Source: (Chen, 2006)

Goodnough presented that game designers should take advantage of learners' curiosity for the purpose of exemplifying intrinsic motivation. Learning control helps the learner make a claim of ownership of activity and promote motivation by presenting learning with choice and feedback (Alessi & Trollip, 2000). All in all, there are 8 major components of which are as follow: 1): A challenge activity that requires skills; 2): The merging of action and awareness; 3): Clear goals; 4): Direct feedback; 5): Concentration on the task at hand; 6): The sense of control; 7): The loss of self-consciousness; and 8): The transformation of time.

After all, not all of the characteristics are necessary so as to improve intrinsic motivation, yet, the more they are integrated in an activity, the more effective it becomes (Alessi & Trollip, 2000). Therefore, when this study applied integrating collaborative Mobile Learning, it had to stick to the Malone's Motivation Theory. For example, it had to find the proper balance of challenge and ability when employed collaborative learning game between children and elderly users since individual's ability and preferences vary from each other, for example, elderly people generally tend to have slower reaction compared to children. But it is not easy to keep a reasonable balance between challenge and ability, so this research took a user-centered design approach that was an iterative



process, sets of tasks regarding usability testing were conducted. Additionally, certain game elements such as hybrid of text, image and animation were included so as to promote motivation. Audio feature is helpful for elderly people with hearing impairment. Considering intrinsic motivators “come from within the person” Alessi & Trollip (2001), they must be highly individualized in order to be effective. Hence, personalization shall be addressed even within the collaborative learning game. For example, it could provide system settings where users could set up settings according to their preferences or needs, such as relatively larger texts or icons, slower motion of game elements, and higher volume from the perspective of Universal Design.

## **2.6. Formative assessment**

Although the advancement of mobile technologies and wireless communication technologies has made Mobile Learning became more mature, by which learners are able to access educational contexts without being limited by space and time, however, there can be a lot of distractions when using mobile devices for educational purposes. For example, unexpected incoming phone calls or messages while learning. Concerns regarding learning efficiency has been widely discussed by researchers in education fields. How to prevent distractions so as to improve learners’ achievements has become a critical point when designing Mobile Learning environments. Precious theories have been identified by diverse previous researchers, they have emphasized the importance of formative assessment in well-designed learning systems in order to improve learners’ learning achievements. In other words, it has played an important role in designing Mobile Learning environments. This also applied to the co-located collaborative learning after all it targeted at improving English learning among older users and children in China. Based on this point of view, formative assessment has been widely recognized by educators and researchers as an important element in conducting learning activities for improving students’ learning effectiveness (Bell & Cowie, 2001), which is a process that provides feedback and support during instruction, such that teachers and students can adjust on-going instruction and learning to improve students’ achievement of planned instructional outcomes (Black & Wiliam, 1998). In fact, in traditional classroom-based teaching, formative assessment has been widely applied by integrating into the interaction between teachers and students. Teachers present learning materials to the students, and after that, tests or quizzes are normally carried out to ensure their learning achievements. So this could be applied to technology-supported education especially nowadays people are heavily depend on it. There were a lot studies indicate formative assessment has been applied into Mobile Learning systems. For example, the research done by (Hwang & Chang, 2011) introduced a Mobile Learning activity that was designed for elementary school students in order to guide them to understand the historical background. A pre-test and a post-test were developed to evaluate the learning effectiveness of the students. The collected data shows positive result that formative assessment is able to improve learning achievements. (Nicol & Macfarlane-Dick, 2006) stated formative assessment enhanced self-regulation that could help for students take control of their learnings. Thus, the proposed co-located collaborative integrated Mobile Learning game should embed formative assessment system in order to promote learning effectiveness. There are diverse different types of formative assessment can be adopted in Mobile Learning systems. For example, a short quiz after tutorial, score systems with rewards. Nevertheless, all of these papers failed to evaluate what types formative assessment systems are better in terms of enhancing learning effectiveness. But on the basis of the theories regarding to meaningful gamification and collaborative learning presented above, in this

research, formative assessment has been applied since the collaborative learning game requires players are co-located, which triggered more communication among them so that they could supervise each other, peer assessment was carried out. In addition, formative assessment happened when users tried to complete tasks by means of collaboration, self and peer assessment was conducted during this process to some extent. By adopting these theories, the proposed application not only helps promote the learners' learning effectiveness, but also motivates the learners.

## **2.7. Universal Design (UD) for Mobile Learning**

Another validate factor for this research is that it is important to develop a universally designed collaborative Mobile Learning game according to the concept: Universal Design. Forty-nine million individuals over the age of fifteen in America had some sort of different disabilities (Brault, 2009). The percentage of population with different kinds of disabilities is expected to increase in the future, and this situation is not quite optimistic in other societies. However, almost all kinds of current Information communication technology products and services create huge barriers in terms of accessibility for people with diverse disabilities such as motor impairment, hearing impairment and vision impairment. Moreover, under some special circumstances people without impairments or disabilities could be "disabled" at some point. For example, mobile applications only support specific mobile platforms; it would be difficult for users to pinpoint on the small touch screen size devices while they are running or on the bumpy roads; or it could be hard to see the touch screen clearly if there is strong sunshine reflection, culture differences like presenting English menus to people cannot speak English and etc. Universal Design encourages products or environments can be accessed without specialized design or situational variations. It could be applicable to many fields, ICT products or services without exception, and it is even more important to apply the theory of Universal Design to the field of mobile education systems, which requires designers supply users with appropriate assistive technologies so that to ensure basic accessibility for people with different kinds of users. Although design for individuals is great in which it could be problem solving, what about making products and environments can be accessible by everyone regardless disabilities or specialized adaptation? Universal Design was presented by previous researchers, which is a concept that intends to promote the accessibility level of products and environments that can be used effectively by all kinds of users without adaptation and stigmatization according to (Story, 1998). In the light of Mace's theory the principles of Universal Design indicate that the intention of Universal Design is that the design of products and environments to be usable by all people, to the greatest extent possible, without the need of adaptation and specialized design (Mace, 1997), they are: 1) Equitable Use; 2) Flexible in Use; 3) Simple and Intuitive Use; 4) Perceptible Information; 5) Tolerance of Error; 6) Low Physical Effort; and 7) Size and Space for Approach and Use. Therefore, from the perspective of Universal Design, below certain aspects shall be addressed when designing the universally designed co-located collaborative Mobile Learning game for children and elderly users. For instance, 1): **user diversity** must be included when apply UD in the collaborative learning game application, which is extremely crucial for this research since the target groups including older users and children, for instance, the variations of the ability of functional senses because of the degradation as people

getting older such as hearing impairment, vision impairment; conflicting individual's preferences or requirements as it is difficult for younger users to concentrate during a relatively long time in parallel to older people, and older people tend to have slower response to the associated actions or tasks; 2) **usability**; 3) **accessibility issues**. Guidelines have been recommended for mobile applications in order to regulate developers or designers when conducting Mobile Learning systems in which users are able to easily and effectively have some work done.

First of all, the primary goal of Universal Design is to create products or environments that can be accessible by all kinds of users without adaptation and specialized design, however, it is not about "one design for all", especially when takes user diversity into account, that was very important in this research since it targeted at both elderly users and children group, and it also might lead to conflicting requirements within user diversity. According to the research done by (Rinessi, Saiach, & Lecuna, 2000), they defined aging as the progressive loss of physiological functions that increases the probability of death. (Mercado-Sáenz, Ruiz-Gómez, Morales-Moreno, & Martínez-Morillo, 2010) summarized different theories regarding the aging process, the Neuroendocrine Theory developed by Dr. Vladimir Dilman elaborated hormones are vital for repairing and regulating the bodily function, and when aging causes a drop in the hormone production, it causes a decline in body's ability to repair and regulate itself as well. In our case, older users tend to have slower response, poor vision ability in parallel to younger users. For instance, older users require relatively bigger icon or font size, whereas younger users do not. In essence, it is not always possible for one design solution to meet all kinds of users' requirements. Assistive technologies or personalization was adopted when design universally designed products or environments in order to make them more accessible by all different kinds of users to the greatest. In the context of the co-located collaborative learning game, personalization was addressed in order to cope with conflicting requirements within users diversity. For example, it provided users with customized settings where user could setup the user interfaces based on their preferences. It also exploited currently built-in assistive technologies with mobile operating systems such as Screen-Reader, Zoom, Invert Colors and etc. For instance, with the help of mobile OSs integrated Screen-Reader like iOS: VoiceOver, Android: TalkBack, it would possible for people with visual impairment to user the application.

Regarding situational variations mention earlier, everyone might experience challenges in terms of situation variations while using mobile devices. Currently thanks to the advancement of modern technologies, efforts have been made by mobile manufacturers, some of these issues can be compensated, at the same time, some of the designers begin to realize the importance of those situational variations. For instance, major mobile manufacturers provide users with built-in screen reader in order to aid people with visual disabilities. Built-in sensors could detect the intensity of environment illumination and thereby auto adjusts the brightness of the screen. Customized settings allows users to setup bigger icons, texts or increase color contrast on the user interfaces for the purpose of reducing required efforts by users in some situations. There are three major mobile operating systems dominating the mobile market that offer different user experiences, such as iOS, Android, and WindowsPhone. From the Universal Design point of view, in order to develop a

universally designed co-located collaborative learning game on the base of this research, theoretically, it shall work properly regardless of different mobile platforms.

Universal Design also suggests sets of guidelines that cover a wide range of aspects that could regulate designers to make ICT products and services more accessible to all the different users groups to the greatest extent. While searching for mobile related guidelines applicable to this research, apparently, there is still lack of approach or even specific guidelines for mobile applications which only focuses on interaction with mobile interfaces and doesn't relate to web contents. However, (Bandeira, Lopes, & Carriço, 2010) identified Web Content Accessibility Guidelines (WCAG) and Mobile Web Application Best Practices (MWBP) as the two most relevant guidelines on ensuring web content accessible and mobile friendly. They presented a new approach to evaluate mobile web accessibility based on WCAG and MWBP. In this research, it adopted only one of the guidelines that suggested by Bandeira, Lopes & Carrico (2010) which is WCAG since it is mobile related. In addition, major mobile operating systems companies such as Apple, Google have introduced guidelines that cover lists of aspects so as to make corresponding mobile applications more accessible to their platforms. For instance, Apples' Accessibility Programming Guide for iOS, Googles' Android Accessibility Testing Checklist.

In order to develop a universally designed co-located collaborative Mobile Learning game, this study took an iterative design approach "user-centered design approach" in which user requirements and user diversity were addressed based on several related research methodologies, such as interview and usability testing. In this research, it proposed the model of the co-located collaborative Mobile Learning game based on literature review illustrates in Figure 4. A collaborative educational Mobile Learning game is developed which aims to guide elderly users and children in English learning, and also to improve communication as well as socialization at the same time. Pre-interview was conducted to collect the ideas towards collaborative learning from representative users, usability testing was carried out in different stages through the whole process of the development, which aims at evaluate both underlying usability and accessibility issues regarding the proposed prototypes. Theoretically, the co-located collaborative Mobile Learning game enables the collaboration between elderly and children users while playing games. In other words, it integrates collaboration mechanism between players by asking them to accomplish tasks step by step using mobile devices. It also embeds those are considered as interesting elements such as figures, animation and audios game elements in order to increase the joy of learning. Special aspects must be emphasized while applying gamification in this research such as scoring system, difficulty levels in order to create meaningful gamification according to Nicholson's theory so that motivate and engage players during learning process. All in all, it potentially offers several advantages, they are: 1): it helps users improve English learning; 2): it requires both brain active and physical practice, which might be helpful for both elderly and children staying healthy; 3): it riches their daily life as well as strengthens the relationship between them; and 4): it makes learning more interesting and players more engaged.

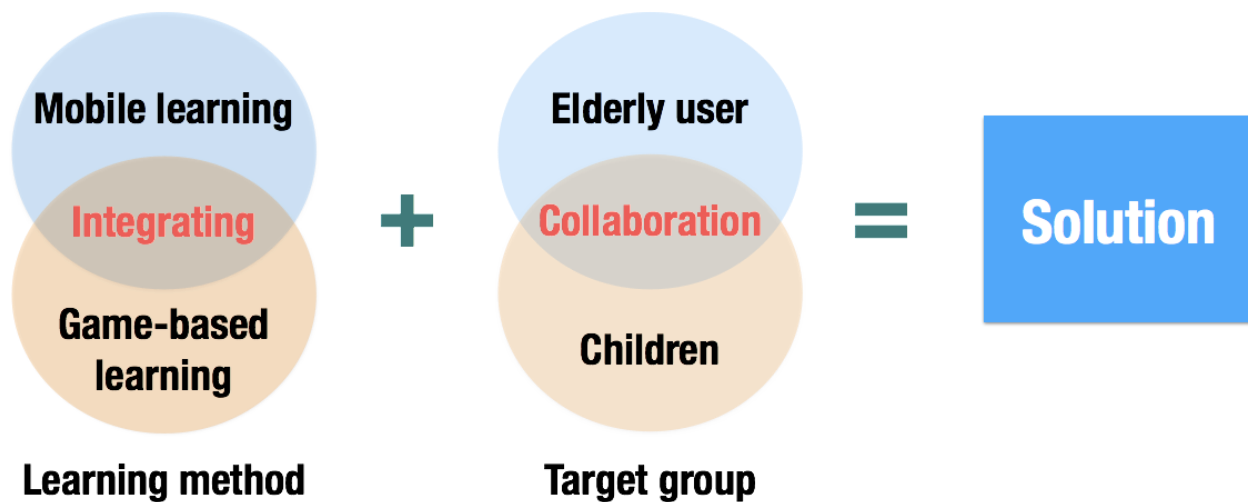


Figure 4: Co-located Collaborative Mobile Learning application model in this research

### 3. Design issues

Through background studies and literature review, the author clarified the need of integrating Collaborative Learning with Mobile Learning. Although there are numbers of applications or programs have been well developed regarding English learning on the mobile market, most of them are designed for individuals. In other words, they are fully depending on individuals' preferences and require individuals accomplishing tasks by themselves. Consequently, learning process tends to be less attractive and engaging to some extent. It is important to emphasize the main research contribution of this research is the proposed mobile game requires collaboration between elderly people and children these two unique target groups. Yet, how to apply collaboration between them users in the game, how to stimulate collaboration between elderly and children by adopting some sort of game which is neither somewhat complicated, nor too shallow in order to encourage both players to engage the learning process. There are also some conflicting requirements within user diversity shall be addressed since the way a mobile user interacts with other community or group members tends to be more variable, asynchronous, and heavily dependent on the user's current context, activity, or interest (Sacramento et al., 2004). For example, varied individuals' ability in terms of physical function senses and personal preferences. Hence, before developing the actual game, in order to identify the user requirements, two relevant preliminary studies regarding popular English learning mobile applications were carried out. Former one was mainly focused on what kind of game features or elements shall be adopted in this research for improving learning motivation and engagement. Latter one was merely concentrated on what kind of gaming mechanisms would be suitable for encouraging collaboration between elderly users and children. In addition, further discussions certain aspects were conducted from the point of view improving accessibility level of the design artifact. For example, ensure a universally designed User Interface for the proposed application. Addressing conflicting requirements with group learning and individual learning in terms of user diversity.

### 3.1. Crucial elements for the application

AppCrawlr offers lots of features to help users or researchers to find all types of mobile applications suit their needs and requirements across diverse platforms such as iOS, Android, Windows Phone devices. However, the author failed to find any Collaborative Mobile Learning applications regarding language learning. So instead, this paper firstly surveyed these following 5 most popular and top rated applications that are either designed for kids or older users based on educational purposes, they are 1): Fun English, 2): Memory, 3): Duolingo, 4): Grammarpolls and 5): English Learning Game Pack-Ottercall. A detailed comparative study was conducted in order to reveal basic elements that are essential for the proposed co-located collaborative game-based learning application. The results indicate that commonly implemented features or elements in educational mobile game applications are images, animation, audio, formative assessment and etc. Below Table 3 depicts the learning outcomes.

Table 3: Comparative study of typical educational applications regarding English learning

App	Image	Audio	Video	Animation	Gaming	Theme-based	Formative assessment	Collaboration
Fun English	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Memory	Yes	No	No	Yes	Yes	Yes	Yes	No
Duolingo	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Grammarpolls	Yes	Yes	Yes	Yes	No	Yes	Yes	No
English Learning Game Pack-Ottercall	Yes	Yes	No	Yes	Yes	No	Yes	No

First of all, all of these 5 applications contain multimedia elements such as image, audio, and video etc. But considering the storage size of videos, it is not very common for applications implanting videos. Nearly all of them implanted animation and gaming mechanisms in order to enrich joyfulness of learning process. Besides, almost all of them applied theme-based learning, which refers to integrating one of the most familiar topics that are attractive to users such as numbers, animals, and colors. Formative assessment is one of the most determining factors in order to promote the learning efficiency and effectiveness. It is worth mentioning that all of these 5 applications present users with relatively bigger icons and texts in the User Interface implementation in comparison to other applications we normally use, this could be a validate checkpoint for this research. In short, the

general implementation of Mobile Learning applications regarding language learning includes multimedia elements, animation, game mechanisms, formative assessment, theme-based learning and etc. However, after reviewing all these mobile applications, a distinct pattern was gathered that there was barely collaboration mechanism required in existing mobile applications markets, which requires collaboration between players to accomplish tasks. Although some of them offer multiplayer options, they demand online communication and drive competition among players (“players VS players”) rather than collaboration. This would not be usable for this research since it requires players to be co-located. Even more, there are few applications have been designed for both elderly and children users together. It can be the highlight of the proposed co-located collaborative Game-Based learning application within two different user groups if Collaborative Learning is included. In conclusion, crucial elements for the proposed mobile collaborative learning game are: images, audios, animation, gaming, formative assessment, and most importantly: collaboration.

There are numbers of mobile games have been developed for educational purposes. For different target groups, developers have designed diverse types of mobile games, such as Strategy, Card-Battle, Social-Turn Based and etc. Another issue has to be considered when integrating Collaborative Learning with Game-Base learning methods. What kinds of gaming mechanisms are considered to be suitable for the older users and children, especially in China in terms of promoting learning motivation as well as learning engagement? This study conducted a relevant comparative study regarding best gaming implementation applications for elderly people and children in accordance with [AppCrawler](#)'s recommendation, they are: 1) Memory Matches; 2) Plexiword Word; 3) Word Monsters; and 4) Play 3D Animal Match Cards - Fun Game for Kids and Older People. Unlike former comparative study, the intention of the latter comparative study was to discuss what genres of mobile games would be suitable for both children and elderly users. The results summarized common gaming implementation mechanisms such as Strategy, Card-Battle, Social Turn-Based and etc. Below the Table 4 presents the outcome of the latter comparative study.

Table 4: Comparative study of common gaming implementations in mobile applications for elderly people and children

App/Gaming type	Strategy	Card-Battle	Action	Social Turn-Based	Multiplayers	Collaboration
Memory Matches	Not applicable	Yes	Not applicable	Yes	Yes	Not applicable
Plexiword Word	Not applicable	Yes	Not applicable	Not applicable	Not applicable	Not applicable
Word Monsters	Not applicable	Not applicable	Yes	Yes	Yes	Not applicable
Play 3D Animal Match	Not applicable	Yes	Not applicable	Not applicable	Not applicable	Not applicable

Through the second comparative study regarding gaming mechanism implementation, the results indicate that in general, Card-Battle and Social Turn-Based are implemented more often when adopting Game-Based Mobile Learning. Strategy and Action are least implemented partially because they are too complicated for younger users to play. Collaboration was not adopted among those 4 representative applications. However, the comparative study failed to demonstrate which gaming mechanism would be more appropriate in the context of the target groups elderly people and children in China, which lead this paper with more focus on others' work in terms of general gaming mechanisms. Besides, vital issue of applying mobile Game-Based learning is to ensure customers' loyalty, for the purpose of enhancing long-term learning rather than short-term.

On the basis of a report on Flurry (2012), by comparing how long users continued to use top 9 free mobile game categories over time to how often they were used, the report leveraged a "loyal matrix" sample. In this scenario, they plotted 90 days retention among more than 300 million consumers using iOS and Android games. In conclusion of their work, Card-Battle gaming is at the least usage frequency position in terms of mobile game loyalty matrix while Social-Turn Based as well as Casino/Poker showed great deal of potential in terms of usage frequency during the 90-day retention experiment. In other words, Social-Turn Based as well as Casino/Poker offers more potential of attracting consumers at a relatively long term in comparison to Card-Battle gaming. They also laid out a demographic chart that showed the Age and Gender of users by diverse genres. Generally, despite of gender variable, younger users prefer Card-Battle gaming while older users prefer Casino/Poker gaming or Social Turn-Based gaming. For example, nearly most of the applications presented above applied Card-Battle gaming mechanism. Not to forget, Chinese Chess is one of the most widely played strategy board games worldwide, being played by approximately over one billion people in China, Taiwan, wherever Chinese have settled. Chinese Chess is also a two-player Collaboration with a complexity level similar to Western Chess according to (Chen, Yang, & Hsu, 2004). Therefore, based upon this, in order to balance the preferences of both sides, the proposed Collaborative Mobile Learning game should combine Card-Battle gaming with Social Turn-Based gaming mechanism such as Chess, Backgammon and Go. It not only requires players' collaboration in order to accomplish tasks, but also promote communication between players. From the perspective of "flown theory", on one hand, it suggests games should not be too difficult, which might cause frustrating feelings for users. On the other hand, it suggests games should not be too simple. In this case, Card-Battle gaming is too easy for elderly users while Social-Turn Based gaming like Chinese Chess with complicated strategy is relatively too difficult for younger users. Hence, in this work, it applied Social-Turn Based Chinese Chess gaming mechanism to Card-Battle gaming while abnegated the perplexed strategy rules of Chinese Chess. So by doing this, it makes the application more user friendly for both elderly users as well as children, and Collaborative Learning is implemented.



### 3.2. Device

Along with the pervasive expansion and proliferation of mobile devices, we are being faced with the world that everyone is accustomed to the daily use of mobile devices. In the light of the report on (THE RADICAL GROUP, 2014), the number of worldwide mobile users reached over 5.6 billion in 2014, by the end of 2018, this number is expected to increase to over 6.2 billion. Roughly 84% of the world population will be using mobile devices by that time. This situation is almost the same in China. Likewise, the number of mobile devices subscribers in China has been skyrocketing since 2011. The market for mobile subscribers reached a new level in terms of saturation in 2012, with 89 percent of the population using a mobile device, and the number of mobile users will reach 1.3 billion by the time of early 2015 according to (Statista, 2015). Statista is one of the world's biggest statistics portal, providing users and researchers with access to relevant data from over 18,000 sources, this increases the statistics validity used in this research. Overtime, even though there are sets of mobile devices hardware manufacturers, there are three major dominating mobile Operation Systems (OSs) in the industry, they are iOS, Android and Windows phones. Each of them has built their own empire, and offers distinct user experiences for the corresponding platform. Although the primary goal of this research is to develop a universally designed co-located collaborative Mobile Learning application, it implies it should function consistently regardless different mobile platforms theoretically. However, due to time limitation as well as mobile OS popularity consideration in China, Android tablets were chosen as the mainly supported devices in this research, the reasons why they were chosen are as follow.

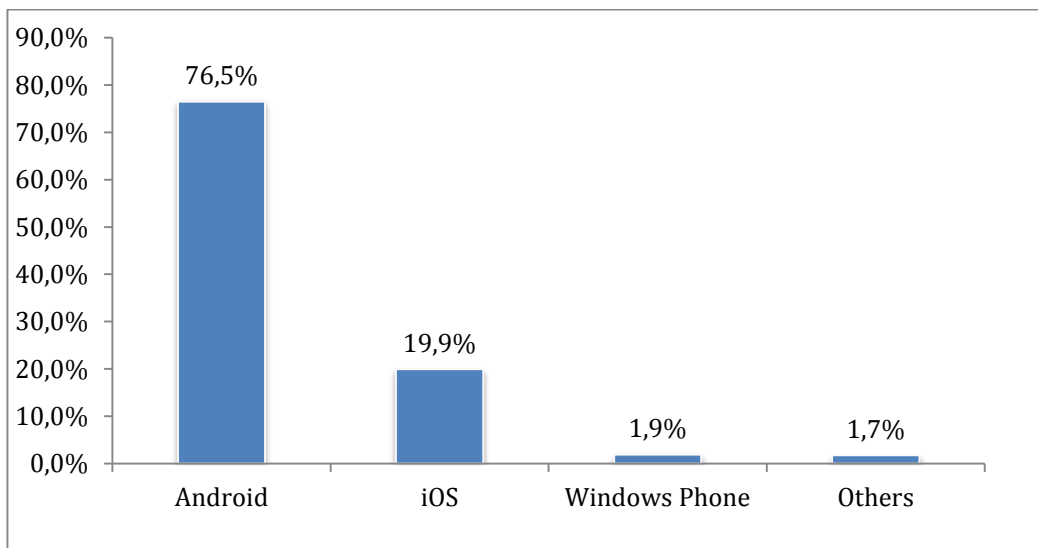


Figure 5: Market share held by smartphone operating systems in China 2014, by share of the Internet traffic.

Source: Statista

According to Statista, Figure 5 indicates mobile OS market sharing situation in China. Obviously, Android OS dominates the market, by sharing 76.5% of mobile OSs by the time of 2014, roughly

sharing the market over 3 times than iOS. In other words, Android devices generally are considered more accessible in terms of popularity and more widely used in China.

As we all know, unlike desktop devices, user experience is decreased in a relatively small screen size. Sometimes, it can be very difficult for users to navigate between different contexts consistently within a small screen size. In this research, for the purpose of providing better user experience while using the proposed co-located Collaborative mobile game, it chose tablets that offer relatively bigger screen size against cell phones. This is extremely important since the target groups including elderly people and children. They might have difficulties in using the application on the small size of touch screen. Cognitive overload may occur in a smaller screen device in which could lead to bad user experiences. For example, if users set up bigger icons or font sizes for the User Interface according to their preferences, tablets that bigger screen size let users navigate within different contexts and perform tasks at a higher level in terms of consistency. On the contrary, it will be very difficult for users to navigate within application on a smaller screen size. In addition, the proposed game not only aims at promoting engagement as well as motivation for the learners, but also helping increasing communication and socialization among children and elderly people in China by requiring both sides to be co-located. In other words, it requires them sitting in front of each other while playing the game, communication is promoted between them at the same time. By this, learning while moving is disabled to some extent. Thus, without over stressing the mobility of learners while using the proposed collaborative game in this research, it adhered to tablets other than other smart phones for the purpose of optimizing the user experiences while using the proposed application.

Table 5: List of most popular tablets on the market

	iPad Air 2	Samsung Galaxy Tab® 10.1	Microsoft Surface 3
Operating system	iOS	Android	WindowsPhone
Display size (inch)	9.7"	10.1"	10.8"
Storage (GB)	16	16	64
Resolution (pixel)	2048*1536	1280*800	1920*1280
Price (\$)	499	349	499

Table 5 lists out 3 most popular tablets in the industry regarding those three major mobile OSs, iOS, Android and WindowsPhone. From Table 5, despite of the variations of other hardware configurations such as storage, screen resolution and etc., Android tablets hold a distinct advantage over other mobile platforms in terms of price friendly. They are more affordable to people in comparison to iPads and WindowsPhone tablets, not to mention the popularity of Android devices in China. Therefore, Android tablets will be the mainly supported devices for future testing in terms of accessibility and usability about the proposed collaborative application in this research.

### **3.3. Graphical User Interface matters**

Graphical User Interfaces (GUIs) plays an essential role in computer as well as mobile

applications designs especially for mobile applications. As we all know, unlike computers, mobile devices generally have relatively smaller screen size, how to optimize mobile performance. Let users capture all the information to the greatest extent at a low lever in terms of efforts has become a major problem for every mobile designer should take into account. In the light of (Toby, 2001), GUIs simplify the usage of computers by means of presenting information in a way that allows intuitive acculturation and manipulation. Using visual widgets to mimic physical objects such as “switches” or “buttons”. No matter how fancy of applications’ functions have been developed, yet it is the GUI ultimately presents itself to users. A good GUI implementation allows users to navigate within the application itself easily at a relatively low effort. On the contrary, poor GUI implementation might lead to distractive, frustrating, high effort required in terms of user experience. Since the primary goal of this research is to develop a universally designed Collaborative Mobile Learning game, it is essential to guarantee accessibility in User Interface (UI) implementations. In practice, accessibility is about designing user interfaces so that more people can access the products in more situations according to (Henry, 2006). In order to make the user interfaces for the proposed game to be perceivable, operable and understandable, a set of guidelines were considered as standards for designing accessible user interfaces for elderly and children. For example, Android Best Practices for User Interface, WCAG and etc. In this study, these 4 key factors were mainly considered in the GUI implementation for the proposed application, 1): color combination; 2): color contrast; and 3): font type; and 4): Android Best Practices for User Interface.

- Color combination

The first impression is everything! Everyone probably get a person's general character from his or her appearance. Likewise, this theory may be applicable to the process of GUI design. There might be sets of factors that affect GUI design work for many reasons, but color always comes to the first priority. Color reflects the overall feeling of the design. Sometimes, color itself can reveal a person's emotions, feelings and even memories. To make the user interfaces more appealing to users, colors need to be implemented. Android Developer suggests Android designers with Color Palette to select colors that fit their own purposes (Google, n.d.). Below Figure 6 shows Android Developer Color Palette. Colors adopted in this research were based on Android Developer Color Palette recommendations.

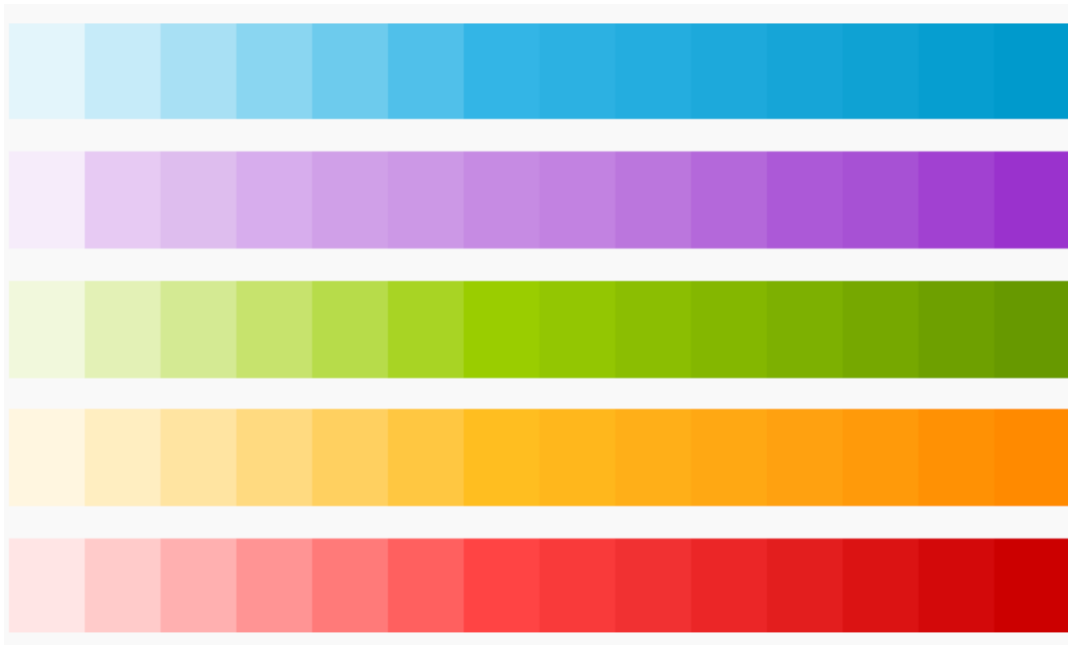


Figure 6: Google Android Developer Color Palette

There are wide ranges of factors affecting choosing colors for this project. For example, studies have approached different conclusions regarding if gender differences could lead to variations of color preferences. However, since either male or female users could play the proposed game, so the variations of color preferences regarding gender differences were not included in this research. Instead, it mainly focused on cultural differences since the target groups are users from China. Madden, Hewett, & Roth (2000) conducted a cross-nation study of color regarding cultural differences among 8 countries including China. The results showed different meanings of same color in different cultures. For example, blue was perceived as cold in the US while loyal in China. Blue was rated as the most favorite color in 5 countries out of 8 while Red as the most favorite color in China. However, from the UD point of view, some users may have red-blue color blind. It will be difficult for them to use the application with excessive use of red. Hence, blue was adopted as the main theme for the proposed application.

Besides, it is important to mention that it is better to create a direct representation in GUI implementation. In other words, good GUI design reflects brand, target groups or initiative of the applications. For example, owing to the fact that main stakeholders of this research were children and elderly people, so it will be better reflect the target groups in GUI implementation. Following Figure 7 depicts the target groups of the proposed application during the user interface design.



Figure 7: Target groups' representatives in GUI implementation

- Color contrast

Another key factor in GUI design is color contrast when combining sets of colors in GUI implementation. Color contrast shall be addressed in this process to ensure accessibility. For example, poor color contrast between widgets or controls in user interface will be difficult to see clearly for people with visual impairment. Color contrast refers to the contrast between foreground color and background color. Color contrast is crucial to GUI design. Guidelines as WCAG, MWBP and Android Best Practices for User Interface emphasized the importance of color contrast. Indeed, good color contrast in different visual components or widgets offers users with good user experiences, especially in mobile applications design because information retrieval is relatively difficult in limited screen sizes in comparison to computers or laptops. Below Figure 8 demonstrates the differences of different color contrast ratios. Obviously, on the premise of same foreground color, left part of Figure 8 will be considered easier to see clearly than the right part of it.



Figure 8: Color contrast differences demonstration

- Font

Unlike computers or laptops, mobile devices have less supported font type. It is important to adopt appropriate font type in the GUI design so that it is easily to read without much effort for the users.

### **3.4. Collaboration and individual learning**

On the basis of previous empirical researches, the problem regarding learning efficiency can be fairly addressed by applying Collaborative Learning. Under certain circumstances Collaborative Learning is considered as more effective than learning alone. For example, in the context of this research, it could be difficult for younger children to fully concentrate on the tasks at a relatively long time span. By adopting Collaborative learning, peer-regulation is triggered at some point. Partners could play a role of supervision for each other. In such case, elderly users could supervise younger children to ensure learning efficiency. Not to mention, collaborative learning enhances critical thinking as well as teamwork skills.

Problems might occur when apply Collaborative Learning in this work. The way a mobile user interacts with other group members tends to be more variable, asynchronous, and heavily dependent on the user's current context, activity, or interest (Sacramento et al., 2004). Since the initial goal of this research is to establish collaboration two different target groups: elderly and younger users. From the perspective of Universal Design, user diversity could lead to many distinct conflicting requirements among users. For instance, the way individuals interact with mobile devices could vary from each other, not to mention the variations of individuals' preferences and abilities. Some might prefer relatively smaller font size while the others prefer bigger ones. In addition, compared to younger people, older people generally tend to be physiological function degradation that results in limitations of physical functions. Therefore, in order to compensate those conflicting requirements between both sides and keep an appropriate trade-off. Ideologically, personalization is adopted for the proposed mobile application for the purpose of making it more universally designed. Personalization in this context means allow users to configure user interfaces based on their preferences accordingly. Therefore, the proposed game should provide users with customer settings, where they are allowed to customize user interfaces settings such as font size, speed of elements' motion, audio prompts and etc. accordingly. By doing this, user diversity is proper addressed and makes the user interface is more accessible for more users.

As Figure 9 illustrates, the proposed application divides the screen into two parts. Left one will be for children and the right part for elderly. In practice, it allows users to personalize user interfaces according to their preferences on the same touch screen. This is used to improve the accessibility of the user interface. However, problems might occur while letting users personalize user interfaces on the same screen. For example, to what extent the personalization should consent to users. As how big of font size and icons would be appropriate in the limited screen size while without affecting user experience. These values need to be found out in the future usability testing. Besides, personalization was validated in accordance with Nicholson's theory. He indicated to create meaningful gamification when applying Game-Based Learning, it is important to allow users to setup their goals freely which simply implies allow users to take ownership of learning, and making learning more active which is also crucial for Collaborative Learning.

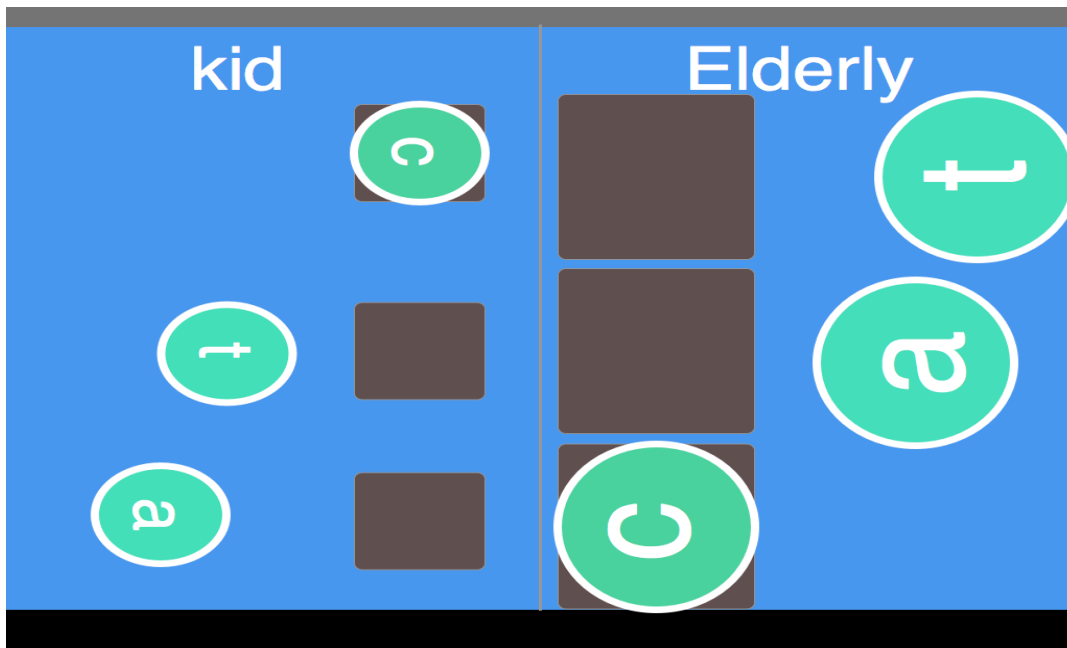


Figure 9: User interface personalization on the same touch screen

### 3.5. Technical features

The technical requirements for the developing, debugging, testing the co-located collaborative learning game were the following:

1): The Eclipse with Android development tool (ADT) Integrated development environment (IDE) and Android version: “Jelly Bean” Software development kit (SDK) 4.2. The version used in this work was Eclipse JUNO and Android SDK 4.2.2.

2): An SAMSUNG tablet with Android “Jelly Bean” operating system. The version of Android operating system was Android 4.2.2.

This study used object-orientated programming language: “Java” to develop the application. In addition, it applied AndEngine Open graphic library (OpenGL), which is a broad free 2D game engine that allows game developers, both experienced and inexperienced, to develop games for Android platform with ease in according to (AndEngine OpenGL, n.d.).

3): Main algorithm implementation: according to AndEngine documentation, a standard AndEngine application must extend from BaseGameActivity, and override those following methods in order as illustrates in Figure 10.

onLoadEngine () → onLoadResources () → onLoadScene () → onLoadComplete ()

```

public class MyActivity extends BaseGameActivity {

@Override

public Engine onLoadEngine() {

return (new Engine object);

}

@Override

public void onLoadResources() {

return null;

}

@Override

public Scene onLoadScene() {

return (new Scene object);

}

@Override

public void onLoadComplete() {

return null;

}}

```

Figure 10: Main algorithm implementation of the proposed application

## 4. Methodology

This section presents the research methodology used in this project and the reasons why they were chosen. To develop a universally designed co-located Collaborative Mobile Learning game, this research integrated accessibility into User-Centered Design approach. The process was experimental, descriptive and iterative. Several associated research methodologies were used in order to cover more details in terms of usability and accessibility issues, such as semi-structured group interview, usability testing, and observation were conducted during usability testing. Heuristic evaluations were



conducted based on Android Accessibility Testing Checklists to reveal accessibility issues of the prototype. In the following sections, the research methods used will be described in more details.

#### **4.1. User-Centered Design (UCD)**

Multiple techniques have been proposed by numbers of previous empirical researchers, they were used for ensuring the usability and accessibility of Information and Communication Technology products or services. In accordance with (Haklay & Nivala, 2010), Human-Computer Interaction (HCI) is a discipline concerned with the design of technological artifacts that are effective, efficient and satisfying to use. In short, HCI takes a User-Centered Design approach to design. The theory of UCD is ensuring that user's requirements and goals are the primary considerations at every stage of the process. UCD process involves usability issues, user characteristics, tasks of design artifacts (Abrams, Maloney-Krichmar, & Preece, 2004) while accessibility focuses products can be usable for a wide range of people including people with disabilities in a wide range of circumstances. Therefore, in order to properly address various user requirements to the greatest extent, and make the design artifacts more universally designed when design the co-located Collaborative Mobile Learning game in this study. In this research, it followed (Henry, 2007) theory that integrates accessibility into UCD process. Furthermore, since the target groups are mainly focus on elderly and younger users. They are respectively very unique because each individual's requirements might differentiate from each other in terms of individuals' abilities and preferences. It will be more suitable for this research that integrates accessibility into UCD process in order to address underlying usability and accessibility issues of the prototypes.

According to International Organization for Standardization (ISO) 9241, the 6 key principles of User-Centered Design are: 1): The design is based upon an explicit understanding of users, tasks and environments; 2): Users are involved throughout design and development; 3): The design is driven and refined by user-centered evaluation; 4): The process is iterative; 5): The design addresses the whole user experience; and 6): The design team includes multidisciplinary skills and perspectives. ISO 9241 – 210:2010 identified few essential activities in line with UCD approach, and they are: 1): Understand and specify the context of use; 2): Specify the user and organizational requirements; 3): Produce design solutions (prototypes); and 4): Evaluate designs with users against requirements

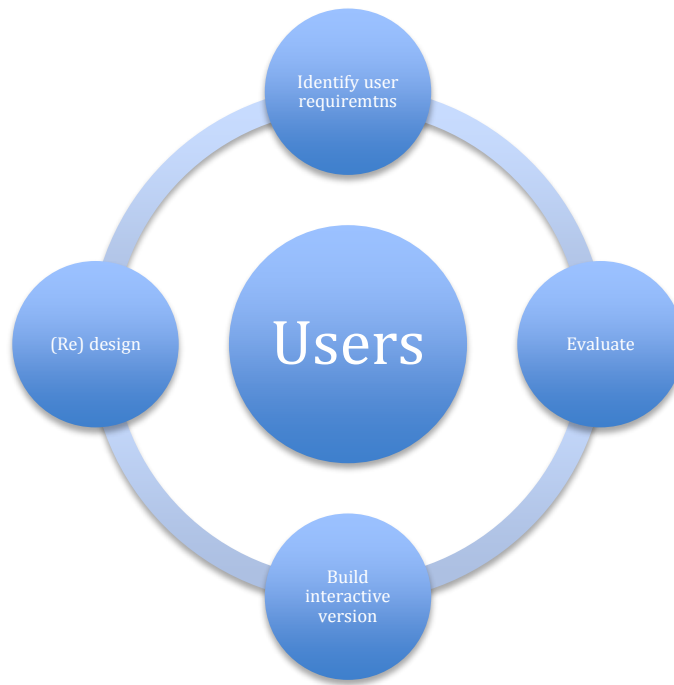


Figure 11: A User-Centered Design model

Table 6 summarizes the set of guidelines regarding UCD approach according to ISO 9241 – 210:2010

Table 6: Set of guidelines regarding UCD approach according to ISO 9241

Guideline	Description
1: Identify user requirements	Foremost, understand and specify the context of use, and identify different user requirements.
2: Produce design solutions, and build interactive prototype	On the condition of guideline 1, find possible solutions and build functional prototypes for further evaluation.
3: Evaluate designs according to user requirements	Evaluations shall be carried out to reveal latent usability and accessibility issues.
4: Redesign and evaluate	On the basis of data collected after Guideline 3, analyze data and redesign shall be implemented. At the end of evaluation, researcher should iterate back to try to improve the usability and accessibility of the prototypes.
5: User-Centered	Make sure users are located at the center of the development, which means users must be involved during the whole process of the development.
6: The process is iterative	Make sure the development process is iterative to improve the effectiveness of the design artifacts.

Hence, in order to identify and refine the detailed user requirements, usability as well as accessibility issues of the prototype so as to provide users with better learning experience while using the proposed Collaborative Mobile Learning game, this study must elaborately stick to the

User-Centered Design model as Figure 11 illustrates. Additionally, various supportive research methods were carried out to gain further constructive feedbacks from the users. The author of this project played the moderator role in different research methods.

#### **4.1.1. Participants characteristic clarification**

Participants who will be involved during the whole UCD process must represent real users who are the members of group people will be using the proposed application. Due to elderly and children users are the main stakeholders of this study, so the participants would be selected from these two certain groups. Besides, they have to have or had experiences with living with grandchildren or grandparents. Regarding how many participants would be sufficient for collecting user requirements and validating design artifacts evaluation to improve the effectiveness of them, previous researchers have argued this very often. Lazar, Feng, & Hochheiser (2010, p.263) pointed out by now, “five users in usability evaluation “ is part of the HCI lore. Based upon this, this project abided to the “five users in usability evaluation” lore. It is worth mentioning that generally in China, the retirement age for elderly is 50 for female, 55 for male. The age for younger children attending school is around 5 years old. Hence, 10 people in total were divided them into 5 groups who represent users from both elderly and children. 5 older representative participants were aged from 50-73, younger participants were from age range 2-5 years old. Gender variable was ignored in this research. Selected participants had varied knowledge level in terms of using mobile devices. User-Centered concept was addressed at some point since theoretically the proposed application will be used for all the targeted users regardless their knowledge level of using mobile devices or applications. Concerning English literacy, all of these participants were English illiterates. They had no English learning experience before so that this research could test out whether the proposed application is helpful for improving English learning. On the basis of UCD theory, UCD requires the development process is iterative. These 10 participants were involved during the whole life circle of the application development from the early concept design stage till final functional prototype. They some of them are currently living with each other while some had experiences in taking care of their grandchildren, which conforms to the background of this research. In addition, a kindergarten teacher who has been working in a kindergarten around 10 years was considered as the expert, she was only included in in the pre-interview session to gain feedbacks from expert’s thoughts regarding Collaborative Learning. Table 7 lists out participants’ characteristic for this research. Pseudonyms were used in order to protect the actual participants’ identity and privacy. Nevertheless, participant consent forms were given to them or younger participants’ parents to brief and seek for their certification for consent (Refer to Appendix for Participation Consent form).

Table 7: 10 participants' characteristics

Pseudonym	Age (years)		Platform	If with any disability		English literacy		Knowledge level of using PDA devices	
	Gender(M/F)			Elderly user	Children	Elderly user	Children	Elderly user	Children
	Elderly user	Children							
Group1	73 F	3.5 F	Samsung tablet	Presbyopia	None	English illiterate	New user	New user	
Group2	64 M	4.5 M	Android 4.2.2	None	None	English illiterate	New user	Experienced user	
Group3	55 M	5 F		None	None	English illiterate	Experienced user	Experienced user	
Group4	58 F	2 F		None	None	English illiterate	New user	New user	
Group5	50 F	4 M	None	None	English illiterate	Experienced user	New user		
Expert	35 F			None		Some		Experienced user	

## 4.2. Semi structured focus group interview

Although survey is one of the most commonly used research methods across all the fields of research, not just Human-computer interaction (HCI). Surveys are used to collect quantitative information from large numbers of population and gaining the relatively “shallow”, “general” thoughts of the topic (Lazar, Feng, & Hochheiser, 2010, pp. 100-123). As a result, survey somehow ended up being broad but not deep. However, interview came in as an alternative approach according to Lazar, Feng, & Hochheiser (2010, pp. 176-215). Direct conversations with fewer focused participants can provide prospective, constructive and useful qualitative data while surveys might miss. Hence, semi-structured interview was chosen because this study wanted to study further regarding how the participants thought about the proposed integrating Collaborative Mobile Learning game; and the collaborative gaming mechanism adopted in the proposal, and allow some constructive or new ideas from participants to be brought up during the interview session. First of all, this study identified the participants for interview (Refer back to Table 7), then it modified the interview questions that need to be neither too broad nor too specific.

At the early stage of proposal, the intention of interview was to make sure whether the users embraced the idea of Collaborative Learning while playing the conceptual application using mobile tablets. Focused groups interview consisted of all of those 11 participants who led by a moderator (the author). In this session, in order to investigate participants’ attitudes towards Collaborative Learning by means of using digital devices, the moderator guided participants through discussions on set of questions regarding Collaborative Learning. First of all, it abided to Think Aloud Protocol, which allowed them speak out their opinions regarding the concept of Collaborative Learning (Jaaskelainen, 2010). If it was not promising, 5 older participants and a field expert were asked to rate the Likert Scale form on a scale from Strongly Disagree, Disagree, Uncertain/Not applicable, Agree, Strongly Agree, to what extent do they agree or disagree with the following questions listed in Table 8. However, 5 children were assumed not able to understand properly regarding those questions, so instead they were asked whether they agreed or disagree with those questions listed in Table 9. The answer should be Yes or No or Uncertain. Interviews were conducted online via using QQ video chat while the moderator was abroad. Before interview, they were presented the Participants Consent Form to seek their consent. Interview was conducted in two days, approximately 60 minutes.

Table 8: Interview questions for 5 older participants (50-73) regarding Collaborative Learning while using digital devices

Interview questions	
1.	Compared to traditional learning methods, how do you agree using digital devices such as cell phones, tablets, iPads to learn English?
2.	How do you agree the idea of learning while playing?
3.	How do you agree the idea of having your grandchildren or children learning together (Collaborative Learning)?
4.	How do you think it would be helpful for decreasing social loneliness and isolation among elderly people and children by having them playing together?

5.	Other comments
----	----------------

Table 9: Interview questions for 5 younger participants (2-5) regarding Collaborative Learning while using digital devices

Interview questions	
1.	Compared to traditional learning methods, do you like using digital devices such as cell phones, tablets, iPads to learn English?
2.	Do you like the idea of learning while playing?
3.	Do you like the idea of having your grandparents or grandchildren learning together (Collaborative Learning)?

### 4.3. Usability Testing

Usability testing refers to tests that involve representative users from target groups attempting identified tasks regarding products' usable features in representative environments on early stages prototypes of computer interfaces in the light of (J. R. Lewis, 2006). In accordance with ISO 9241, usability is defined as the effectiveness, efficiency and satisfaction with which representative users achieve specified goals in specified environments. In the context of the co-located collaborative learning game, it defines effectiveness as the accuracy in which users can complete representative tasks successfully without too much errors. While requiring time and efforts to representative tasks are defined as the application's efficiency. Finally, the comfort, acceptability, and attraction of the application, which consideration of the learnability, memorability, errors and also cognitive load all result in user satisfaction. However, they are very subjective and need longer period of time to be tested. Table 10 summarizes the definitions of those five attributes associated with usability in the context of the research according to ISO 9241. These definitions could be enlarged with Universal Design perspective. For example, tests regarding learnability, efficiency, and satisfaction of the prototype with more focus on people with disabilities and in certain situations could help to address accessibility issues of the prototype.

Table 10: Definition of usability in the context of this research according to ISO 9241

Usability Attributes	Description
Learnability	The application should be intuitive and easy to learn that users could subsequently start to learn English with it, even if for those users who possess low level of ICT literacy.
Efficiency	The application should be efficient to use and require less efforts so that once the user has learned about how to operate it, meanwhile, a higher level of productivity should also be possible.
Memorability	The application should be easy to memorize, for example, after certain period of time not using it, users are able to get along the application quickly without staring learning everything all over again.
Errors	The application should have a lower error rate. Although it allows users to make few errors while using it, they can still easily recover from them. Fatal errors or bugs should be avoided.

Satisfaction	The application should be pleasant to use without generating negative feelings, users subjectively are satisfied when using the application, and state they like it. It is also relevant to user acceptance.
--------------	--

Hence, for the purpose of discovering the underlying usability issues in terms of effectiveness, efficiency within the application itself as well as users' satisfaction, this research conducted tests regarding usability and user acceptance testing. Additionally, Lazar, Feng, & Hochheiser (2010, pp. 250-277) identified tasks related usability testing are as follow: 1): testing prototypes that have only been built on paper (known as paper prototypes); 2): testing prototypes that look complete but have a human behind the scenes responding (known as the "Wizard of Oz" technique); 3): testing working versions of software before it is officially released; and 4): testing software that has already been implemented in existing system.

All of these tasks presented above regarding usability testing have one primary goal which is to improve the usability of ICT products or services by revealing flaws or errors in them, and fix them subsequently. However, Lazar, Feng, & Hochheiser confirmed there are different types of usability testing. For instance, user-based testing, expert-based testing and automated testing. In other words, people often refer usability testing as user-based testing or user testing, which refers to a group of representative participants attempting a set of representative tasks. In fact, there are various usability and accessibility evaluation methods available to evaluate the usability and accessibility issues of the products. In this research, it divided them following 3 categories, 1): usability testing method, 2) usability inquiry method, and 3) accessibility inspection method. The following sections describe them in details.

Lazar, Feng, & Hochheiser (2010) indicated usability testing method can take place in different stages of the development process. For example, formative testing that refers to usability testing takes place at the very early stage of in development. Formative testing tends to be more exploratory and mainly to test the design concept at a relatively lower cost, and it may adopt low fidelity paper-based prototypes. Likewise, summative testing that refers to usability testing takes place when there are functional or interactive prototypes are ready to be evaluated. Summative testing tends to evaluate the effectiveness of the specific designs and find out flaws in them. Therefore, both formative testing and summative testing were adopted in this research. The primary goal of this method was to improve the usability issue of the prototypes were tested, and identify what areas where users struggled a lot so as to recommendations or improved design shall be conducted. During the different stages of the development, participants were given sets of different representative tasks that were associated with different features of the tested prototypes. Due to the varied focuses in different phases of usability testing, those 10 participants were involved in different phases. For example, all those 10 participants were asked to participate during the summative testing while only 5 older participants participated in formative testing.

### **4.3.1. Formative Testing**

According to (Rubin & Chisnell, 2008), formative testing tends to take place at informal settings with more communication between tests participants and moderator. Throughout literature reviews and background studies, a low fidelity paper-based prototype was created at the early stage of the development to prove the concept design. Figures 12-14 illustrate paper-based main interfaces of the proposed collaborative game. The main purposes of formative testing in this research were regarding:

1): How to present English on the divided screen for both sides so that users could watch their own and partner's progress while sitting on the opposite side; 2): How to implement UI personalization in details in terms of icon size, the route and spend of single letter cards' movement. Hence, in order to seek constructive feedbacks from the participants in this session, it mainly focused on those 5 older users who could give constructive suggestions while younger users aged between 2-5 presumably cannot provide useful and constructive feedbacks. Partially because children cannot interact with the low fidelity paper-based prototype so that they were assumed cannot understand it properly. During this session, moderator guided participants with the paper-based prototype, and instructions and description were given so as to help them understand properly about how the paper-based prototype will function in the future, features it should implement. After that, they were allowed to verbalize their thoughts, feelings, and recommendations regarding the low fidelity paper-based prototype. Let them speak out with regard to the concept design. For the purpose of encouraging them to be more critical, they were not limited by prepared questions. Formative testing was conducted online via QQ video chat. Audio messages were recorded in this session so that future data analyzing could be conducted. Formative session lasted nearly 45 minutes according to the recorded audio messages.

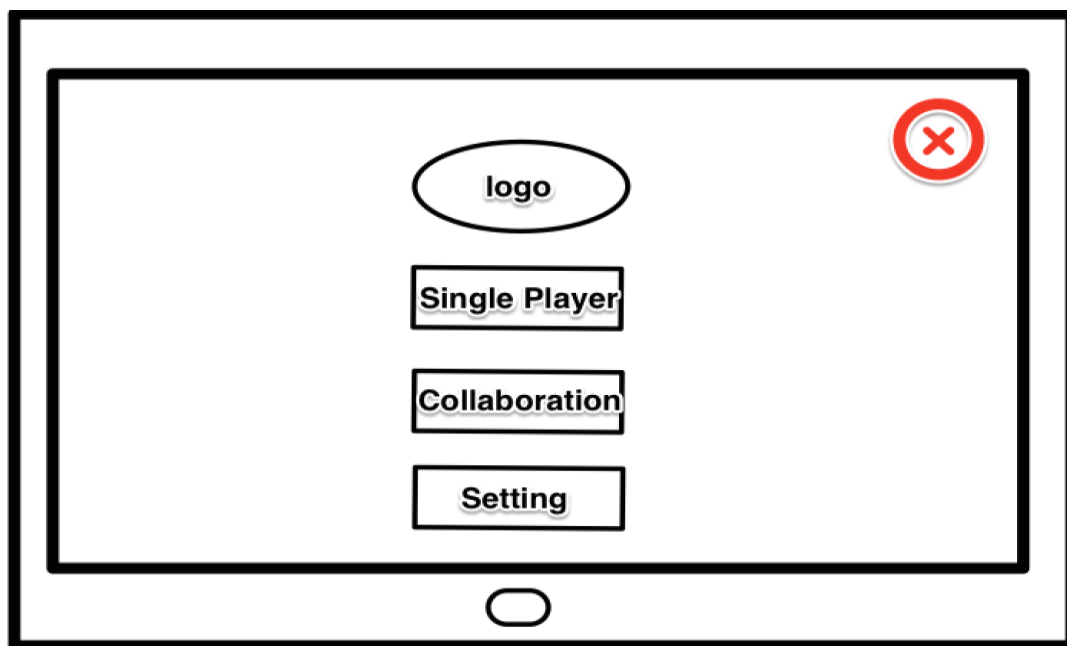


Figure 12: Main interface of the low fidelity paper prototype



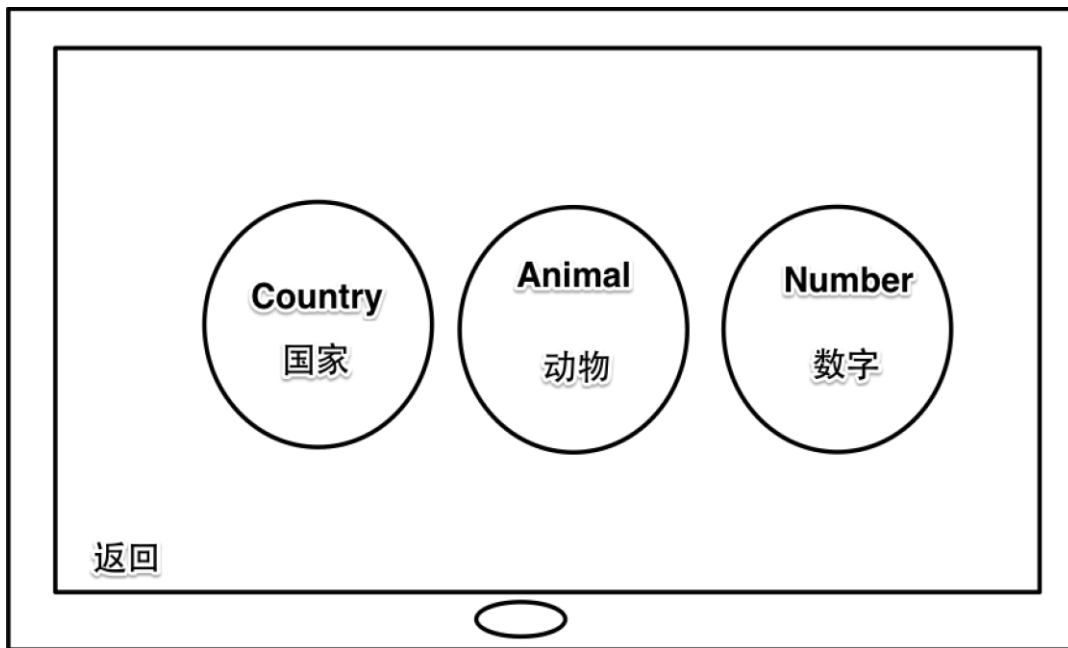


Figure 13: Theme-chosen interface of the low fidelity paper prototype

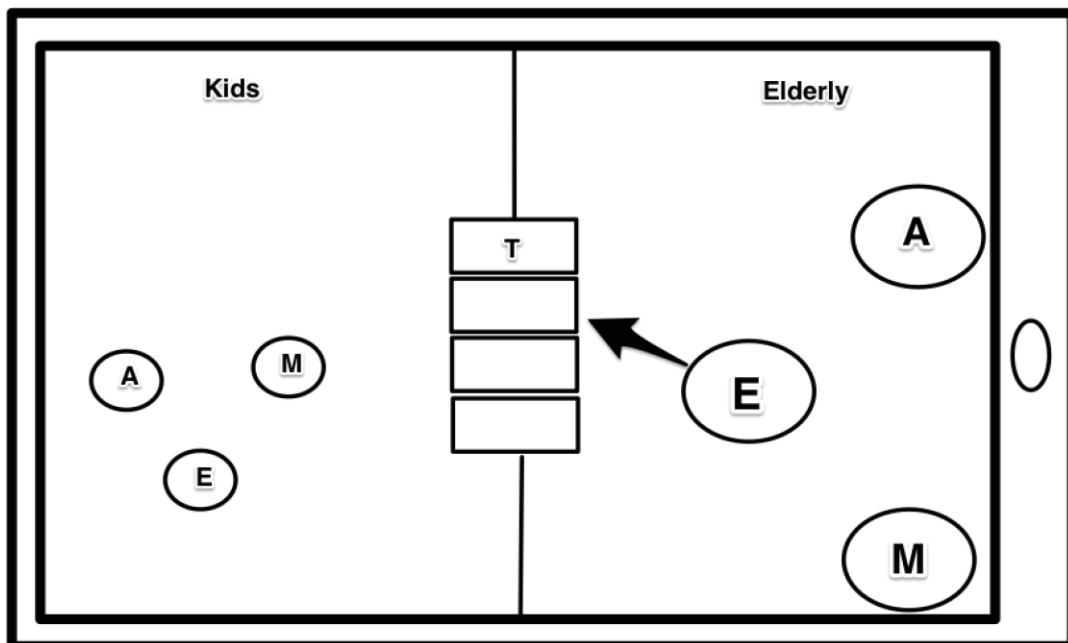


Figure 14: Main gaming scene of the low fidelity paper prototype

#### Description of low fidelity paper-based prototype:

The application will require players to be co-located. In other words, they have to sit in front of each other when playing the game. In the main interface, the game provides users with three different menus: 1) Single player mode, where users can play word-spelling game by themselves; 2) Collaboration mode, where triggers collaboration between users and requires them achieving tasks together; 3) Setting, where players can personalize user interface such letter cards' size as Figure 14 depicts. Speed of single letters movement, fast or slow accordingly. In accordance with the research

done by (Furio et al., 2013), they conducted a preliminary study among 150 participants in order to find out subjects preferences among children age range from 5 to 10. The result showed top 3 preferred subjects were 1): nature and living organisms; 2): multiculturalism, solidarity, tolerance; and 3): science and technology. Thus, the game adopted those top 3 subjects and gave each a representative theme in this project: 1): Animal; 2): Country; and 3): Numbers. Once users choose Collaboration mode, the application presents users with different themes (Refer Figure 13) that are attractive to users, and then a random English word presents itself to users and separate into single letter cards. Meanwhile, single letters are presented in random order and are floating in irregular route on the half screen (Refer Figure 14). Users have to spell the word step by step together in turns. The game requires players spelling the word in correct order by turns. Not to forget, it allows making mistakes, only if they spell correct word, then players can go next word and so.

### **4.3.2. Summative Testing**

#### ***4.3.2.1. Milestone 1***

After analyzing data collected from formative testing, functional prototypes have been developed according to participants' feedbacks. Users were able to interact with functional prototypes. Summative testing have been conducted so as to find out a majority bugs and flaws of tested prototypes. In the light of ISO 9241, the process of User-Centered Design approach is iterative. Summative testing has been summarized in two main milestones in this research: milestone 1 and milestone 2. During milestone 1, based on the feedbacks gathered from formative testing, the first viable prototype has been developed in which users could setup system settings, and get some work done with it. Colors have also been applied with it. To test out major usability issues with it, sets of tasks have been identified as listed in below Table 11. In this section, for the purpose of discovering underlying usability issues, all of those 10 participants were asked to perform a set of representative tasks. Before participants were asked to perform the tasks, firstly they were asked about their knowledge level of using digital devices and applications. If they already had experiences in using them, testing started right away. If they were not familiar with them, they were provided time and instructions to get familiar with the device so that the knowledge of using the functional prototype can be fairly equal. After testing, participants were allowed to give recommendations and their opinions towards the prototype. Observation with focus on the efforts required for setups were conducted while participants were asked to perform tasks. The main purpose of summative testing milestone 1 was to collecting qualitative data from interview after testing to reveal major bugs and flaws the participants were dissatisfied and struggled while using the first viable prototype. However, to make participants feel comfortable during testing, time spent on performing tasks was not recorded during this phase, participants somehow ended up being critical. It is worth pointing out that even though usability testing could take place anywhere, tests regarding summative testing were conducted mainly at home since the proposed application requires participants to be co-located. Besides, Mobile Learning process happens at informal settings in general like at home.

Table 11: Summative testing tasks for milestone 1

Tasks	
T1	Go to Setting, set up icon size for elderly users to big, for children to normal.
T2	Go to Setting, set up speed of letters' movement for elderly user to slow, for children to fast.
T3	Switch on audio prompt
T4	Switch on system audio feedback
T5	Choose animal theme from given lists
T6	Start to play

#### 4.3.2.2. Milestone 2

So far, functional prototype has been improved over time. Improved design has been carried out after analyzing data collected from milestone 1. In order to discover more underlying usability issues during milestone 2, participants were asked to perform a list of tasks, which were the main usable features for the co-located collaborative learning game. Major bugs and flaws were fixed based on results of milestone1 so that prototype has become more usable in comparison to previous version. Before each group of testers configuring system settings, the moderator modified the system settings since the prototype was able to store configuration information from last time it was open. Time for personalizing user interfaces of the prototype, however, were recorded in this session. It will be considered as the standard to evaluate the attributes associated with usability of the prototype, such as learnability, efficiency and etc. Whenever they finished configurations, they were given 10 minutes to play the game. Participants have been observed throughout the whole process with more focused on the way they collaborated when accomplishing tasks together. However, since they have been involved during summative testing milestone 1, they were assumed that their knowledge of using this application was the same at some point. In order to capture the fair amount time spent on using it, testers were given same amount of time 60 seconds to get familiar with the improved implementation of functional prototype. This was important to ensure the time used to complete the tasks were as accurate as possible, and not affected by the experience and knowledge of using the application. Table 12 lists out the tasked this research had for the milestone 2. Videos were recorded while they were performing tasks. After the testing, the moderator has conducted the interviews to seek more inputs from the testers.

Table 12: Summative testing tasks for milestone 2

Tasks	
T1	Go to Setting, set up icon size for elderly users to big, for children set to medium.
T2	Go to Setting, set up speed of letters' movement for elderly user to slow, for children to fast

T3	Switch on audio prompt
T4	Switch on system audio feedback
T5	From given options, select “3s” for how long English words present themselves
T6	Select difficulty level to “medium”, and learning theme to “country”
T7	Start to play

This method involved in collecting qualitative data from participants, and it provided developer information regarding what participants really wanted. In this research, the most frequently used usability inquiry methods were focus groups interviews that were conducted after usability testing. However, in order to test user acceptance and satisfaction towards the prototype of the proposed Collaborative Mobile Learning game, a list of interview questions were identified and conducted after summative testing milestone 2. The results will be considered as the standard of evaluating the satisfaction attribute associated with usability regarding the tested prototype. However, they are very subjective and fully depending on individuals. Below Table 13 enumerates the interview questions regarding testers’ satisfaction towards the application. Audios were recorded during interview session.

Table 13: Interview questions regarding testers satisfaction of the prototype

Interview questions	
1.	Do you find it is too difficult to perform all the tasks?
2.	Do you find it is interesting to play the game with your grandparents or grandchildren together?
3.	Do you think you can actually learn basic English words by this game?
4.	Will you spend time to play the game with your grandchildren or grandparents in the future?
5.	Other comments?

#### **4.4. Accessibility Testing**

Heuristic evaluation was conducted according to accessibility guidelines on a Samsung Tablet with all defaulted setting since the primary goal of this research is to develop a universally designed collaborative educational mobile game. Accessibility addresses the game should also be accessible for people with disabilities under specific situation, including assistive technologies. In this project, it took a heuristic evaluation accessibility inspection method, which allowed the designer to check the existing problems against established guidelines. Most importantly, the primary goal of heuristic evaluation was to test if the prototype work properly with assistive technology such as Android built-in TalkBack. A short evaluation was conducted based on a sets of relevant established guidelines. For example, Android Accessibility Testing Checklist Guidelines, WCAG, and etc. However, while looking through guidelines related to mobile applications, clearly, there is lack of universal guideline that mobile application developers could abide to. As argued in literature review, Android Accessibility Testing Checklists guidelines were selected in this project. Few guidelines suggested by WCAG and MWBP were selected for the purpose of creating accessible user interfaces. Android Accessibility

Testing Checklist recommends 6 mandatory tests in order to ensure a minimum level of application accessibility (Android Developer, n.d.). Table 14 presents guidelines based on official instructions.

Table 14: Relevant accessibility guidelines applied in this research

Android Accessibility Testing Checklists Guidelines	Description
1. Directional controls	Verify the application can be operated without the use of a touch screen, so that it can still function with the use of keyboard or gesture navigation.
2. TalkBack audio prompts	Verify that user interface controls that provide information (graphics or texts) or allow user action have clear and accurate audio descriptions when TalkBack is enabled and controls are focused.
3. Explore by Touch prompts	Verify that user interface controls that provide information (graphics or text) or allow user action have appropriate audio descriptions when Explore by Touch is enabled.
4. Touchable control sizes	All controls where a user can select or take an action must be a minimum of 48 density pixel (dp) (approximately 9mm) in length and width
5. Gestures work with TalkBack enabled	Verify that app-specific gestures, such as zooming images, scrolling lists, swiping between pages or navigating carousel controls continue to work when TalkBack is enabled.
6. No audio-only feedback	Audio feedback must always have a secondary feedback mechanism to support users who are deaf or hard of hearing, for example, haptic feedback or visual alert shall be provided if available.
WCAG 2.0- Guideline 1.4.3: The visual presentation of text and images of text has a contrast ratio of at least 4.5:1, except for the following: (Level AA)	<b>Large Text:</b> Large-scale text and images of large-scale text have a contrast ratio of at least 3:1;
MWBP 1.0-Guideline 5.4.16: Do not rely on the support of font related styling.	Mobile devices often have few fonts and limited support for font sizes and effects (bold, italic etc.) As a result of this, the use of font size, face or effect, for example to highlight an answer or a stressed word, may not achieve the desired effect.

In summary, there were three main tasks conducted in the research methodology phase on the basis of integrating accessibility into User-Centered Design (Henry, 2007). First was focused interview at the early stage of the proposal, to seek for their relatively deeper feedbacks on the idea of having grandparents participating in children’s learning activities using digital devices together.

Secondly, user testing and data collection were conducted through different stages of the development process with different focuses. 10 people in total, divided them into 5 groups who represented users from both elderly and children target groups. At different stages of usability testing with different focuses, number of participants from different groups were involved. For example, 5 young participants were excluded during formative testing that was to test the concept design. Tasks regarding usable features of prototypes were different as well throughout usability testing. Those features will be the main usable features for the co-located Collaborative Mobile Learning game.

Lastly, to fairly address the accessibility issues of the prototype, a short heuristic evaluation was conducted based on few guidelines related to mobile applications in this research. Apparently, there are few standard guidelines have been made regarding educational mobile applications. Some major mobile OSs representatives provide basic guidelines in order make their platforms accessible to the greatest extent for all kinds of users including people with disabilities. In this research, heuristic evaluation was conducted in the light of Android Accessibility Testing Checklists guideline, after all, the fundamental device of this research was Android-based.

## 5. Data Collection and Results

In the section, it presents the data collected throughout the User-Center Design process. After reviewed and analyzed these data, improved design implementation has been carried out correspondingly. The following sections describe results associated with different research methods.

### 5.1. Semi structured focus group interview

To seek selected participants' thoughts or opinions concerning Collaborative Learning while using digital devices, interviews conformed to the Think and Speak Aloud Protocol. Table 15 and Table 16 list out those 10 participants and 1 field expert's feedbacks regarding the extent of agreement in terms of Collaborative Learning using digital devices.

Table 15: Interview results regarding Collaborative Learning for 5 older participants

Interview questions	Elderly 1	Elderly 2	Elderly 3	Elderly 4	Elderly 5	Expert 1
1. Compared to traditional learning methods, how do you agree using digital devices such as cell phones, tablets, iPads to learn English?	Strongly Disagree	Disagree	Agree	Uncertain	Agree	Strongly Agree
2. How do you agree the idea of learning while playing?	Strongly Disagree	Uncertain	Agree	Agree	Agree	Strongly Agree
3. How do you agree the idea of having your grandchildren or children learning together (collaborative learning)?	Disagree	Uncertain	Strongly Agree	Agree	Strongly Agree	Strongly Agree
4. How do you agree it would be helpful for decreasing social loneliness and isolation	Uncertain	Uncertain	Strongly Agree	Uncertain	Agree	Agree

---

among elderly people and children by having them playing together			
5. Other comments	Modern technologies too advance for them	A lot of distractions	Important to have parents participating in children’s learning

---

Table 16: Interview results regarding Collaborative Learning for 5 young participants

Interview questions	Child 1	Child 2	Child 3	Child 4	Child 5
1. Compared to traditional learning methods, do you like using digital devices such as cell phones, tablets, iPads to learn English?	Yes	Yes	Yes	Uncertain	Yes
2. Do you like the idea of learning while playing?	Yes	Yes	Yes	Uncertain	Yes
3. Do you like the idea of having your grandparents or grandchildren learning together (collaborative learning)?	Yes	Yes	Yes	Uncertain	Yes

---

From Table 16, nearly all the younger participants stated clearly that they would learn with their parents or grandparents together by means of using digital devices. Child 4 was too young to give useful feedbacks, so use uncertain instead. Nevertheless, some of those 5 older participants hold different standpoints. For example, Elderly 1 and Elderly 2 pointed out they felt frustrated or overwhelmed to use modern technologies because they were too advanced to them. On the contrary, Elderly 3, 4 and 5 advocated the idea of Collaborative Learning. They claimed they would spend time with their grandchildren to learn by playing games. Moreover, field expert identified it is very important to have parents or grandparents involving in early stage of younger children’s education in which parents or grandparents could supervise them as well as encourage them at the same time. In brief, most of the participants showed evident interests in the Collaborative Learning by using digital devices. Through interview, older people have knowledge of using mobile devices presented less interests in technology-supported education.

## **5.2. Usability Testing**

### 5.2.1. Formative Testing

Both Elderly 3 and 5 supported the idea of applying personalization for improving user interface accessibility. Elderly 3 suggested remove Single player mode. Instead, focusing on Collaboration. In addition, he pointed out it will be better present each side English letter cards in divided screen in left-to-right order since people are accustomed to read from left to right. This will give each side about the progress of the word spelling game. Elderly 5 indicated the game should provide information for counting how many words have been done, and it should offer more options in terms of customizing user interface. According to their feedbacks, Table 17 summarizes key outcomes from those 5 older participants about the low fidelity paper-based prototype during formative testing.

Table 17: Results of formative testing according to 5 older participants about the paper-based prototype

---

#### Results of formative testing

---

1. Remove Single Player mode because there are numbers of applications have been developed, so instead with more focus on Collaboration mode
  2. In System Settings, provide users with audio prompt option. For instance, when users touch the single letter card, audio prompts are triggered at the same time, which are crucial especially for English learning in terms of pronunciation.
  3. Regarding the movement of the single letters cards, it is better to have them moving or floating in regular route. Otherwise, if it is a long English word, there must be single letter cards everywhere on the screen, which might be distractive and irritating for users while playing
  4. Generally, people are accustomed to read from left to right, therefore, for each side, it should present users with words in sequence from left to right respectively, then separate into single letter cards. As Chinese chess, each side has their own cards and “territory”.
  5. Provide users with more options regarding the speed of single letter card movement, some of users may do not want them move at all, which is validate to this research, give users freedom regarding learning to the greatest extent. For example, provide users with option “null” concerning the movement of single letter cards.
  6. Colors need to be implemented for future function prototype.
- 

### 5.2.2. Summative Testing

#### 5.2.2.1. Milestone 1:

Based on the results of formative testing, functional prototype has been developed that users can interactive with. In addition, it offered several essential features. For instance, it allowed user to choose from different word themes, and even customize settings based on individual’s preferences. Following Figure 15-17 list out main interfaces of the functional prototype during milestone 1.



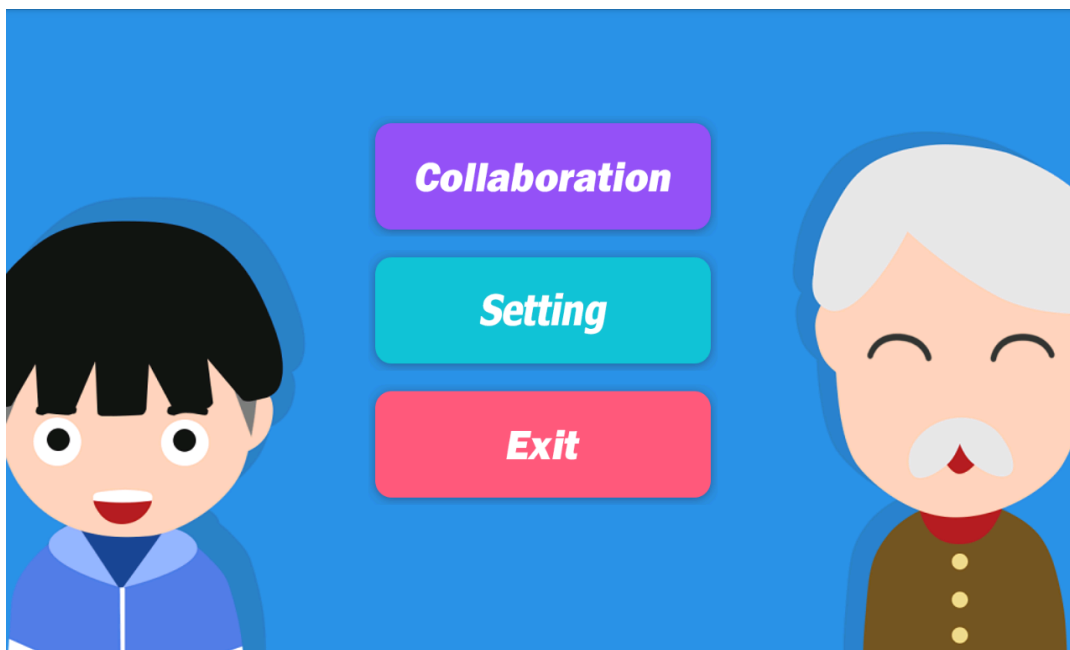


Figure 15: Main interface of improved prototype during milestone 1

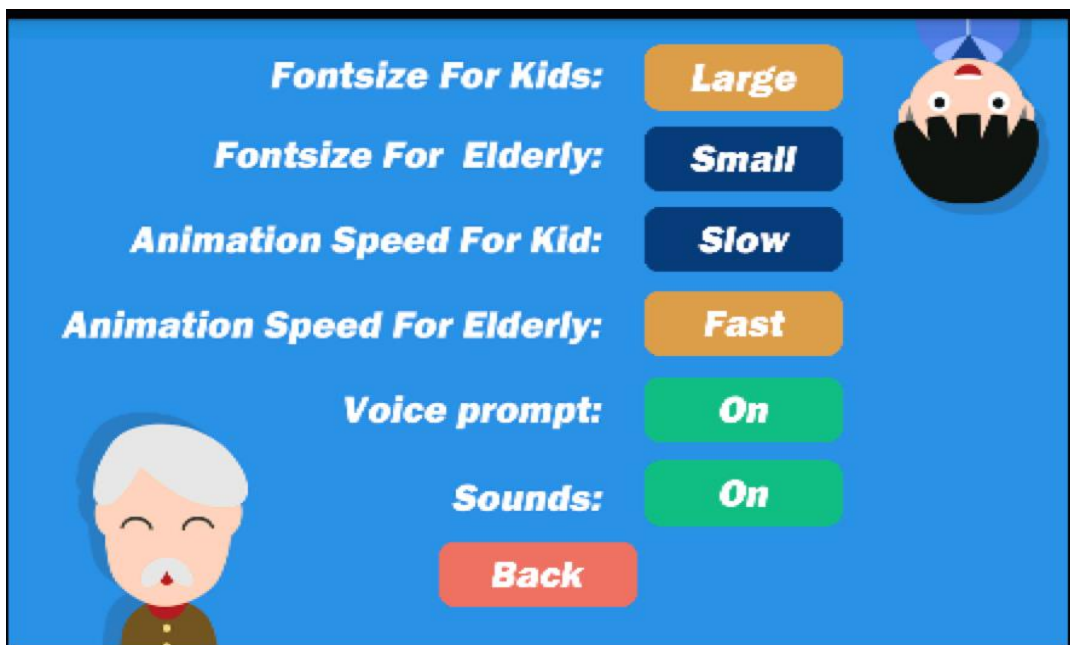


Figure 16: System settings interface of improved prototype during milestone 1



Figure 17: Main gaming scene of improved prototype during milestone 1

After reviewing the audio tracks recorded from the interviews after testing, Table 18 and Table 19 summarize the qualitative data collected from interviews, and present them as recommendations of corresponding usability issues for future improvements. The reason why time did not recorded in this phase was that the system language was in English. Participants fully depended on moderator's instructions. All of participants pointed out that the words presenting time was too short to memorize them.

Table 18: Recommendations for user interfaces of the prototype according to 10 participants

Recommendations regarding User Interfaces of the prototype	
1.	Provide language settings, such as Chinese menu.
2.	Font size and icons for big option are not big enough.
3.	Reduce the speed of single letter cards movement when users select fast animation speed, it is too fast for users to tap it correctly, especially for older testers.
4.	Lack of go back function or button in theme-chosen interface, otherwise users have to restart the game if they want to go back during the main gaming scene
5.	Remove single letter cards' background color transparency variations while they are floating, it

---

is hard to see clearly if the background color transparency is too high.

6. Increase color contrast or combine different color themes in order to increase visual contrast between controls or widgets, particularly the half screen for elderly users marked red in Figure 17, it is difficult for users to see clearly.
  7. It is better to use figures or pictures to illustrate Chinese meanings of English words other than Chinese characters since most of children at age range from 2-5 years old cannot read Chinese characters. In addition, by this, it in a way improves more communications between elderly users and children. For example, when children cannot understand them, grandparents can always explain to them.
- 

Table 19: Recommendations for gaming mechanism applied for the prototype according to 10 participants

---

Recommendations regarding gaming mechanism

---

1. Increase time span since most of participants reflect each word's presenting time is too short to memorize it, sometimes, they do not realize and the word is already separated into single letter cards. Provide users with fairly reasonable English words presenting time after which they split into single letter card.
2. Offer difficulty options based on the length of words such as easy, medium and difficult.
3. Too much effort required when users want to customize animation speed or icon size (Refer to Figure 16). For example, if user wants to set up fast speed, it requires more than Tap 2 times. Some suggest listing out all the options in single buttons, so only one single Tap could setup easily according to their preferences.
4. Allow users to spell the English word not in specific order. In other words, it is ok not to fill the adjacent letter comes after original correct sequence since the game requires collaboration between both sides. For example, if it is a relatively long word, one might remember first part of it, the other might remember last part of it. Depicts in Figure 18.



Figure 18: Screenshot of gaming scene

5. Stop letters' movement after failure trial once in order to mark it was already tried, and it was wrong
  6. Save the customized settings from last time so that when users restart the game, the settings are able to automatically recover to the exact same as last time.
-

There were few findings while observing testers performing the tasks. Firstly, even the system language was in English that users were not familiar, all the younger participants show clear interests in the prototype, and they stated they will play the game with their parents or grandparents. Secondly, too much effort required in terms of Taps when participants wanted to change the systems again. For example, if users wanted to switch letter cards size from big to medium, they needed to Tap twice on the same button. If they Tap one more, they had to go all away to the start. Thirdly, if players chose fast speed of letters' movement, it was too fast for them to pinpoint letters. If they choose small size option for letter cards, they were too small to touch for both users. Font and icon size is not big enough for older users. Therefore, the prototype cannot work consistently under specific situations. For example, it will be hard for users to Tap the cards correctly even in a stable environment. Not to mention, if they were in an unstable environment like bumpy roads or players have Parkinson. The prototype failed to meet requirements in terms of both usability and accessibility.

#### **5.2.2.2. Milestone 2**

Improved design has been implemented on the basis of participants' feedbacks from summative testing milestone 1. Figures 19-22 below depict four major interfaces of the improved prototype during milestone 2.

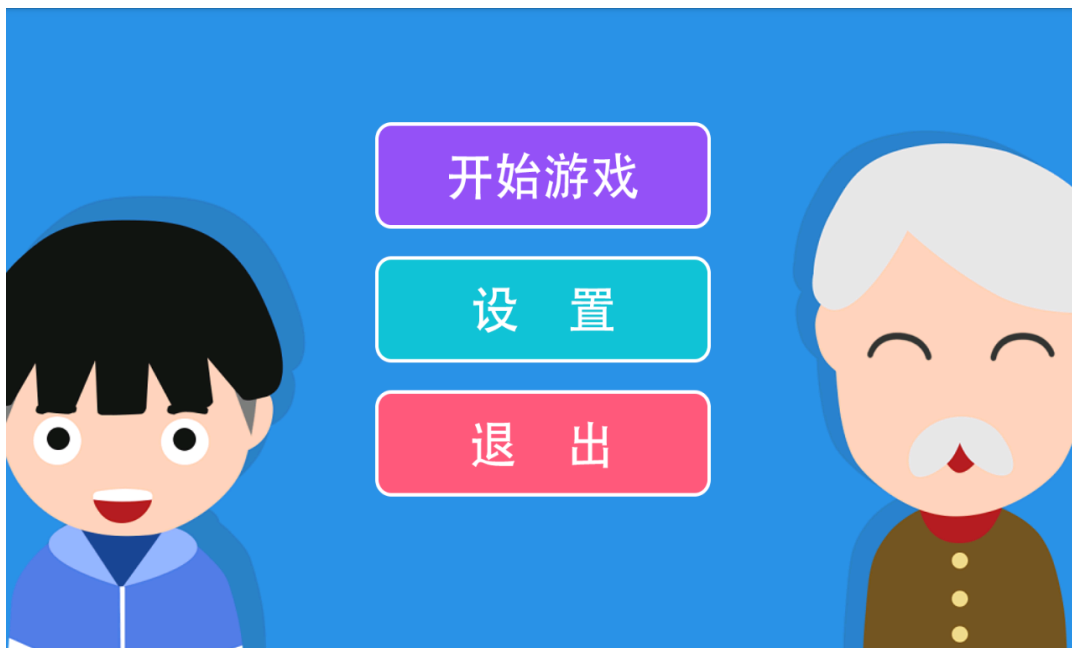


Figure 19: Main interface of the improved prototype during milestone 2



Figure 20: System setting interface of the improved prototype during milestone 2

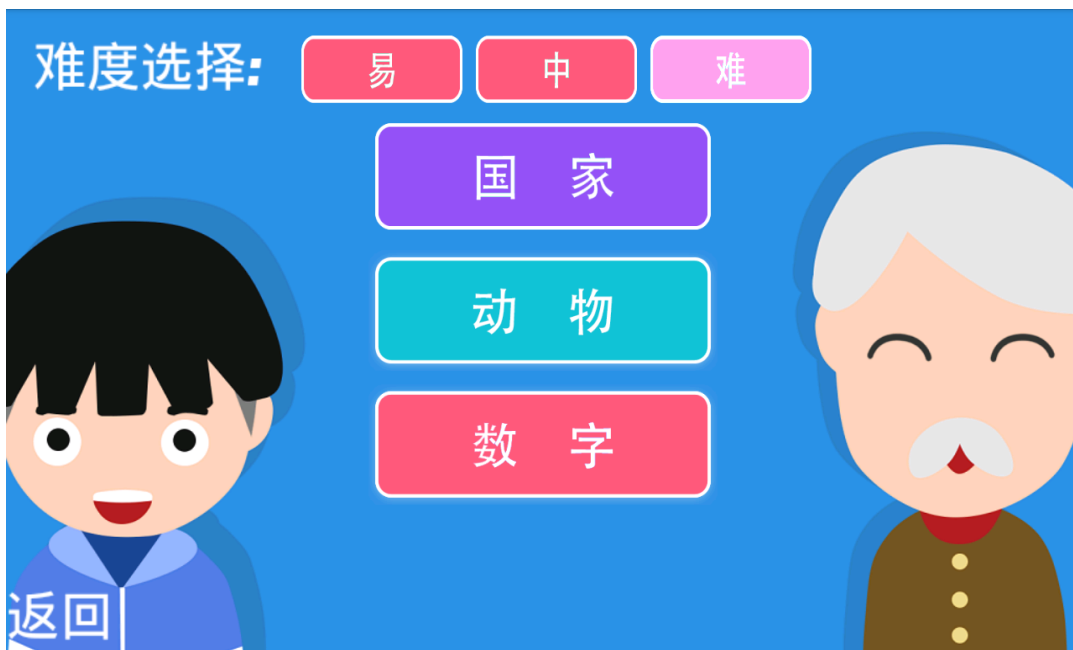


Figure 21: Theme and difficulty level chosen interface of the improved prototype during milestone 2



Figure 22: Main gaming scene of the improved prototype during milestone 2

Time used to complete the required tasks was used to evaluate how much effort required when users personalized user interface accordingly. It would be considered as the standard for evaluating the learnability as well as efficiency associated with usability while using the tested prototype. During summative testing milestone 2, Group 4 was failed to conduct the required tasks since the 2-year-old child was too young to follow the moderator's instructions. However, she showed obvious interests at the game. Table 20 shows the time required for performing tasks. The results could not be totally precise because the 'actual' time required were not always resulted from the application, but also the familiarities of the users with digital devices or applications. For example, the results from Table 20, Group 3 shows clearly advantage over Group 1 since both of the participants are experienced users with cellphones or tablets, even though they were given same amount of time to familiar with the application before tested. It is important to point out the observation and time recordings were conducting by the same person, which leads to possibility for data inaccuracy since the person conducting both tasks might not be focus enough.

Table 20: Time required for completing tasks during summative testing milestone 2

Tasks	Time spent (in seconds)				
	Group 1	Group 2	Group 3	Group 4	Group 5
1. Go to Setting, set up icon size for elderly users to big, for children set to medium.	23.81	19.50	9.50	Failed to be conducted	11.56
2. Go to Setting, set up speed of letters' movement for elderly user to slow, for children to fast	13.52	10.28	5.58		7.34
3. Switch on audio prompt	8.78	7.63	2.78		4.12
4. Switch on system audio feedback	9.31	5.47	2.12		3.36
5. From given options, select "3s" for how long English words present themselves	7.84	4.15	2.54		3.54
6. Select difficulty level to "medium", and learning theme to "country"	18.69	14.45	6.86		8.76

From Table 20, there were still distinct differences of time required for performing tasks between Group 1 and Group 3 even if participants were assumed to have fair knowledge of using PDAs since they were already familiar with the application. Both of older and young participants in Group 3 were experienced users so that they could achieve tasks easily without much effort. It did not cost too much time to setup settings even for those who have relatively less experience with digital devices according to the results of Table 20. Therefore, usability of the tested prototype is guaranteed at some point in terms of learnability and efficiency. Regarding usability attribute errors, whenever participants were asked to configure system settings, they could accomplish tasks without many errors in a short time. Fatal bugs such as sudden crash or not responding did not occur during testing, so the tested prototype had a low rate in terms of errors. The application could save the users' customized settings from last time, memorability of it was improved to some extent. Pertaining to the satisfaction or user acceptance towards the prototype, interviews were conducted immediately after they finished tasks. The results are presented in the following Table 21.

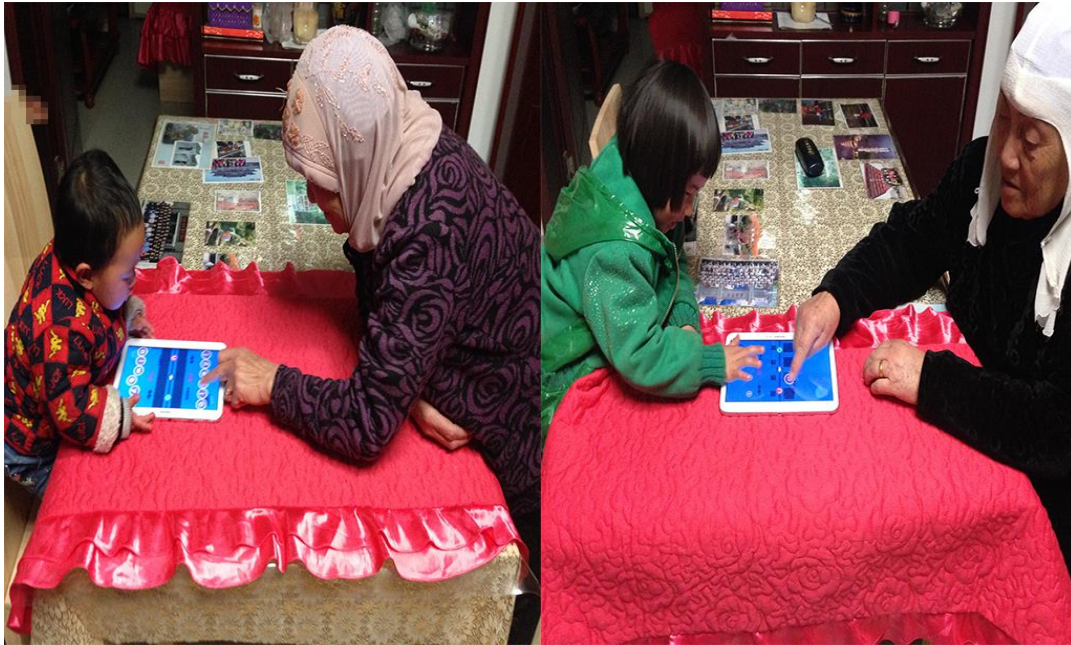


Figure 23: Participants group 4 and group 1 performing tasks during summative testing milestone 2

In addition, there were also few findings have been identified while observing the participants. When they were asked to configure the settings, children tended to be impatient since they cannot read the Chinese characters, and they fully depended on older participants' help. But whenever finished configurations, most of them dived into the game. During the given 10 minutes playing, if audio prompt was on, whenever they touched the letters, they mimicked the pronunciations of them. When they touch the "microphone" icon on the screen, pronunciations of the English words were presented, this is very important to English learning. During testing, communications apparently were improved between them while playing the game. For example, if the children were not sure the next step or vice versa, they needed others' help in order to finish the word together. Sometimes, if the younger participants were not sure the meaning of those figures applied with the application, the older participants could always explain to them. For instance, what is Norway, where is it. However, the learning engagements of Collaborative Learning could be affected by the way people cooperating. As in Group 5, Elderly 5 tended to be very impatient if Child 5 needed for time to decide. Instead of encouraging, Elderly 5 directly did tasks for Child5. Besides, comparing with milestone 1, less effort required in terms of Tap during testing milestone 2. Only single Tap could set up the corresponding features. Both older and younger participants were smiling while playing. After that, majority of participants stated they would play the game with their grandchildren or grandparents in the future. Not to forget, they claimed it was fun to play with their grandchildren or grandparents.

Below Table 21 presents the results of user satisfaction interviews. The results will be considered as the standard of evaluating user satisfaction and acceptance towards the tested prototype.



Table 21: Interview results of user satisfaction and user acceptance

Interview questions	Group 1	Group 2	Group 3	Group 4	Group 5
1. Do you find it is too difficult to perform all the tasks?	No	No	No	Failed to be conducted	No
2. Do you find it is interesting to play the game with your grandparents or grandchildren together?	Yes	Yes	Yes		Yes
3. Do you think you can actually learn basic English words by this game?	Yes	Yes	Yes		Yes
4. Will you spend time to play the game with your grandchildren or grandparents in the future?	Yes	Yes	Yes		Yes
5. Other comments?		Limited capacity of vocabulary database, and parents could also play with their children		Child 4 was too young to follow the instructions	New technologies are more interesting than traditional ways when apply them to educational contexts

Participants were subjectively satisfied with the prototype according to the interview results depict in Table 21. Nearly all the participants advocated the idea of having parents or grandparents participating in children’s learning life. They claimed it was easy and interesting to play the prototype even for those new users to digital devices. Furthermore, they stated that they would spend time to play with their grandchildren or grandparents in the future. In short, on the basis of the results gathered from summative testing milestone 2, overall the prototype performed well in terms of usability. Time and efforts required for personalizing user interfaces demonstrated the prototype was easy to learn and effectively to use. Fatal errors did not occur during testing explained users can use it

for English learning at a low error rate. The ability of storing users' configuration information helps users to memorize it. The results of interviews after testing showed participants were satisfied with the prototype. Communication and socialization were clearly improved via using it. In addition, personalization of user interfaces helps it can be accessible under specific circumstances. For example, it will help users to pinpoint on the touch screen if they setup big icons and font size on the bumpy roads while traveling.

However, due to time limitation, posttests never were conducted regarding the learning outcomes while using the prototype. Nevertheless, the day after they were asked to perform tasks, when the moderator presented some of the words on the game to some of participants, they can recognize them and tell the Chinese meanings even they cannot spell the word correctly by themselves.

### 5.3. Accessibility Testing

Below are the final results of heuristic evaluation using Android Accessibility Testing Checklists and WCAG.

Table 22: Heuristic evaluation on Android Accessibility Testing Checklists

Android Accessibility Testing Checklist	
1. Directional controls	Meeting requirement but partially. The application cannot be operated using keyboard without the use of touch screen
2. TalkBack audio prompts	Not meeting requirements. Nearly none of the controls or widgets within the interfaces work properly within TalkBack feature
3. Explore by Touch prompts	Not meeting requirement, there is no audio description of buttons or menus while TalkBack is switched on
4. Touchable control sizes	Meeting requirement. All the buttons and menus are longer than 48dp (approximately 9mm)
5. Gestures work with TalkBack enabled	Not meeting requirement. Gestures do not work with TalkBack enabled
6. No audio-only feedback	Meeting requirements. For example, the background color transparency of buttons changes while they are selected.

Overall, the prototype worked limited within the Android integrating screen reader: Talkback. For example, all the buttons on the user interfaces barely provided texts descriptions of their functions. Partially because the user interfaces were create by Java code dynamically instead of using Extensible Markup Language (XML) Android Developer recommend. Gestures did not work within the prototype contexts.

Android Design recommends good color contrast between visual components is crucial for offering good user experience. Yet, it does not propose the exact contrast ratio is sufficient. According

to W3C recommendation, Mobile Web Best Practices (MWBP) 1.0 primary goal is to improve user experience of the Web while using such devices(W3C, 2008). It also indicates the importance of color contrast in mobile Web implementations. However, WCAG 2.0 proposed the exact color contrast ratio for Web accessibility. In this project, it referred WCAG to improve the accessibility of prototype user interface, and several relevant guidelines were selected. Short heuristic evaluation was conducted in terms of color contrast as well as font type. Below Figures present the results.



Figure 24: Letter cards used in early functional prototype during milestone 1

By means of using W3C Color Contrast Analyzer, below Figure 25 depicts contrast ratio of the main theme color (Figure 15-17) and letter cards (Figure 24) used in prototype during summative testing milestone 1.

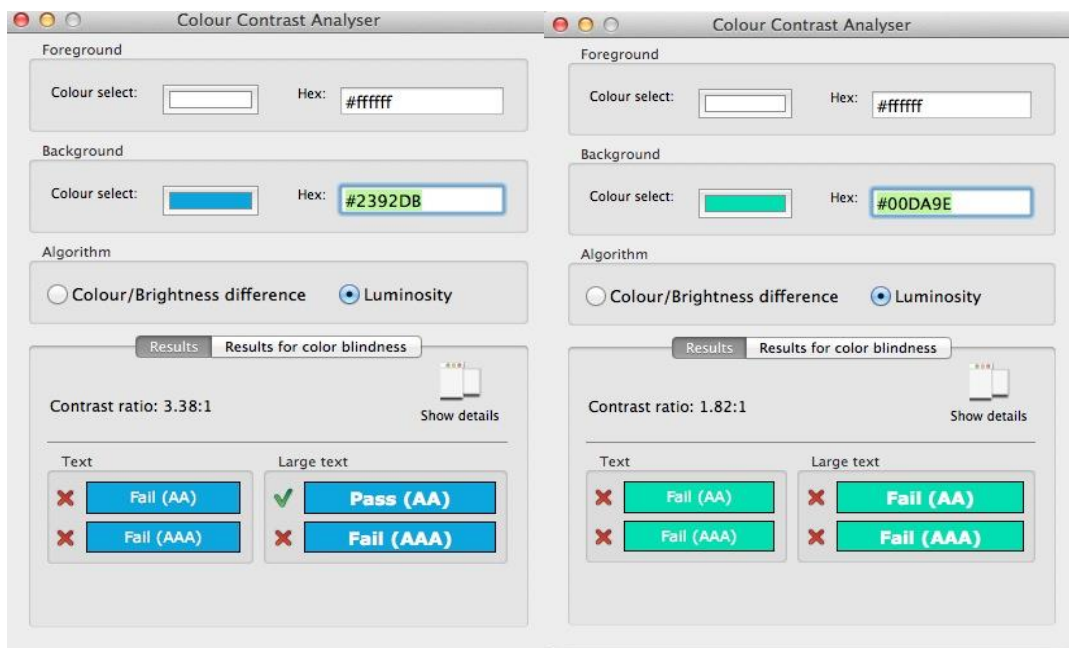


Figure 25: Screenshots of using Color Contrast Analyzer

According to WCAG 2.0- Guideline 1.4.3: The visual presentation of text and images of text has a contrast ratio of at least 4.5:1, except for the following: (Level AA)

**Large Text:** Large-scale text and images of large-scale text have a contrast ratio of at least 3:1. WCAG 1.4.3 Level AA requires large texts should have a contrast ratio of at least 3:1. However,

considering the target groups include elderly people who may have lower vision and special environments, the prototype approached Level AAA instead of fulfilling the least requirements. Main theme color was switched from #2392DB to #0B71E6 with currently contrast ratio 4.65:1. Background color for letter cards from #00DA9E to #CC4C06 with contrast ration 4.56:1. Both meet Level AAA for large texts in accordance with WCAG. Figures 26-27 demonstrate the contrast ratio of main colors used in the user interfaces implementation using W3C Color Contrast Analyzer.

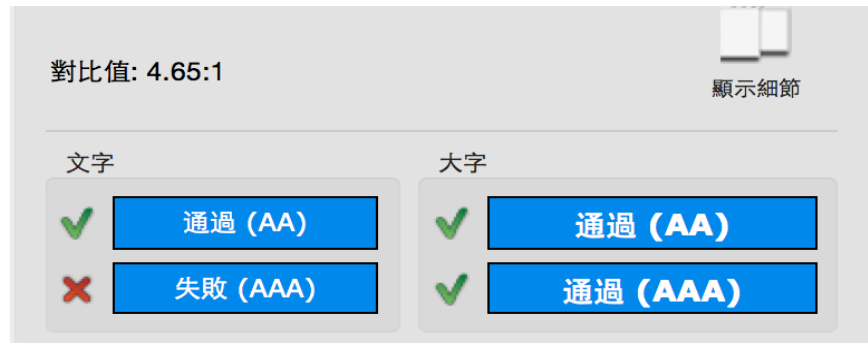


Figure 26: Improved contrast ratio for main theme color using in prototypes



Figure 27: Improved contrast ratio for letter cards

MWBP 1.0-Guideline 5.4.16: Do not rely on the support of font related styling. Since it do not to propose what types of font would be considered easier to read on the touch screen. Other sources where found in line with W3School.com. In general, san-serif font types such as Arial, Verdana are considered easier to read other than serif fonts on computer screens such as Times New Roman, Georgia (W3School, n.d.). Below Figure 28 depicts the adopted Font types revolution for the prototype during milestone 1 to milestone 2.

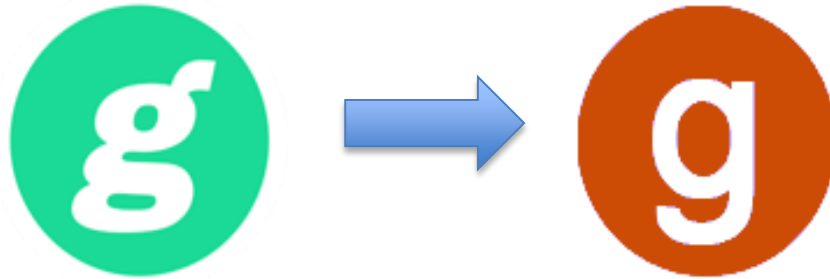


Figure 28: Improved font type adopted for letter cards

In summary, for the purpose of creating a universally designed mobile educational game that requires collaboration between elderly and children. The usability and accessibility issues were addressed in the process of integrating accessibility into User-Centered Design. Pre-interview results indicate participants embrace the concept: “Collaborative Learning”. Few research methods were applied at the different stages of the development, from the early concept design till final functional prototypes. Data collection and analyzing were conducted so that improved designs were implemented subsequently. Data presented in this section well addressed those attributes associated with usability according to ISO, which are the standard for evaluating the design artifacts’ usability. For example, time spent on performing tasks during summative testing milestone 2 demonstrate the tested prototype was easy to learn, and effective to use at a low error rate as well as less efforts required. Interview outcomes during usability inquire method identify the participants are subjectively satisfied while using the collaborative mobile game. The ability of storing system settings information allows users recover back to last time when restart the application, by this memorability of it is improved in a way. However, heuristic evaluation results based of accessibility guidelines such as Android Accessibility Testing Checklists, WCAG and etc., indicating the application still has severe limitations in terms of accessibility. Therefore, improvements need to done in the future.

## 6. Discussion

Since the ultimate goal of this project is to develop a universally designed Collaborative Mobile Learning game for elderly and children in China, for improving English learning and socialization. Universally designed in this context means addressing both usability and accessibility of the game. Hence, this research integrated accessibility into UCD process. User diversity requires designers should understand different types of users. In this research, personalization of user interfaces addresses user diversity and improved the accessibility of it in different situations. For example, users are allowed to personalize user interfaces according to their preferences or abilities. Presumably, it will be helpful for users using the game in a very unstable environment such as bumpy roads while traveling or people have Parkinson. Several research methods were conducted during this process, such as interviews, usability testing, accessibility testing, and etc. To properly understand users characteristics, 10 participants with different age, knowledge levels of using digital devices were involved in this process

(Refer to Table 7). However, number of participants at different stages of the development varied.

Pre-interviews were carried out with focusing on the participants' opinions towards Collaborative Learning using digital devices. The results showed most of the participants supported the idea. Since the selected children were mainly aged from 2-5, they were asked if they agree or not regarding those questions instead of rating the Likert Scale. Just in case of they could not understand the interview questions. However, the data collected in this phase was mainly quantitative data. Using survey among a large population for collecting people's opinions regarding Collaborative Learning could increase the reliability of data collected in this phase. 10 representative users were not sufficient for quantitative data, consequently generalization to larger community is not convincing within such a small amount of participants

Formative testing was conducted during the early concept design that inspired by background studies and literature review. It aimed at collecting qualitative data by talking with the participants about the paper-based prototype. Therefore, It only targeted at those 5 elderly participants because the paper-based prototype cannot be interacted with. In other words, younger participants (aged 2-5) cannot gain the general functions of the prototype will implemented, so they were assumed could not give constructive suggestions regarding the concept design. But this might lead to exclusion of young participants' requirements. During testing, Elderly 1, 2 did not give any useful suggestions since they were completely new to mobile devices. On the contrary, Elderly 3, 5 were critical. They suggested the prototype should apply Chinese Chess mechanism by giving each side cards, this is extremely important for the gaming mechanism adopted in this research. They all suggested for factors for personalizing user interfaces. Both formative testing and Interviews were conducted online by the time I was in Norway. Recorded audio tracks were very helpful for covering all the details participants have mentioned.

In order to reveal major underlying usability issues of the functional prototype, tests were divided into milestones during summative testing. All the 10 selected participants were involved in those two milestones. During milestone 1, the goal of usability testing was to cover major fatal bugs and design issues since it was the very first viable functional prototype. By the time, Chinese language was not supported for the prototype. Participants heavily depended on moderator's instructions to achieve tasks since all of them were English illiterates. So, time for performing tasks did not recorded. Instead, with more focuses on interviews after testing and observation during participants performing tasks. Child 4 was too young to follow the moderator's instructions. But, she had obvious interests at the prototype and wanted to play by herself (Refer Figure 23). Nearly all the participants stated the time for presenting English words was too short to catch up. During interview, four Children claimed it was very interesting of the prototype such as the animation of letters, the design of user interfaces, but they could not understand the meanings since they cannot read Chinese characters by their age. During observation, I found it was difficult for both of participants to track letters if they setup small icons or fast speed of the floating cards. Instead of presenting all the raw data collected in this phase, I summarized them and present them as recommendations of the prototype for future improvements (Refer Table 18 and 19). It is worth mentioning that for those older participants had no experiences using digital devices and young participants, they could not give any useful feedbacks. Thus, it is

importation to keep interview questions as simple as possible for them, especially for young children. For example, the answers for interviews questions should be either Yes or No.

Improved design has been implemented based on the results of milestone 1. The purposes of summative testing milestone 2 were to prove the usability of the prototype in terms of learnability, efficiency, memorability, error rate and finally user satisfaction. Time and efforts (Taps) required for accomplishing tasks were considered as the efficiency and learnability of the prototype. Errors rate was gathered throughout observation and reviewing the video recorded during testing. After tests, participants were asked to answer questions to seek their satisfaction regarding the prototype. Although memorability of the prototype needed to be tested in a longer period of time, storing configurations information so that the prototype could recover back to the previous states enhances the memorability of the prototype. For example, the prototype can recover back to previous settings if it was restarted. Overall, the usability of the prototype was improved in comparison to previous versions.

However, there were few limitations that might lead to the quantitative results from the user testing were unreliable in few ways. First, observation and time recording were conducted simultaneously which could be improved because there might be lack of focus in either of the tasks. Videos recorded were very helpful for reviewing observation during testing. The identified tasks were as the same order as they were listed in the system setting. It would be better to collect required time if they were asked to perform tasks in random order. In this case, the time spent will be more accurate for evaluating the efficiency of the prototype. Secondly, even though the participants were involved during the whole process of the application development, and they were given time to get familiar with it. Still variable in terms of the knowledge variations of using mobile devices cannot be excluded. Interview questions were somehow ended up not being specific enough for seeking participants' opinions towards the prototype. It could be better to identify questions relevant to the usable features of the prototype. Besides, another variable was the disability or impairment participants had. For example, Group 1: older participant had Presbyopia while others not. As a result, this project had to rely heavily on observation and interviews, which were the qualitative outcomes from the user testing. During observation, communication and socialization was enhanced between participants. However, the way of how they collaborate or communicate while playing the game could also affect the learners' engagement and motivation. For instance, if parents or grandparents took absolute leaderships during playing the collaborative learning game, it will cause children lack of patient and self-confidence. Consequently it will cause decreasing of their engagement and motivation. Likewise, if they took reasonable leaderships and be supportive, children's engagement and motivation increase in this case. Social-Turn based gaming mechanism was adopted to ensure the collaboration is less affected by the way they cooperate. They were allowed to help each other rather than to replace other's work.

Furthermore, this project was not able to conduct tests regarding to accessibility using real participants with various disabilities or using persona to simulate. Conversely, it conducted a short heuristic evaluation based upon Android Accessibility Testing Checklist and WCAG. While searching for the appropriate guidelines recommended by W3C for this research, there were no one precise and

standard established guidelines for evaluating mobile application. The closest standard and published guideline is MWBP 1.0 and it is also not very updated as the latest version was updated in December 2010. MWBP is more focused on mobile Web applications rather than other categories Therefore, it limited heuristic evaluation to be more precise and accurate. It turned out that tested prototype performed poorly within the accessibility features integrated with Android. For example, nearly all the visual components did not provide additionally texts descriptions. They did not support Android integrating screen reader TalkBack. Therefore, people with disabilities such as visual impairment would not able to use the prototype completely by themselves. Accessibility of the prototype is not guaranteed for them. Situational variations were not tested in this research as well. For instance, ask participants to perform tasks while the devices is shaking or moving to simulate erratic environments. Besides, in order to make the application universally designed, theoretically, the co-located collaborative mobile application should function properly regardless of mobile platforms. Due to time limitation, the mainly supported mobile OS was Android and tests were conducted based on Android Tablets. The accessibility of the application heavily relies on mobile OS, which integrates diverse accessibility features as Figure 29 and 30 depict. Each mobile OS integrated accessibility features vary from each other, and this could lead to different user experiences while using them for improving accessibility of using the prototype in this research. Not to forget, the corresponding accessibility guidelines established by different mobile Oss are also different. For example, Accessibility Programming Guide for iOS, Android Accessibility Testing Checklist for Android.

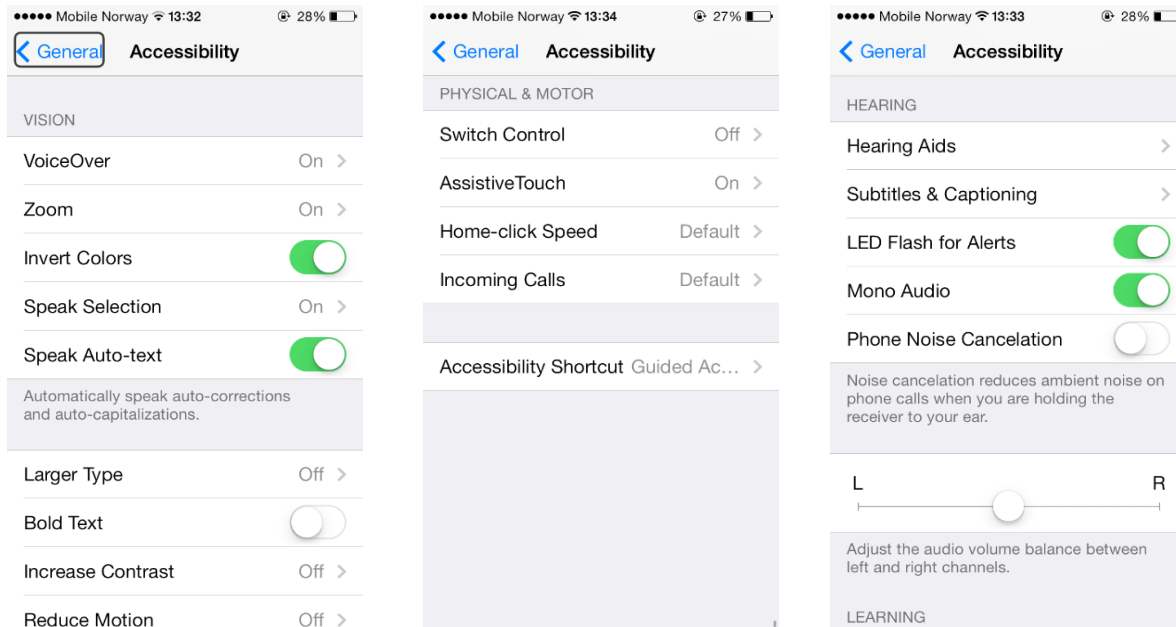


Figure 29: iOS built-in Accessibility features



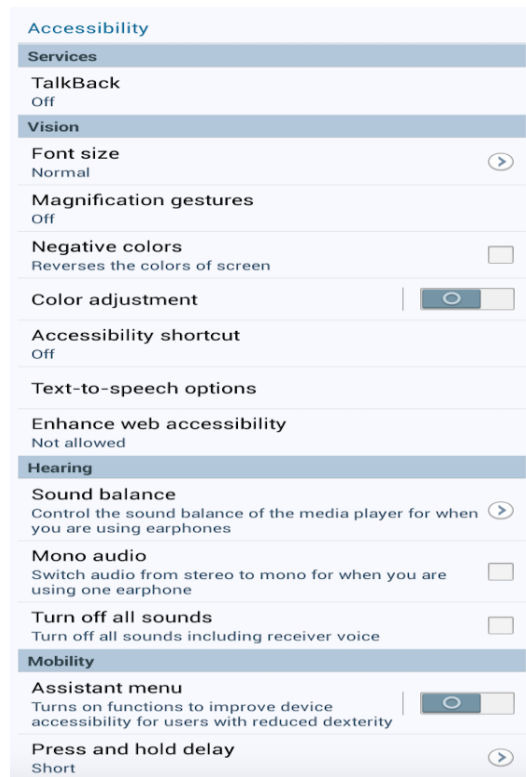


Figure 30: Android built-in Accessibility features

In addition, owing to the prevalence of mobile devices, it has raised huge concerns with regard to privacy and security. Indeed, currently some of the existing web-based Mobile Learning programs or applications in order to provide users with better user experience, they apply user profiling by collecting users' personal information. In such case, users' personal information might be exposed or hacked without notification, which will cause severe problems in terms of privacy, such as bank account information, personal information and etc. However, in the context of the application in this research, it requires players are co-located so that to promote communications between them. So online communication and network connectivity is not required. None of personal information was collected by the application in this research.

## 7. Conclusion

This section presents a brief overview of the contributions made in this research and conclusions.

This work based on the unique Chinese culture background, and proposed the implementation of the co-located Collaborative Mobile Learning game for elderly users and children, for improving English learning and socialization among them. The main contribution of this project is the design and development of the co-located Collaborative Mobile Learning prototype. User interfaces personalization was adopted within the same screen to help improve the accessibility of them. Viable prototypes that addressed identified problems and constituted the future co-located Collaborative Mobile Learning game. For the purpose of making the game universally designed, this project integrated accessibility into User-Centered Design. Evaluation regarding the usability and accessibility

the prototypes were conducted with different research methods, such as Interviews, usability testing, observation, and heuristic evaluation.

As with any solutions, technologies are not the final answer, but rather valuable alternatives for assisting educations. In this research, a Game-Based educational Collaborative Mobile Learning application was proposed to help English learning and to improve socialization among elderly users based on the unique culture factor in China and national phenomena “empty nesters”, “left-behind children”. In order to make it universally designed so that a wide range of users could use it effectively and easily including different situations, even for those completely new users, this research integrated accessibility into UCD based on (Henry, 2007) for the purposes of properly addressing diverse user requirements, usability and accessibility issues. Personalization was applied in the user interface to meet users’ different requirements including conflicting ones. Several research methods were adopted to serve the research question, such as semi structured focus group interview, usability testing, observation and heuristic evaluation. Usability testing was conducted at different stages of the development process with different focuses to reveal underlying usability issues with the prototypes. For example, early stage formative testing of the paper-based prototype was to validate the concept design. Summative testing was carried out when there were different viable prototypes ready. Qualitative data were collected by interviews, observation while user performing tasks. Heuristic evaluation with focus on accessibility using relevant accessibility guidelines gave comparatively different results than empirical methods like interview and usability testing. On one hand, by solely evaluating using guidelines, this project investigated the latent accessibility issues of the prototype. On the other hand, user observation and interviews both provided more human-centred awareness about the tested prototypes during testing phase with lists of questions and tasks in terms of usability. So far it is possible to answer the research question based on the following aspects associated with Universal Design.

First of all, consider the user diversity within two different target users groups including elderly and children, personalization was adopted to cope with diverse users’ requirements including those conflicting requirements such as the variations of each individual’s physical function abilities as well as preferences. For example, it provides customer settings where users could personalize system settings based on their preferences. By this, it could keep a reasonable trade-off between conflicting requirements within diverse user groups. Users are allowed to set up either big or small letter cards, different floating speeds of letter cards and etc. The prototype allows users taking ownership of their learning, which is also important for creating meaningful collaborative gamification. As in this project, users are also allowed to choose different learning time or difficulty levels within given options. Most importantly, they are not required choosing difficulty levels step by step.

Secondly, regarding situational variations, the prototype was assumed work partially related to physical environments since everyone might face challenges using it under those certain circumstances. For instance, auto adjustment of brightness of screen enables users could see the touch screen clearly at different levels of illumination. Personalization of user interfaces was considered to be helpful for improving accessibility of the prototype. However, it failed to function consistently regardless mobile platforms (only support Android in this research) due to time limitation. In terms of culture differences, it only provides users with Chinese menu rather than in other languages. For the consideration of optimizing user experience, it initially targeted at mobile tablets instead of smart phones in which big screen size implemented even though it supported different screen sizes.

The majority of usability issues were revealed and fixed through the whole process of User-Centered Design, from early stage of concept test till final functional interactive prototype.

Through usability testing, data were collected and improved designs have been made in order to improve the usability of the prototypes. Overall, it performed well in terms of those attributes associated with usability according to those results collected during testing, such as learnability, memorability, efficiency, errors and user satisfaction. Time spent on performing tasks during usability testing milestone 2 indicated the application was fairly effectively and easily to use at a low error rate, even for those completely new users of mobile applications (short instructions if needed). Interview results after testing showed most of the participants were subjectively satisfied while using it. However, by solely evaluating with regard to the accessibility issues of the prototype based on relevant guidelines (results refer to Table 20), it turned out it worked very limited within the Android integrating screen reader: TalkBack. Accessibility issues were not well addressed in this case.

Finally, despite that the project failed to conduct systematic testings in terms of evaluating learning outcomes by using of the game, however, during usability testing, I found out that participants communications were clearly improved, and they were fully focused on the tasks when playing the game. For example, older testers explained the exact Chinese meanings of those English words or figures applied if young participants were not able to understand them. Besides, nearly all of those participants claimed it was interesting to play with their grandchildren or grandparents. Therefore, this is a promising for applying the co-located Collaborative Mobile Learning game that aims at promoting the engagement of learning since both Collaborative Learning and GBL used in this research are considered as the potential means of promoting motivation as well as engagement among learners. It also helps for promoting communication and socialization between them. Consequently, strengthen their relationship. Not to forget, Collaborative Learning fosters the ability of self-regulation, critical thinking as well as teamwork skills, which will be the fine characters everyone should possess.

## 8. Future work

There are still limitations of the prototype shall be addressed in the future. First of all, improved design must be implemented in terms of accessibility in the future since currently the prototype for the co-located Collaborative Mobile Learning performed poorly based on Android accessibility feature TalkBack according to the results of heuristic evaluation. For example, it should provide additional texts or descriptions of widgets or controls in the user interfaces so that it will work properly within assistive technologies such as TalkBack, VoiceOver and etc. The prototype should also provide corresponding versions on iOS and WindowsPhone. Systematic tests regarding accessibility need to be carried out in the future instead of solely conducting heuristic evaluation based on guidelines. Accessibility tests should cover two aspects: people with disabilities using assistive technologies and situational variations. Hiring people with disabilities to conduct tests could help the designer address comprehensive accessibility issues of the prototype. Situational variations tests could help the prototype work consistently within different environments such as dark illumination, unstable situations and etc. Although it allows users personalise user interfaces, options are still limited. For example, so far each feature is given up to two or three selections. It will be better to provide users more options with more features for personalizing, such as color combination, font size for system settings. The majority of usability and accessibility issues should be addressed properly. Although nowadays mobile operating systems have done so much better to make mobile devices and applications more accessible to all kind of users by integrating diverse accessibility features, they are still in their infancy compared with desktop devices. In future, mobile operating systems should think

about the problem regarding how to make their products and applications accessible to people with multi-disabilities. Beyond that, published mobile applications on the markets shall not only work compatibly with the integrated accessibility features, but also provide suitable adaptations towards different groups of users.

Systematic tests regarding learning outcomes in a long term should also be conducted as well in the future if the prototype is fully developed. After all, its initiatives are help to improve English learning and socialization among children and elderly people in China.

The following aspects of the prototype should be improved. For example, currently the words database is too small to last for a long time. Users will easily get bored within such small amount of word vocabularies. Memoribility and user saticsfaction regarding usabillity should be tested in a long period of time. In terms of application's life circle, it is important to make sure the application lasts for a long term without losing attraction to the users since the initial idea of applying technology-supported education systems or applications is to improve learning. Indeed, it has become one of the most important problem the designers have to take into account when applying them. Because in a short term, most of these technology-riching educational applications perform really well, however, if it is in a long term, it will be a whole different story. Hence, it is very crucial to ensure application's life circle when applying the co-located Collaborative Mobile Learning game in this research. It is worth pointing out that although the initialtive of this research is to create a universally designed educational Collaborative Learning game for elderly people and users, it also can be played by parents with children or even peer-to-peer. In fact, it can be played by diverse age groups, not only elderly and children.

While searching for the right guidelines applicable for this research, obviously, there is still lack of unified standards or frameworks to restrict designers when applying Mobile Learning. Most of the related guidelines are more focus on web applications rather than other catergoties. Due to lack of universally standards or frameworks for applying Mobile Learning applications, which lead to mobile educational applications flood on the market. Therefore, certain authoties should issue uniformed frameworks or guidelines in the future, which could be used to regulater developers or designers. For example, how to create meaningful gamification when applying game-based Mobile Learning systems? Meanwhile, they could raise the awareness among designers of the importance of comforming to guidelines that cover a wide range of aspects when applying techonology-supported education.

As with other methods, every technology has some limitiations and weaknesses, and Mobile Learning is no exception. Although Mobile Learning seems quite interesting and promising because of the advancement of mobile and wireless communication technologies, there are plenty of challenges Mobile Learning has no alternative but coping with in terms of physical attributes of mobile devices such as small screen size, short battery life, and small amount of memory and etc. In the light of Scanlon (2014), Accessibility issues occurred because of cost barriers for certain groups of users or even in some specific situations. For example, smaller screen sizes decrease user experience in comparison to computers or laptops. From the perspective of Universal Design, in situations like using mobile devices directly under the sun or on the bus while its shaking, sometimes it can be difficult for users to see or to pinpoint on the touch screen, not to mention challenges people with disabilities might have in these circumstances. All of these situations might happen and cause troubles to users when applying Mobile Learning. However, in this study it failed to deal with the above presented challenges pertaining to the physical attributes of mobile devices. On the contrary, it mainly focused on the software solutions instead of hardware. For example, personalizing bigger icons and font sizes were adopted in the user interface, higher color contrast according to WCAG was applied to improve user experience while using the prototype. The most severe issue confronted by Mobile Learning is

the lack of sound theoretical frameworks and guidelines that can guide effective instructional design and evaluate the quality of Mobile Learning environments. Unlike Computer-Mediated Learning, there is no such frameworks and guidelines for designing Mobile Learning systems that can be uniform standards.

## Reference

- Abras, C., Maloney-Krichmar, D., & Preece, J. (2004). User-centered design. Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications, 37(4), 445-456.
- Alessi, S. M., & Trollip, S. R. (2000). Multimedia for learning: Methods and development: Allyn & Bacon, Inc.
- Android. (n.d.). Accessibility Testing Checklist | Android Developers. from [http://developer.android.com/tools/testing/testing\\_accessibility.html](http://developer.android.com/tools/testing/testing_accessibility.html)
- Bandeira, R., Lopes, R., & Carriço, L. (2010). Towards mobile Web accessibility evaluation. Free and Open Source Software for Accessible Mainstream Applications (FOSS-AMA), colocated with ETAPS, 27-28.
- Banister, J., Bloom, D. E., & Rosenberg, L. (2010). Population aging and economic growth in China.
- Bates, A. T. (2004). Technology, e-learning and distance education: Routledge.
- Bekebrede, G., Warmelink, H. J. G., & Mayer, I. S. (2011). Reviewing the need for gaming in education to accommodate the net generation. Computers & Education, 57(2), 1521-1529.
- Belanger, Y. (2005). Duke University iPod first year experience final evaluation report. Retrieved May 3, 2014, from [http://cit.duke.edu/pdf/reports/ipod\\_initiative\\_04\\_05.pdf](http://cit.duke.edu/pdf/reports/ipod_initiative_04_05.pdf)
- Bell, B., & Cowie, B. (2001). The characteristics of formative assessment in science education. Science education, 85(5), 536-553.
- Black, P., & Wiliam, D. (1998). Assessment and classroom learning. Assessment in education, 5(1), 7-74.
- Brault, M. W. (2009). Review of changes to the measurement of disability in the 2008 American Community Survey. Wash ington, DC: US Census Bureau.
- Cenoz, J., & Jessner, U. (2000). English in Europe-The Acquisition of a Third Language: Multilingual Matters.
- Chen, S.-J. Y. J.-C., Yang, T.-N., & Hsu, S.-C. (2004). Computer chinese chess. ICGA Journal, 27(1), 3-18.
- Connolly, T. M., Stansfield, M., & Hailey, T. (2007). An application of games-based learning within software engineering. British Journal of Educational Technology, 38(3), 416-428.
- Csikszentmihalyi, M., Kolo, C., & Baur, T. (2004). Flow: The psychology of optimal experience. Australian Occupational Therapy Journal, 51(1), 3-12.
- De Lucia, A., Francese, R., Passero, I., & Tortora, G. (2009). Development and evaluation of a virtual campus on Second Life: The case of SecondDMI. Computers & Education, 52(1), 220-233.
- Deterding, S. (2012). Gamification: designing for motivation. interactions, 19(4), 14-17.
- Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. Paper presented at the CHI'11 Extended Abstracts on Human Factors in Computing Systems.
- Dillenbourg, P. (1999). What do you mean by collaborative learning? Collaborative-learning: Cognitive and Computational Approaches., 1-19.
- Dictionaries, O. (n.d.). Oxford Dictionaries. Retrieved April,4, 2015, from

<http://www.oxforddictionaries.com/definition/english/mobile>

- Elearning-companion.com. (2013). The Disadvantages of Online Learning. Retrieved May 20, 2014, from <http://www.elearning-companion.com/disadvantages-of-online-learning.html>
- European Commission. (n.d.). Ageing report. Retrieved May 2, 2014, from [http://ec.europa.eu/economy\\_finance/articles/structural\\_reforms/2012-05-15\\_ageing\\_report\\_en.htm](http://ec.europa.eu/economy_finance/articles/structural_reforms/2012-05-15_ageing_report_en.htm)
- Foreign language learning statistics. (n.d.). Retrieved March 7, 2014, from [http://epp.eurostat.ec.europa.eu/statistics\\_explained/index.php/Foreign\\_language\\_learning\\_statistics](http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Foreign_language_learning_statistics)
- Furio, D., Gonzalez-Gancedo, S., Juan, M. C., Segui, I., & Rando, N. (2013). Evaluation of learning outcomes using an educational iPhone game vs. traditional game. *Computers & Education*, 64, 1-23. doi: Doi 10.1016/J.Compedu.2012.12.001
- Google. (n.d.). Color Palette. Retrieved April, 13, 2015, from <http://developer.android.com/design/style/color.html>
- Gokhale, A. A. (1995). Collaborative learning enhances critical thinking.
- Haklay, M. M., & Nivala, A. M. (2010). User-Centred Design. *Interacting with geospatial technologies*, 89-106.
- Helsper, E. J., & Eynon, R. (2010). Digital natives: where is the evidence? *British educational research journal*, 36(3), 1-18.
- Henry, S. L. (2006). *Understanding web accessibility Web Accessibility* (pp. 1-51): Springer.
- Henry, S. L. (2007). *Just ask: integrating accessibility throughout design*: Lulu. com.
- Hsu, Y. C., & Ching, Y. H. (2013). Mobile computer-supported collaborative learning: A review of experimental research. *British Journal of Educational Technology*, 44(5), E111-E114.
- Hwang, G.-J., & Chang, H.-F. (2011). A formative assessment-based Mobile Learning approach to improving the learning attitudes and achievements of students. *Computers & Education*, 56(4), 1023-1031.
- Illinois University. (2008). Strengths and Weakness of Online Education. Retrieved May 20, 2014, from <http://www.ion.uillinois.edu/resources/tutorials/overview/weaknesses.asp>
- ISO. (2010). *Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems*.
- Iwarsson, S., & Ståhl, A. (2003). Accessibility, usability and universal design-positioning and definition of concepts describing person-environment relationships. *Disability & Rehabilitation*, 25(2), 57-66.
- Jenkins, H. (2009). *Confronting the challenges of participatory culture: Media education for the 21st century*: Mit Press.
- Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in human behavior*, 19(3), 335-353.
- Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research methods in human-computer interaction*: John Wiley & Sons.
- Leme, R., Zaina, L., & Casadei, V. (2014). *Interaction With Mobile Devices by Elderly People: The*

- Brazilian Scenario. Paper presented at the ACHI 2014, The Seventh International Conference on Advances in Computer-Human Interactions.
- Lewis, J. R. (2006). Usability testing. *Handbook of human factors and ergonomics*, 12, e30.
- Lewis, S., Pea, R., & Rosen, J. (2010). Collaboration with Mobile Media: Shifting from 'Participation' to 'Co-creation'. Paper presented at the Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE), 2010 6th IEEE International Conference on.
- Liu, T., Wang, H., Liang, J., Chan, T.-W., Ko, H., & Yang, J. (2003). Wireless and mobile technologies to enhance teaching and learning. *Journal of Computer Assisted Learning*, 19(3), 371-382.
- List of countries by number of mobile phones in use. (n.d.). Retrieved March 5, 2014, from [http://en.wikipedia.org/wiki/List\\_of\\_countries\\_by\\_number\\_of\\_mobile\\_phones\\_in\\_use](http://en.wikipedia.org/wiki/List_of_countries_by_number_of_mobile_phones_in_use)
- Mace, R. (1997). What is universal design. The Center for Universal Design at North Carolina State University. Retrieved Retrieved November, 19, 2004.
- Madden, T. J., Hewett, K., & Roth, M. S. (2000). Managing images in different cultures: A cross-national study of color meanings and preferences. *Journal of international marketing*, 8(4), 90-107.
- Marlatt, E. A. (1996). ENFI—An Approach to Teaching Writing Through Computers. *American annals of the deaf*, 141(3), 240-244.
- Mercado-Sáenz, S., Ruiz-Gómez, M. J., Morales-Moreno, F., & Martínez-Morillo, M. (2010). Cellular aging: theories and technological influence. *Brazilian Archives of Biology and Technology*, 53(6), 1319-1332.
- Mikołajewska, E., & Mikołajewski, D. (2011). E-learning in the education of people with disabilities. *Adv Clin Exp Med*, 20(1), 103-109.
- Muñoz, C. (2014). Exploring young learners' foreign language learning awareness. *Language Awareness*, 23(1-2), 24-40.
- Murphy, C. (2011). Why games work and the science of learning. Paper presented at the Interservice, Interagency Training, Simulations, and Education Conference.
- Motiwalla, L. F. (2007). Mobile learning: A framework and evaluation. *Computers & Education*, 49(3), 581-596.
- Nation, U. (2013). World Population Ageing 2013. Retrieved September, 25, 2014, from <http://www.un.org/en/development/desa/population/publications/pdf/ageing/WorldPopulationAgeing2013.pdf>
- Newark-French, C. (2012). Mobile App Usage Further Dominates Web, Spurred by Facebook. Retrieved April, 25, 2015, from [http://www.flurry.com/bid/80241/Mobile-App-Usage-Further-Dominates-Web-Spurred-by-Facebook-.VTtbys7p\\_9k](http://www.flurry.com/bid/80241/Mobile-App-Usage-Further-Dominates-Web-Spurred-by-Facebook-.VTtbys7p_9k)
- Nicholson, S. (2012). A user-centered theoretical framework for meaningful gamification. *Games+ Learning+ Society*, 8(1).
- Nicol, D. J., & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in higher education*, 31(2), 199-218.
- Jenkins, H. (2009). Confronting the challenges of participatory culture: Media education for the 21st



century: Mit Press.

- Jaaskelainen, R. (2010). Think-aloud protocol. *Handbook of Translation Studies*, 1, 371.
- Lazar, J., Feng, J. H., & Hochheiser, H. (2010). *Research methods in human-computer interaction*: John Wiley & Sons.
- O'Neil, H. F., Wainess, R., & Baker, E. L. (2005). Classification of learning outcomes: evidence from the computer games literature. *Curriculum Journal*, 16(4), 455-474.
- Prensky, M. (2005). Computer games and learning: Digital game-based learning. *Handbook of computer game studies*, 18, 97-122.
- Prensky, M. (2002). The motivation of gameplay: The real twenty-first century learning revolution. *On the horizon*, 10(1), 5-11.
- Resta, P., & Laferrière, T. (2007). Technology in support of collaborative learning. *Educational Psychology Review*, 19(1), 65-83.
- Rinessi, J. F. G., Saiach, S. S., & Lecuna, N. (2000). Eventos celulares en el envejecimiento. *Revista de Posgrado de la Cátedra Vía Medicina N*, 100, 21-23.
- Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. Paper presented at the Computer supported collaborative learning.
- Rubin, J., & Chisnell, D. (2008). *Handbook of usability testing: how to plan, design and conduct effective tests*: John Wiley & Sons.
- Rutledge, P. *The Positive Side of Video Games: Part III*.
- Scanlon, E. (2014). Mobile Learning: location, collaboration and scaffolding inquiry. *Increasing Access*, 85.
- Shuler, C. (2012). iLearn II: An Analysis of the Education Category on Apple's App Store. from <http://www.ioanganzcooneycenter.org/publication/ilearn-ii-an-analysis-of-the-education-category-on-apples-app-store/>
- Sacramento, V., Endler, M., Rubinsztein, H. K., Lima, L. S., Goncalves, K., Nascimento, F. N., & Bueno, G. A. (2004). MoCA: A middleware for developing collaborative applications for mobile users. *Distributed Systems Online, IEEE*, 5(10), 2-2.
- Rinessi, J. F. G., Saiach, S. S., & Lecuna, N. (2000). Eventos celulares en el envejecimiento. *Revista de Posgrado de la Cátedra Vía Medicina N*, 100, 21-23.
- Roschelle, J., & Teasley, S. D. (1995). The construction of shared knowledge in collaborative problem solving. Paper presented at the Computer supported collaborative learning.
- Statista. (2015). Number of mobile cell phone subscribers in China from February 2014 to February 2015 (in millions). Retrieved April, 15, 2015, from <http://www.statista.com/statistics/278204/china-mobile-users-by-month/>
- Story, M. F. (1998). Maximizing usability: the principles of universal design. *Assistive technology*, 10(1), 4-12.
- THE RADICAL GROUP, I. (2014). *Mobile Statistics Report, 2014-2018*. Retrieved April,14, 2015, from <http://www.radicati.com/wp/wp-content/uploads/2014/01/Mobile-Statistics-Report-2014-2018-Executive-Summary.pdf>

- TheAtlantic. (2013). In China, It's the Grandparents Who 'Lean In'. Retrieved September,16, 2014, from <http://www.theatlantic.com/china/archive/2013/09/in-china-its-the-grandparents-who-lean-in/280097/>
- Toby, B. H. (2001). EXPGUI, a graphical user interface for GSAS. *Journal of Applied Crystallography*, 34(2), 210-213.
- Tomaka, J., Thompson, S., & Palacios, R. (2006). The relation of social isolation, loneliness, and social support to disease outcomes among the elderly. *Journal of aging and health*, 18(3), 359-384.
- Vanderheiden, G., & Tobias, J. (2000). Universal design of consumer products: current industry practice and perceptions. Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.
- Warschauer, M. (1997). Computer-mediated collaborative learning: theory and practice. *The Modern Language Journal*, 81(4), 470-481.
- W3C. (2008). Mobile Web Best Practices 1.0. from <http://www.w3.org/TR/mobile-bp/-d0e1240>
- W3School. (n.d.). CSS Font. from [http://www.w3schools.com/css/css\\_font.asp](http://www.w3schools.com/css/css_font.asp)
- Warschauer, M. (1997). Computer-mediated collaborative learning: theory and practice. *The Modern Language Journal*, 81(4), 470-481.
- White, E. L., & Gillard, S. (2011). Technology-based literacy instruction for English language learners. *Journal of College Teaching & Learning (TLC)*, 8(6), 1-6.

## **Appendix**

### **Appendix-Participant Consent Form**

#### **Introduction and purpose:**

This testing aims to get feedback of users regarding to the co-located Collaborative Mobile Learning game application.

#### **Procedure:**

If you or your child agrees to take part in this voluntary testing, you or your child will be involved in three different stages. Stage1: you and your child will be asked to give feedbacks about list of questions. The total time is less than 10 minutes. Stage 2 and 3: you or your child will be asked to perform a number of tasks with regards to the application. The total time required is approximately 30 minutes. At the end of testing, you or your child will be asked a few questions to seek more feedbacks of using the applications or your opinion of certain questions. Audio and Video might be recorded in different stages. Photos will be taken while performing testing and published on my master thesis.

#### **Voluntary Nature of the testing/Confidentiality:**

Your participation in this study is entirely voluntary and you may request to stop if you feel any discomfort during the testing. Your name will be kept confidential and your information or testing result will be represented using pseudonyms to protect confidentiality.

#### **Participant certification:**

I have read the above information and I consent to participate this testing.

Name of participant: \_\_\_\_\_

Signature: \_\_\_\_\_

Date: \_\_\_\_\_