Faculty of Cognitive Sciences and Human Development

DESIGN AND EVALUATION OF A MOBILE LEARNING APPLICATION TO INTRODUCE COGNITIVE SCIENCES

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PhD ☐

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DESIGN AND EVALUATION OF A MOBILE LEARNING APPLICATION TO INTRODUCE COGNITIVE SCIENCES

ALIXIA LEE HWEI LIH

This project is submitted
in partial fulfilment of the requirements for a
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The project entitled 'Design and evaluation of a mobile learning application to introduce cognitive sciences' was prepared by Alixia Lee Hwei Lih and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfilment of the requirements for a Bachelor of Science with Honours (Cognitive Science).

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A-

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ABSTRACT

Cognitive Science is a relatively young field as compared to other scientific fields. It is seen as a challenge to educate the Malaysian society about Cognitive Sciences. This study aims to design relevant content for a mobile learning application to introduce Cognitive Sciences. Four higher secondary school students from Kuching, Sarawak were selected to participate in this study. A think aloud protocol was conducted to observe the verbalization of thoughts of the respondents when interacting with the content presented. A questionnaire adapted from the Learning Objectives Review Instrument (LORI) v1.5 model and a standardized interview were also carried out to understand the perspectives of respondents towards the learning content. The results obtained from the think aloud protocol revealed that the respondents had shown a positive reaction as they went through the Cognitive Sciences content in the mobile application. The questionnaire adapted from the LORI v1.5 Model and the interview, however, had found three problems in the content design namely motivation, accessibility and reusability. In short, modifications had to be made to the learning content in order to produce effective content for a mobile learning application in introducing Cognitive Sciences.

Keywords: Cognitive Sciences, learning content, mobile application.

ABSTRAK

Sains Kognitif merupakan bidang yang agak muda berbanding dengan bidang Sains yang lain. Ia dilihat sebagai satu cabaran untuk mendidik masyarakat Malaysia tentang Sains Kognitif. Kajian ini bertujuan untuk mereka kandungan yang relevan untuk aplikasi pembelajaran mudah alih bagi memperkenalkan Sains Kognitif. Empat orang pelajar sekolah menengah di Kuching, Malaysia telah dipilih untuk mengambil bahagian dalam kajian ini. Protokol *think aloud* dijalankan untuk memerhatikan pengujaran fikiran responden apabila berinteraksi dengan kandungan pembelajaran yang dikemukakan. Soal selidik yang disesuaikan daripada Model Alat Penilaian Objektif Pembelajaran v1.5 dan temu bual terpiawai dijalankan untuk memahami perspektif responden terhadap kandungan pembelajaran. Keputusan yang diperoleh daripada protokol *think aloud* menunjukkan bahawa responden telah memberi reaksi yang positif apabila mempelajari kandungan Sains Kognitif dalam aplikasi mudah alih tersebut. Namun begitu, soal selidik yang disesuaikan daripada Model Alat Penilaian Objektif Pembelajaran v1.5 dan temu bual tersebut mendapati tiga masalah dalam reka bentuk kandungan iaitu motivasi, kebolehcapaian dan kebolehgunaan semula. Secara keseluruhan, pengubahsuaian terhadap kandungan pembelajaran diperlukan bagi menghasilkan kandungan yang berkesan untuk aplikasi pembelajaran mudah alih dalam memperkenalkan Sains Kognitif.

Kata kunci: Sains Kognitif, kandungan pembelajaran, aplikasi mudah alih.

CHAPTER ONE

INTRODUCTION

The digital technology has been advancing so rapidly that it has integrated itself as an important aspect in today's society (Higgins, Xiao & Katsipataki, 2012). It is a common sight to see the present generation to possess a form of digital device. The group of young people who utilizes the use of digital technology is called the "digital natives" (Prensky, 2001) or "new millennium learners" (Pedró, 2006). This generation also shares a common trait of preferring to socialize in a digital world rather than having physical contact with others. As a result of this trend, it has brought about a new technique of learning that encourages technology-assisted learning as compared to the conventional method of merely using textbooks to learn (Samsiah Bidin & Azizah Abu Ziden, 2013). This style of learning is called mobile learning.

Mobile learning (also known as m-learning) is the use of mobile technology to provide access to learning content and information resources anytime and anywhere (United Nations Educational, Scientific and Cultural Organization, 2016). There are tremendous benefits of mobile learning in this digital age as it fulfils the characteristics of the new generation. According to Cohen (2015), mobile learning provides easy access to the learners to obtain information instantaneously. The young generation grew up being surrounded by technology thus, this style of learning appeals to them who desire for instant gratification (Kukulska-Hulme & Shield 2007). It adopts the concept of flexible learning whereby it gives mobility to the users to learn regardless of time and place as information can be accessed instantly at their fingertips.

Besides, mobile learning offers a personalized learning experience to the learners (Shuler, 2009; Virvou & Alepis, 2005). Mobile learning applications delivers a private virtual

world to the learners that allow them to learn at their own pace. In contrast to conventional learning whereby all the students are expected to keep up with their peers and excel accordingly, mobile learning underlines learners' individual progression. This provides them with a sense of privacy and motivation as they are able to learn without having to be compared to others.

Likewise, mobile learning encourages self–regulated learning as it allows learners to take control of their own learning (Samsiah Bidin & Azizah Abu Ziden, 2013). Mobile learning opens up the opportunities for learners to play an active role in their learning progress by encouraging them to determine their personal goals and work towards them. Makoe (2010) mentioned that once they are able to exercise control over their own learning, learners are then expected to able to adopt personalized learning strategies that will assist in their learning development.

Mobile learning also fits into diverse learning environments (Chen, Kao, Sheu & Chiang, 2003; Motiwalla, 2007). Be it in a classroom or outside the classroom; in the city or the rural areas, mobile learning gives the learners the freedom to learn in different contexts. It incorporates formal learning into informal learning by combining classroom instructions with mobile learning applications to enhance interaction and engagement of the learners in their learning process (Prensky, 2007; Zhang, 2003). This makes learning fun as learners learn to apply skills acquired from their surroundings instead of the old-fashioned and uninteresting way.

From the evolution of technology, it is apparent that science is ever-changing as well in order to accommodate the progression of time. Cognitive Science has emerged in the past recent decades as a major discipline that contributes to the important study on the human mind and intelligence. Its roots date back to mid-1950s when researchers began to develop theories of mind. In 1975, Cognitive Science Society was formed and the journal *Cognitive*

Science began (Smelser & Baltes, 2001). Cognitive Science emphasizes on cognitive processes that are computational as a comparison of natural and artificial intelligence. There are five main fields in Cognitive Science namely Psychology, Neuroscience, Artificial Intelligence, Linguistics and Philosophy (iCogSci, 2012).

According to iCogSci (2012), there are currently 81 universities worldwide that offer Cognitive Science courses with 61 universities in the United States and Canada but only 7 universities in Asia. Among the 7 Asian universities, Universiti Malaysia Sarawak is the only university in Malaysia offering the Cognitive Science program since 1994 (Universiti Malaysia Sarawak, n.d).

Mobile Learning Applications

Many learning institutions worldwide have adopted mobile learning in order to adapt to the changing times in the education field. Stanford University (2009) conducted the Dunia Moja project as a collaboration between Stanford University and three universities in Africa, namely University of the Western Cape in South Africa, Mweka College of African Wildlife Management in Tanzania and Makerere University in Uganda. The purpose of this project is to provide access to course materials, field research and assignments in Environmental Science using mobile technologies so that students from these universities are able to share their local experiences and to foster an understanding with their global connections.

Apart from this, Athabasca University has developed interactive and multimedia content for its English as second language (ESL) learners (Woodill, 2011). It emphasizes on interactive content to include the development of skills for the learners in English grammar and English pronunciation. MobileMath is another initiative that was implemented in Trinidad and Tobago to motivate Caribbean students to improve their Mathematics through tutorials, quizzes and fun facts. In a study carried out by Kalloo and Mohan (2012), many students failed Mathematics as they do not understand the lessons taught in the classroom.

Thus, MobileMath was created in view of the need for a solution to improve the students' performance in Mathematics.

Similarly, Malaysia is one of the countries that followed lead in applying mobile learning in its education field. Open University Malaysia implemented the use of SMS to support distance learners by sending announcements, course contents and learner assessments (Zoraini Wati Abas, Chng & Norziati Mansor, 2009). This approach helps its students, who are mostly comprise of working adults, to keep track of important dates and assignments on top of making learning more flexible for them.

On top of this, a mobile learning application was developed in Malaysia to teach fundamental topics in Basic Computer Architecture (Kamaludin, Kasim, Selamat & Hui, 2012). This application includes modules in the form of notes, flash cards and quizzes that can be accessed on mobile devices even while offline. Also, Bujang and Riaz (2012) has developed M-Jako Iban as a mobile dialogue-based application to introduce the Iban language in Malaysia. It uses the storytelling approach to teach the Iban language as a form of engaging and entertaining way of promoting the language to non-native speakers.

Problem Statement

Cognitive Science is a relatively young field as compared to other scientific fields and many people, especially in the South East Asia region, have limited exposure to this field. This is due to the fact that there is only one higher institution in Malaysia offering the Cognitive Science course. Additionally, there is a lack of digital learning materials accessible to the public despite ample mobile learning applications being available in the market. At present, there is only a mobile application called 'Cognitive Science' in App Store where it allows users to download journals that are related to Cognitive Science. Therefore, it is seen as a challenge to educate the society, especially in Malaysia, about Cognitive Sciences.

Research Objective

General objective. The main objective of this project is to design relevant learning content for a mobile learning application to introduce Cognitive Sciences to higher secondary school students in Malaysia.

Specific objectives

I. To design the learning content at introductory level for a mobile application to introduce Cognitive Sciences.

II. To evaluate the learning content of a mobile application in introducing Cognitive Sciences.

Research Questions

I. What are the components that need to be included in the content to introduce Cognitive Sciences?

II. How effective is the learning content of the mobile application in introducing Cognitive Sciences?

Scope of the Project

To achieve the above objectives, the scope of this project is designed as an introductory course to the main branches under Cognitive Science. The mobile learning application will only be available in English. The content is based on the textbook *The Cognitive Sciences: An interdisciplinary approach*. Other than that, this mobile application is targeted for higher secondary school students who are interested to know about Cognitive Sciences.

Significance of the Project

Currently, there are no mobile learning applications in the market to teach about Cognitive Sciences. With the development of this application, it provides an introductory platform to nurture the interest of young students in this field. This mobile application also

acts as a catalyst to introduce Cognitive Sciences to higher secondary school students in Malaysia, thus creating awareness among them at an earlier stage.

Definition of Terms

Mobile Learning. Mobile-learning (m-learning) is the the use of mobile technology to enable learning anytime and anywhere (Crompton, 2013). It allows teaching and learning across multiple contexts, through social and content interactions as well as to extend to spaces beyond the traditional classroom.

Cognitive Science. Cognitive Science is an interdisciplinary study of the human mind and its processes. It encompasses philosophy, psychology, artificial intelligence, neuroscience, linguistics, and anthropology (Thagard, 1996).

Summary

As Cognitive Science is a relatively young field, especially in South East Asia region, it is no surprise that the society lacks of knowledge in this field. Therefore, this project aims to design relevant content on introductory level for a mobile learning application to expose Cognitive Sciences to the public. The learning content of this mobile learning application will be evaluated as well so that it aligns the objective of creating awareness among Malaysian secondary school students towards Cognitive Sciences, thus cultivating their interest to carry out more research in this field. The next chapter discusses the literature related to this study.

CHAPTER TWO

LITERATURE REVIEW

Mobile Learning

The development of technology has transformed the education field and made the industry to upgrade from its conventional ways. The penetration of technology has also produced learners who are becoming increasingly computer literate. Consequently, online learning (e-learning) was birthed in 1999 and it was the first term that connected learning with technologies (Keegan, 2002). It is defined as teaching and learning supported by electronic media and tools. E-learning is an effective approach to distance learning whereby learners are able to share knowledge electronically. It provides a comprehensive learning experience as it utilizes computer and communication technology to make learning more ubiquitous for learners. This no longer restricts the process of teaching and learning as learners can access contents online even though they may be geographically dispersed.

As the 2000s progressed, technologies advanced to provide other forms of mobile technology. Students were bringing technology such as hand phones and PDAs everywhere that it became an international phenomenon (Goggin, 2006). Educators then saw this as an opportunity to enhance the delivery of their lessons by utilizing mobile devices to connect to the young people. Pedró (2006) observed that the new generation has the tendency to do things differently than their predecessors; by multitasking, preferring to use multimedia than writing, communicating over the virtual network, wanting to have fun and having a faster-paced lifestyle. This causes a big adaptation in the style of teaching and learning that allowed mobile learning (m-learning) to take place so rapidly.

M-learning took e-learning a step further in allowing students to learn virtually anywhere when a mobile signal is available (Oller, 2012). M-learning enhances the potential

learning by allowing instant access to information by using mobile devices. Jones (2011) suggested that the smartphones, commonly owned, are especially ideal for personalised informal learning as it provides the convenience to learners instead of them bringing chunky computers around. This type of learning can be applied in various settings that enable learners to learn through interactive and collaborative environments.

The model of delivery of knowledge has adapted from distance learning (d-learning) to electronic learning (e-learning) then to mobile learning (m-learning) of this day (Behera, 2013). Many educators and researches are still exploring new techniques for mobile devices usage to improve the teaching and learning process. Crompton (2013) also agrees that m-learning is the future of learning as it embodies learner-centred education, in that learning will soon be omnipresent to learners.

Content Design

A good content design is essential to fulfill the needs of the users. Government Digital Service (2016) recommended that the design should focus on user requirements instead of creating content that is difficult for them to understand. While planning the content, the design should encompass most of the major learning styles such as auditory, visual and kinesthetic learning (Park, 2005). As each individual possesses different learning styles, the content should cater to different groups of learners. Other good content strategies include reducing the amount of content published and to break down huge chunks of information into smaller pieces. According to the information processing model by Atkinson and Shriffin (1968), humans can only retain 5-7 pieces of information in information processing. A good content design should also include a variety of content formats to attain the attention of the users. Lastly, care should be given to avoid duplicating content as it can cause confusion to the users.

Instructional Design

Instructional Design (ID) is the systematic process of developing instructional specifications in a consistent and reliable manner to ensure the quality of instructions (Reiser & Dempsey, 2011). The process starts with analysing learning needs and goals to the development of the design to fulfil those requirements. The concept of Instructional design dates back to the 1950s where Skinner (1954) suggested to include small steps, frequent questions and immediate feedback in the process of designing effective instructional materials.

ADDIE Model

The ADDIE model which stands for Analyze, Design, Develop, Implement and Evaluate, was originally developed in 1975 (Forest, 2014). It was first designed by Florida State University for the U.S. Army but later applied in all U.S. Armed Forces branches to create effective training programs for complicated subjects.

The ADDIE model was constructed according to an earlier ID model called the Five Step Approach. It was developed by the U.S. Air force to provide feedback, constraints and flexibility in planning instructional design (Ryder & Redding, 1993). Practitioners then made revisions of the original version to make the model more interactive and dynamic. They retained the five-step segments from the Five Step Approach and added more sub-stages in the five phases for ADDIE model. It was in the mid-1980s that the current version appeared.

Since then, ADDIE has been widely accepted and used as an ID model. It works as a step-by-step framework in the design and development for educational and training programs. Many educators and instructional designers find this model useful as the stages were clearly defined to assist implementation of effective training tools. The ADDIE model also ensures course development to be organized in a structured way whereby learners will be able to accomplish the objectives of the course.

Gagné's Nine Events of Instruction

Gagné's model is based on the information processing model of the mental events that occur when one is presented with various stimuli (Gagné, Briggs & Wager, 1992). Gagné (1992) proposed a unique set of events that help to design effective learning materials by applying the behaviorist approach.

Gagné's Nine Events of Instruction helps to achieve the goals in instructional design as the users are able to relate to the content delivered by associating it with prior knowledge. Questions are also probed to the learners so that they may recall what they have learned. However, if they are unable to remember, cues are given to prompt their recollection of the previous lessons. The learners are also able to internalize new concepts by linking them to real world examples and life situations.

Gagné (1992) has generated these nine principles based on the cognitive dynamics that influence the user's abilities to learn and retain information. The nine events of instruction can also be adapted to accommodate both the content to be presented and the students' level of knowledge. This model is useful in building a framework for the preparation and delivery of instructional content that focuses on the learning outcomes and how to arrange specific instructional events to achieve those outcomes.

Think Aloud Protocol

Jääskeläinen (2010) refers think aloud protocol as the empirical process used in gathering research data. The investigator is able to obtain information through the reasoning process of the subject and use it to improve the problems identified from the tasks. This method is derived from classical introspection in cognitive psychology where one analyses their own thought processes (Ericsson & Simon, 1980). Similarly, during data elicitation in known as 'thinking aloud', the subject verbalizes their thoughts, opinions and feelings when

they perform a task. The subject is allowed to pause when necessary during task performance as only certain parts of the cognitive process can be verbalised (Jääskeläinen, 2010).

However, think-aloud is only accessible to the information processed in working memory and that unconscious thoughts are not verbalized. On top of this, having a high cognitive load limits the verbalization process as the subject tends to forget to articulate their thoughts. Despite these limitations, Jääskeläinen (2010) stated that think aloud protocol is able to yield a wider knowledge base from the subject as it gives an insightful perspective on cognitive processes in progress.

Learning Object Review Instrument

According to Vargo, Nesbit, Belfer and Archambault (2003), the Learning Object Review Instrument (LORI) was designed for the E-Learning Research and Assessment Network (eLera) the Portal for Online Objects in Learning (POOL). Learning objects are the materials in the form of images, texts and interactive simulation used in online learning. When content is designed for reuse, LORI facilitates the comparison among learning objects by using a common review format. In the evaluation of a learning object, LORI focuses on nine items namely content quality, learning goal alignment, feedback and adaptation, motivation, presentation design, interaction usability, accessibility, reusability and standard compliance. The quality of each item is evaluated on a rating scale of five. The reviewer may also cross out the item if the item is not relevant to the learning object. Results should then be displayed in a set of averaged scores for each item or summarized as a single average score for all items and all comments should be recorded.

Summary

This project focuses on the content development of a mobile learning application to introduce Cognitive Science. Findings from journals and researches have provided the basis in designing effective learning content and the evaluation of the content design which further

pointed towards the prospects of mobile learning in this generation. The next chapter discusses on the method employed in conducting this project.

CHAPTER THREE

METHODOLOGY

Research Design

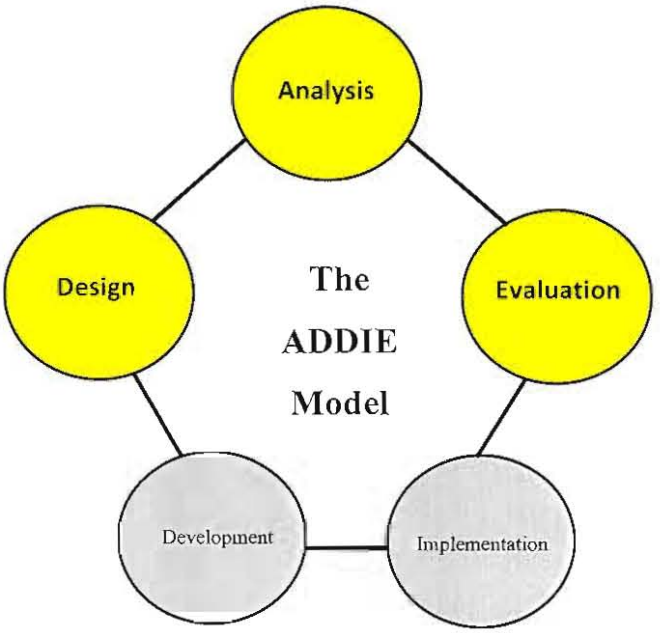

Figure 1. ADDIE Model

The ADDIE Model (as shown in Figure 1) was used as the framework to develop the content design in this project. ADDIE refers to a cyclic development life cycle that comprises 5 stages, namely Analysis, Design, Development, Implementation and Evaluation respectively. However, only the Analysis, Design and Evaluation phases were carried out in this project.

Analysis Phase

In the analysis phase, the instructional goals and challenges were specified as well as the learner's skills and knowledge was being identified. The respective instructional goals for the learners in each chapters was: to state all the cognitive processes in the Introduction module; to retell the three memory systems in the Psychology module; to draw the human

brain accurately in the Neuroscience module; to tell apart human intelligence and artificial intelligence in the Artificial Intelligence module, to describe the rules of language in Linguistics module, and to answer verbally the mind-body problem in the Philosophy module.

The major challenge faced in obtaining the instructional goals was that there would be no supervision to ensure the learners could achieve these goals during self-learning. Apart from this, the skills of the learners determined were reading, writing, comprehension and critical thinking on top of knowledge in English and Science. From these aspects, the various key components were then listed to ensure analysis was thorough.

Target audience. The target users were identified so that the content matched their level of knowledge and intelligence. For this project, the focused group of users were mainly secondary school students in Form Four and Form Five who were interested to know about Cognitive Sciences.

Learning goals. The learning objectives were specified to distinguish what the users had learnt and what would be learnt after completing the learning materials. The learning goals of this mobile application were for users to distinguish, relate and explain the basic approaches of Cognitive Science in addition to demonstrate understanding by identifying the concepts found in each contributing discipline.

Structural characteristics. The structures of the content design were listed so that the resources were not duplicated. The whole course of Cognitive Science was broken down into individual modules for each discipline namely Introduction, Psychology, Neuroscience, Artificial Intelligence, Philosophy and Linguistics. An assessment was given at the end of the chapter in the form of quiz to test on what the users had learnt.

Accessibility of resources. The learning materials were planned so that the content design was organized in an orderly manner for learning to take place efficiently. The syllabus

for this mobile application was mainly based on *The Cognitive Sciences: An interdisciplinary approach* textbook by Sobel and Li (2013). Further information was also obtained from the Internet to be put as assessment at the end of each module.

Design Phase

In the design phase, several concerns were addressed in order for the planned instructional design to be developed successfully. The approach in this stage was arranged systematically by following a set of rules in Gagné's Nine Events of Instruction so that each component of the content design could be executed in detail.

Gain attention. A conversational approach and multimedia were mostly used in the mobile application to gain the attention of students. By using various elements such as graphics and real life scenarios, the content was able to arouse the users' interest.

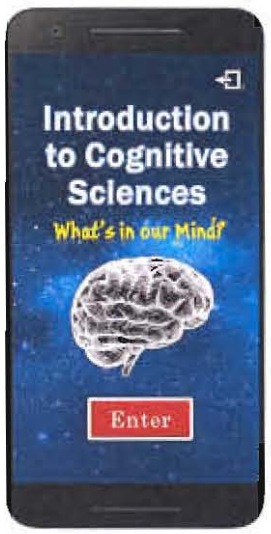

Figure 2. Graphics were used to attract attention of users.

Inform learners of objectives. The students were informed of the objectives before they start a module to help them grasp the overall idea of what they would learn in that module (refer to Figure 3).

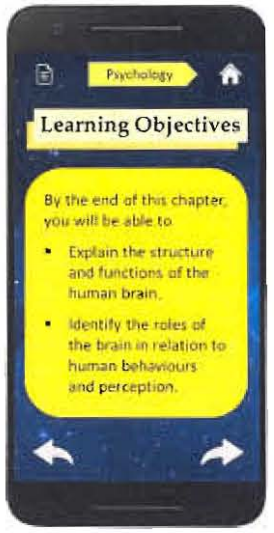

Figure 3. Learning objectives gave a guideline of the module to the learners.

Stimulate recall of prior learning. Figure 4 shows the questions asked to help users to associate new information by stimulating recall of prior learning. This refreshed the users' memory before they proceeded to learning new facts.

Figure 4. Questions were asked to prompt users' prior learning.

Present the content. The content of the mobile application (as shown in Figure 5) was presented in small chunks so that the cognitive process of the users was not overloaded. A variety of information such as examples, diagrams and tables was used to elicit learning.

Figure 5. The information was broken down in small pieces to help users understand better.

Provide guidance. The users were provided with a learning guide on how to remember new facts and information. Tips were given through visual cues, mnemonics, acronyms or images (refer to Figure 6).

Figure 6. Images helped to enhance users' recollection.

Elicit performance. Figure 7 depicts how real life scenarios were able to elicit the performance of the users. This allowed the students to practice the theoretical knowledge that they had learnt.

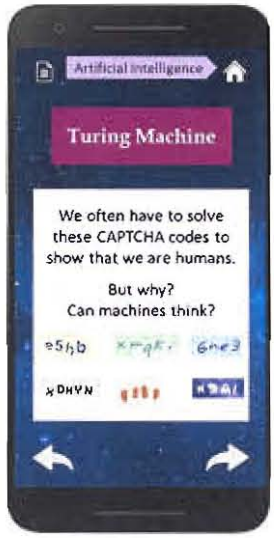

Figure 7. Real life scenarios to help users apply the theories that they had learnt.

Provide feedback. A feedback in form of simple exercises was provided to gauge the users' performance and understanding (refer to Figure 9). The users should know the progress of their learning from time to time.

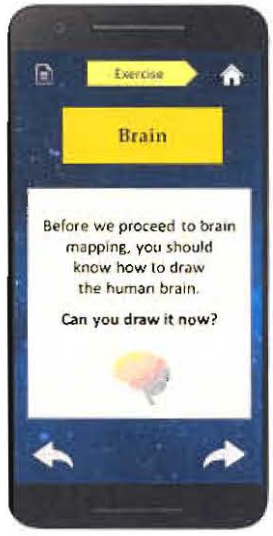

Figure 8. Exercises gave feedback to users on their learning progress.

Assess performance. The users were assessed through quiz questions at the end of each chapter as shown in Figure 9. By doing so, the learner's performance was reviewed to determine the effectiveness of their learning.

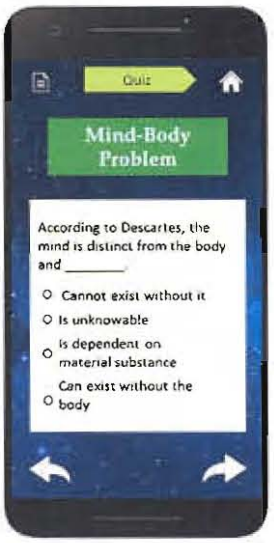

Figure 9. An assessment was given in the form of quiz.

Enhance retention and transfer. Figure 10 shows the summary at the end of the chapter to enhance the retention and transfer of knowledge for a particular topic. This provided an overall recap of the key concepts in the topic that the learners had just covered.

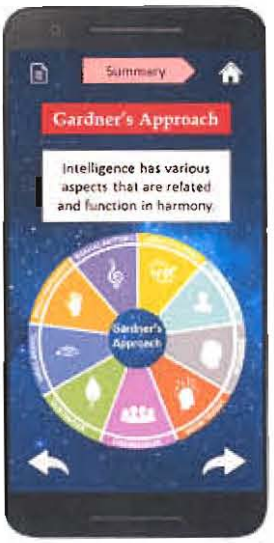

Figure 10. A diagram summarizing the main points for that chapter.

Evaluation Phase

The last stage for this project was evaluation. A formative evaluation was used to formulate a picture of learning whereby changes could be made to the product before the final implementation (Morrison & Kemp, 2013). The evaluation was carried out by think aloud protocol followed by a questionnaire adapted from LORI V1.5 model (as illustrated in Figure 11) and an open ended interview.

Adapted LORI v1.5 Model
Content Quality
The clarity of ideas in conveying facts and information.
Content Design
Flow of the presentation of visual and worded information.
Interest towards content
The appeal level of the content for the users.
Motivation
The tendency of the users to continue looking through the content.
Feedback
The perception of users towards the content.
Accessibility
Availability of the content to accommodate users from different backgrounds.
Reusability
Ability to be used in varying learning contexts.

Figure 11. Adapted LORI v1.5 Model.

The adapted LORI v1.5 model contained seven main criteria, namely content quality, content design, interest towards content, motivation, feedback, accessibility and reusability.

Content quality referred to the clarity of ideas in conveying facts and information. This was essential in conveying the learning content across to the users. Content design referred to the flow of the presentation of visual and worded information. Content design was

important to ensure smooth flow of knowledge transfer from the mobile application to the users during knowledge acquisition. Interest towards content also referred to the appeal level of the content for the users. Content that was appealing was able to capture their attention and maximized the users' learning process.

Apart from this, motivation referred to the tendency of the users to continue looking through the content. An effective learning content design was able to give the users motivation to finish browsing through the content. Feedback referred to the perception of users towards the content. The feedback was categorized into positive or negative based on the experience of the user when using the mobile application to study the content.

Next, accessibility referred to the availability of the content to accommodate users from different backgrounds. A good content should be made accessible to users regardless of their academic background and preferred language. Reusability referred to the ability to be used in varying learning contexts. The learning content should be easy to understand so that users were able to apply the knowledge from the multidisciplinary approach of Cognitive Science.

Population, Sample and Sampling Method

For this project, the target population was higher secondary school students in Kuching. The sample chosen were four higher secondary school students comprising of two males and two females in Form Four and Form Five respectively. The type of sampling procedure used in this project was purposive sampling. The requirement for respondent selection was that the students are either in Form Four or Form Five.

Study Procedure

Think aloud protocol. The target sample user was identified as a respondent for this project. The respondent was first presented with the content that had been developed into the mobile learning application and briefed thoroughly on the think aloud session. The goals of

the session and the recording method were also explained to the respondent. The user was then informed on how to carry out the think aloud process and that he could take a break at any point of the session. The respondent was given time to clarify any doubts before he was requested to sign an informed consent form.

During the think aloud session, the respondent was given the task of learning a module of his choice. The respondent was asked to verbalize his thoughts and feelings starting from the home page of the mobile application until the end of the selected module. By now, the respondent had been briefed on the functions of the mobile application so as to not disrupt the flow of thinking aloud. The respondent was also reminded to pay attention to the content design and express his interest or confusion accordingly. Throughout the session, the researcher observed the respondent quietly while taking note of the thinking aloud process so as not to interrupt his train of thought. On top of this, a digital camera had been set up to record the reactions from the respondent to be reviewed afterwards.

Questionnaire. After the think aloud session, a questionnaire adapted from LORI v1.5 Model (as shown in Appendix B) was given to the respondent to be filled in. The questionnaire consisted of seven aspects with a rating score of 1 to 5, in which 1 signified very bad and 5 signified very good. Descriptions of each criterion had also been given to provide explanation to the respondent on the scoring sheet.

In – depth Interview. Lastly, an interview was conducted by using a standardized open-ended interview (refer to Appendix C). The purpose for having an in-depth interview was to obtain insightful information from the perspective of the respondents. This approach also ensured that each set of interview given contained the same exact questions to all four respondents.

The interview was conducted face-to-face and six questions were prepared according to the objectives of the research. All the responses from the respondent were then recorded by

using an audio recording device to facilitate the transcription process later on. The researcher also took notes by using pencil and paper during the interview.

The whole process of think aloud session, questionnaire and interview were repeated for the remaining three respondents. When the data collection was done, the data was then compiled and transcribed to Microsoft Word for further analysis.

Summary

This chapter has discussed on the research methodology used in this project. The study design is a qualitative approach whereby the data collection is done by applying think aloud protocol, questionnaire and a standardised open-ended interview. The results and findings of the project will be discussed in the next chapter.

CHAPTER FOUR

RESULTS AND DISCUSSION

Overview

The findings are obtained from three different data collection methods: (1) think aloud protocol (2) questionnaire and (3) in – depth interview.

Respondent Profile

This study has involved four respondents consisting of two male and two female students from Kuching, Sarawak. They have fulfilled the criteria of study which is that they are higher secondary school students. Respondent 1 is a male Form Four student whereas respondents 2 is a female Form Four student; respondent 3 is a male Form Five student and respondent 4 is a female Form Five student. The selection of the respondents, however, does not consider their race, religion, age or even academic background.

Think Aloud Protocol

The results from the think aloud protocol are summarized in Table 1. It has been observed that some of the respondents gave similar reactions towards the learning content during the think aloud session.

When the respondents first started exploring the mobile application, they gave a positive impression of the multimedia selection. As contrary to the conventional learning materials with wordy information, all the respondents expressed delight in the variety of format in which the content was being displayed. For instance, Respondents 1 and 3 described that they liked the graphics and colours used while Respondent 4 felt that the background and home page were interesting.

As the respondents browsed through the module, the respondents enjoyed the conversational approach and think bubbles. However, the respondents tend to rush through

the content as they progressed through the session like Respondent 2 who clicked "Skip" without reading properly even from the beginning. This pattern could be seen in the learning objectives section as well, as the respondents tend to skip or spent little time reading the outline. This was observed in Respondent 1 who skipped reading the learning objectives.

On top of this, some of the respondents like Respondents 1 and 2 failed to answer the questions asked in the beginning of the chapter that were supposed to stimulate their prior learning. As for Respondent 3, he did not answer the question aloud even though he was observed to have paused at that page. All the respondents also spent more time reading when the information was displayed in text form over other stimuli like images. Respondents 2 and 4, however, were noted to have read aloud all the content presented even in images, tables and diagrams.

Next, in the aspect whereby guidance was provided to help the respondents remember, Respondent 1 needed assistance in associating difficult concepts. Respondent 2 remembered better when images were given while Respondents 3 and 4 could remember based on the cues given. The respondents also recalled better when they could apply the theories that they have learnt into practice. However, Respondent 2 was observed to have struggled in relating theories to real life examples given.

Besides, Respondent 2, 3 and 4 managed to complete the exercises given to gauge their learning progress although Respondent 1 could not perform as expected of him. The quiz assessment at the end of the chapter also reflected on their level of understanding. Respondent 4 managed to answer all the quiz questions correctly while Respondents 1, 2 and 3 made some mistakes as they were unfamiliar with the topic. Lastly, Respondent 2 tend to rush through the summary as she reached the end of the module. Respondents 1 and 3 read aloud the entire summary while Respondent 4 tend to forget to read the summary out loud.

Table 1

Results of Think Aloud Protocol

Item	Observation
Item 1	Respondent 2 clicked "Skip" without reading the introduction properly. Respondents 1 and 3 expressed liking towards the graphics and colours used. Respondent 4 described the background and home page as interesting.
Item 2	Respondent 1 skipped reading the learning objectives. Respondents 2, 3 and 4 read aloud the learning objectives.
Item 3	Respondents 1 and 2 could not answer some questions at times. Respondent 3 tend to forget to answer the questions aloud. Respondent 4 answered the questions aloud.
Item 4	All the respondents read longer when text is present. Respondents 2 and 4 read aloud the content in all images, tables and diagrams.
Item 5	Respondents 1 needed help in remembering difficult concepts. Respondent 2 remembered better when images were given. Respondents 3 and 4 could remember based on the guidance given.
Item 6	Respondents 1, 3 and 4 recalled better when they applied to real life scenarios. Respondent 2 could not relate theories to real life scenarios.
Item 7	Respondent 1 was unable to perform as expected of him. Respondents 2, 3 and 4 could answer the exercise given.
Item 8	Respondents 1, 2 and 3 answered incorrectly when unfamiliar with the topic. Respondent 4 managed to answer all the quiz questions correctly.
Item 9	Respondent 2 rushed through the summary of main points. Respondents 1 and 3 read aloud the entire summary. Respondent 4 tend to forget to read the summary out loud.

Questionnaire

The results from the adapted LORI v1.5 Model (shown in Table 2) indicated that the respondents felt that the information conveyed was clear. There was also a smooth flow in the representation of visual and worded content as both Content Quality and Content Design scored an average of 4 out of 5 respectively. This was followed by 3 out of 5 for Interest Towards Content and Feedback. The respondents were said to have a neutral perception towards the introductory learning content for Cognitive Sciences. Finally, Motivation, Accessibility and Reusability scored only 2 out of 5. The content was deemed to have low accessibility and reusability as language and unfamiliarity towards Cognitive Sciences posed as hindrances.

Table 2

Results of Adapted LORI V1.5 Model Questionnaire

	R1	R2	R3	R4	Average
Content Quality	4	3	4	5	4
Content Design	3	4	5	4	4
Interest towards content	3	4	3	3	3
Motivation	2	3	2	3	2
Feedback	2	4	3	3	3
Accessibility	2	2	2	2	2
Reusability	2	2	1	2	2

Interview

Objective 1 – To determine the clarity in content conveyance

Questions 1 and 2 are related to Objective 1 which aims to determine the clarity in content conveyance. The respondents were asked on their understanding of the content and their opinion on the representation of content.

Question 1: Did you face any difficulties in understanding the facts and information given?

All the respondents replied that they generally understood the facts and information given even though the topics were new to them. Respondent 2, however, said that she did face difficulties in understanding the concepts presented in the Artificial Intelligence module and suggested that more examples should be added as explanation.

Question 2: What do you think of the overall representation of the visual and worded information?

In this question, all the respondents answered that they like the flow of visual and worded information. Respondent 3 described that the small chunks of information and visual aid that came hand in hand really helped him to learn in a fun way.

Objective 2 – To identify personal interest towards the content

Questions 3 and 4 aim to explore the personal interest and motivation towards the content as stated under Objective 2.

Question 3: Does the content appeal to you to want to learn about Cognitive Sciences?

All the respondents, apart from Respondent 3, expressed neutral interest in the content on Cognitive Sciences. Respondent 3 felt that the content is stimulating and it is different from conventional textbooks.

Question 4: Does the content motivate you to finish all the modules in the mobile application?

Respondent 1 and 2 replied that they were not motivated to finish all the modules as they find there are too many modules to cover and each topic was very saturated. On the contrary, respondent 3 and 4 said they might continue to browse through all the content available.

Objective 3 – To find out effectiveness of the content design

Question 5 under Objective 3 aims to find out the effectiveness of content design. Respondents were asked to provide answers regarding the accessibility and reusability of the content design.

Question 5: Do you think the content is able to cater to users coming from different background?

For this question, all the respondents disagreed that the content was able to cater to a wide range of users. Respondent 4 explained that this was because language can pose as a problem and peers from Art stream may not understand the content as well as the Science students.

Question 6: Do you think you are able to apply the content that you have learnt in future?

Respondent 1 described that the content may be comprehensive but there were no hands-on applications for practice. Respondent 3 echoed his sentiment whereas the remaining two respondents were unsure on whether they would apply the theories that they have learnt in time to come.

Discussion

The results obtained from the think aloud protocol revealed that the respondents had shown a positive reaction as they went through the Cognitive Sciences content in the mobile application. This reflected that the content design that followed the suggested guidelines in

Gagné's Nine Events of Instruction Model was accurate although there were modifications that have to be made to the content design in order to enhance its effectiveness.

As for the outcomes from the questionnaire adapted from LORI v1.5 Model as well as from the interview, it was found to produce three problems in the content design namely motivation, accessibility and reusability.

It was known that the motivation to finish the learning content was a challenge as some of the respondents found the topics too saturated and difficult to understand. As the learning content was supposed to be designed at introductory level for higher secondary school students, it should be revised to accommodate the level of understanding of users who have no knowledge in Cognitive Sciences.

Following on, the learning content posed to have an accessibility problem as it was unable to cater to a wide range of users. The content was primarily focused on Science topics which would be difficult to grasp for students from Art stream. Therefore, the learning styles of the users as well as their academic capabilities have to be taken into account so as to design contents that are relevant to introduce Cognitive Sciences.

Lastly, the reusability of the content was said to be a problem in the learning content. As the respondents were unfamiliar with Cognitive Sciences, they were unsure on how to apply the knowledge on the multidisciplinary approach in other fields. There was also no hands-on application for the respondents to practice the theories that they had learnt.

Summary

This chapter discusses on the findings of the project. It includes the results obtained from the think aloud protocol, questionnaire and in – depth interview. The overall results show that the respondents are keen to attempt the introductory learning content on Cognitive Sciences even though they are unfamiliar to this field. The five problems that aroused from the learning content have been highlighted and will be addressed in the final chapter.

CHAPTER FIVE

OVERVIEW OF THE MOBILE APPLICATION

This chapter provides a walk-through of the mobile learning application that has been created, which is called "Introduction to Cognitive Sciences".

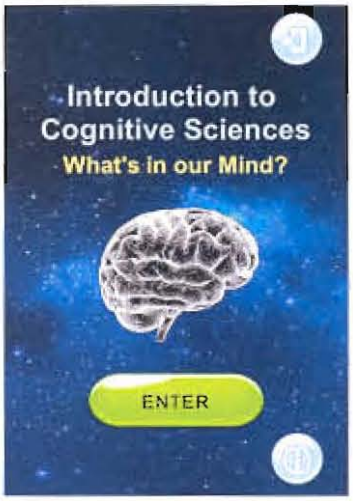

Figure 12. Home page.

Figure 13. Information page.

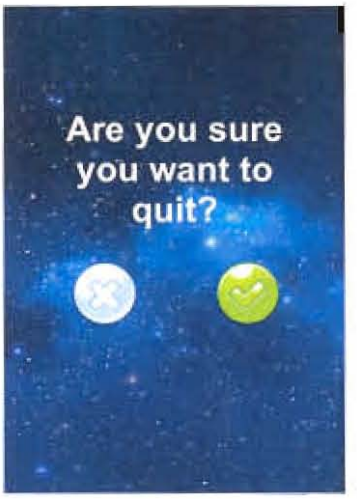

Figure 14. Quit menu.

Users are greeted with the "Enter" button on the home page as well as an "Exit" button on the top and an "Information" button on the bottom of the page. When the users press on "Enter", they will be brought to the Modules selection page.

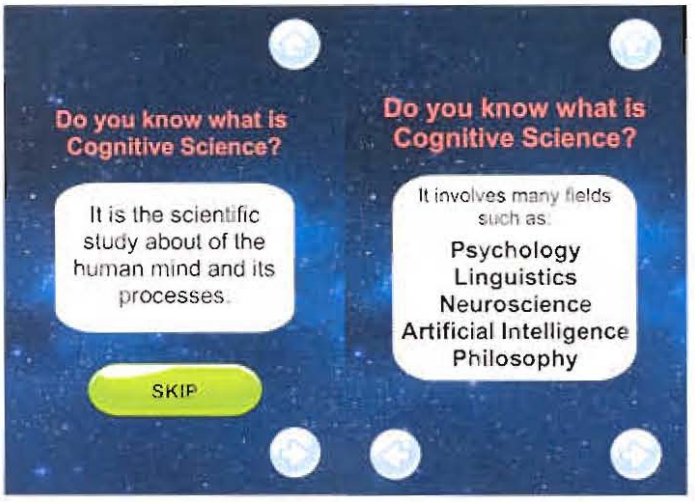

Figure 15. Definition of Cognitive Sciences.

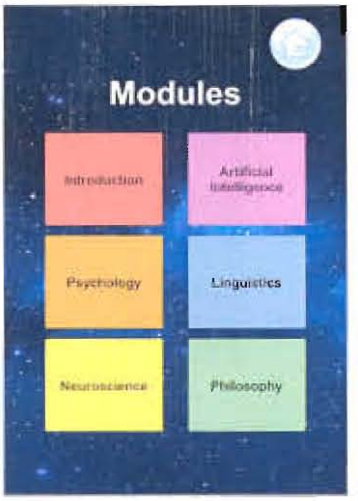

Figure 16. Module selection.

From here, the navigation through the mobile application is simply by pressing on the "Next" or "Back" buttons. If the users wish to exit the current module at any point, they may click on the "Module" icon to proceed to another module or the "Home" button to exit.

The Introduction Module

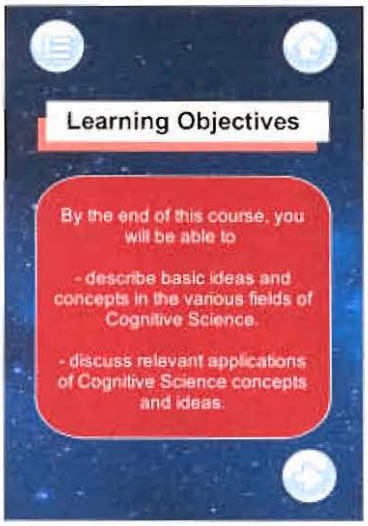

Figure 17. Learning objectives.

Figure 18. Learning content.

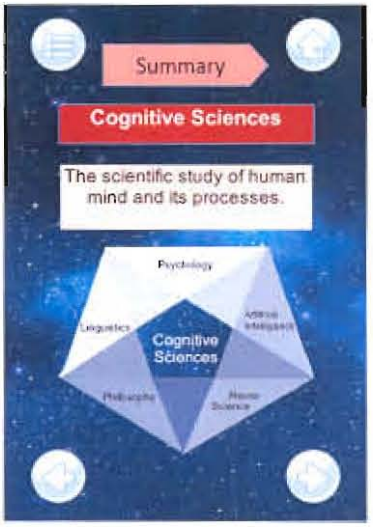

Figure 19. Summary page.

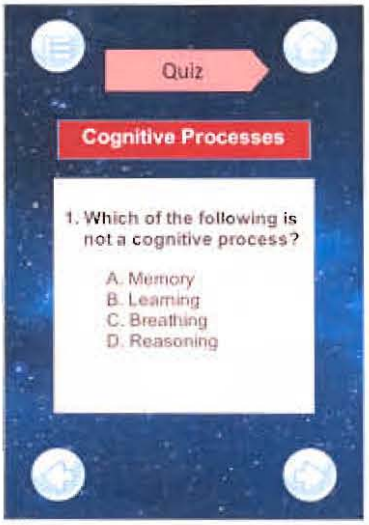

Figure 20. Quiz questions.

Figure 21. Quiz answers.

The users are first informed of the learning objectives of the selected module before being presented with the learning content. The summary is provided at the end of the module to help users remember what they have learnt. Finally, an assessment in the form of quiz is given to test the progress of the users.

The Psychology Module

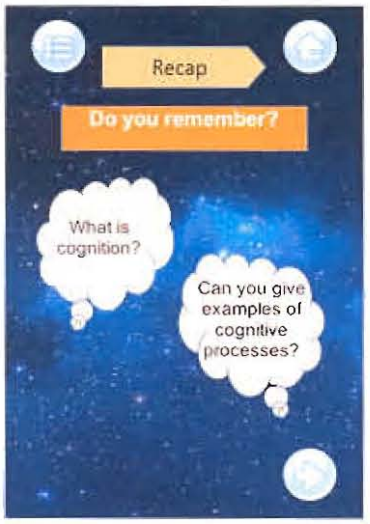

Figure 22. Recap for Introduction module.

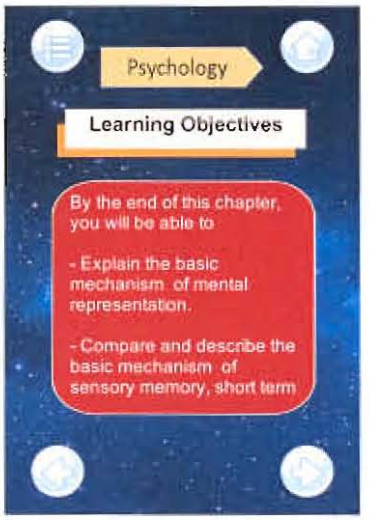

Figure 23. Learning objectives.

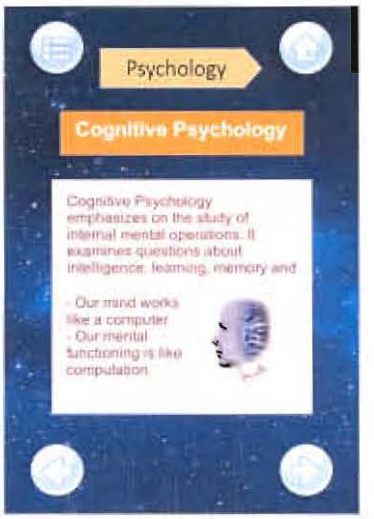

Figure 24. Learning content.

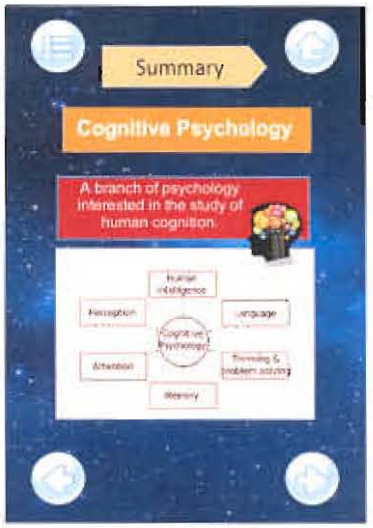

Figure 25. Summary page.

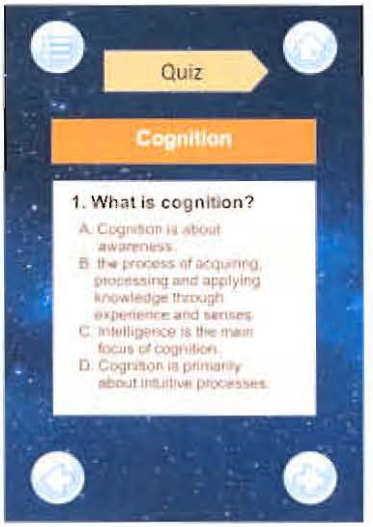

Figure 26. Quiz questions.

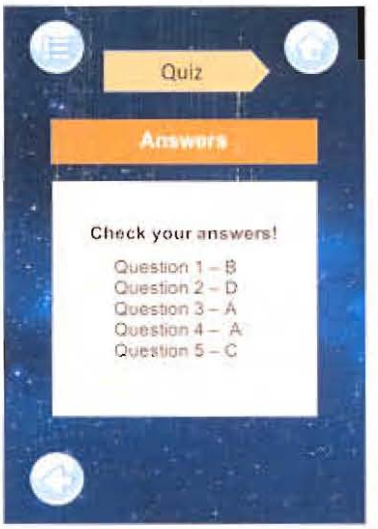

Figure 27. Quiz answers.

Once the users have finished a particular module, they may move on to the following chapter. A recap is given at the beginning of the next module to refresh the users' memory before they start the new topics.

The Neuroscience Module

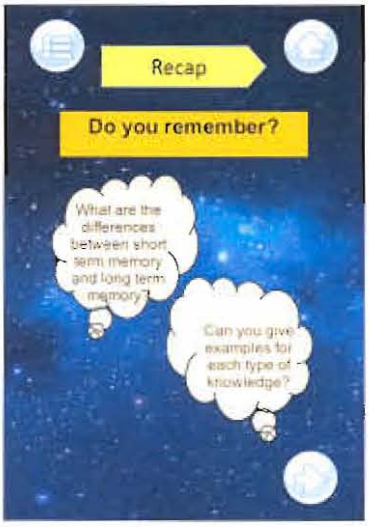

Figure 28. Recap for Psychology module.

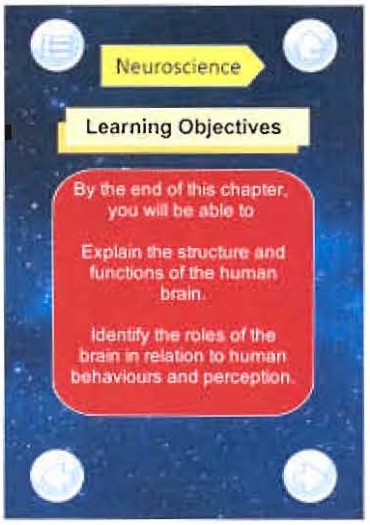

Figure 29. Learning objectives.

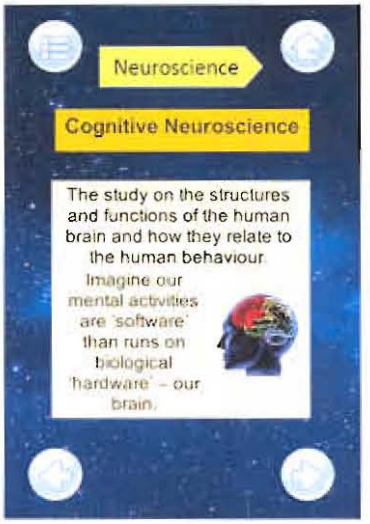

Figure 30. Learning content.

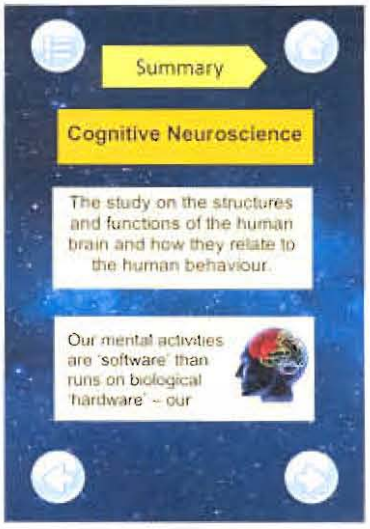

Figure 31. Summary page.

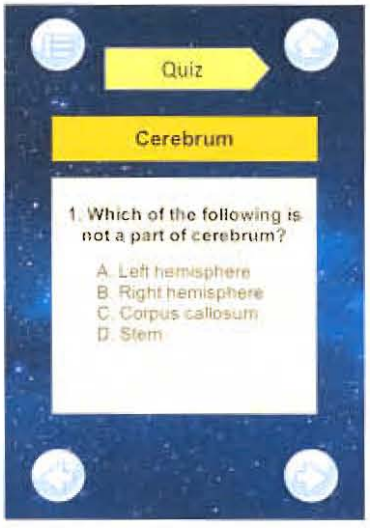

Figure 32. Quiz questions.

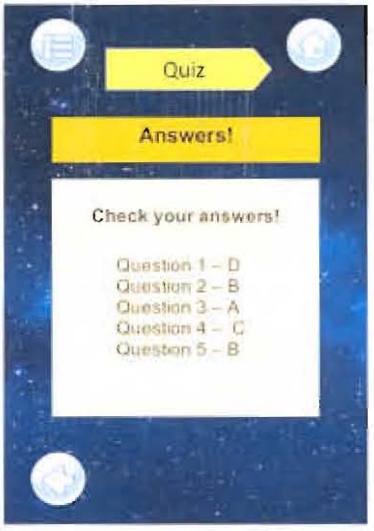

Figure 33. Quiz answers.

The Artificial Intelligence Module

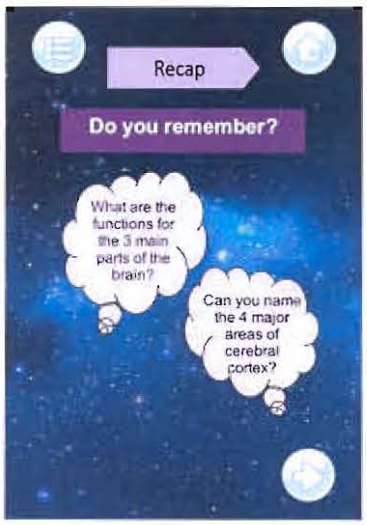

Figure 34. Recap for Neuroscience module.

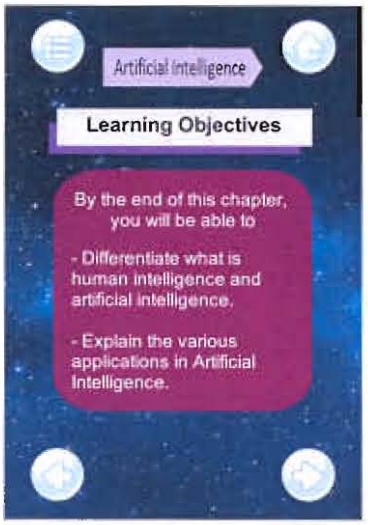

Figure 35. Learning objectives.

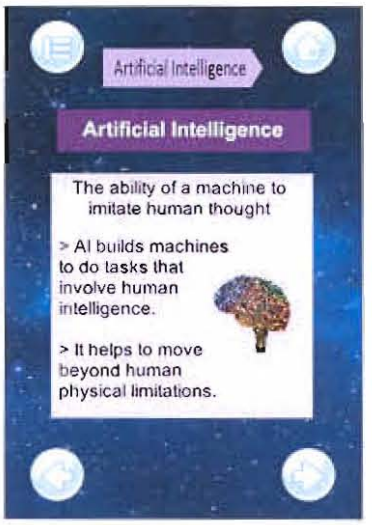

Figure 36. Learning content.

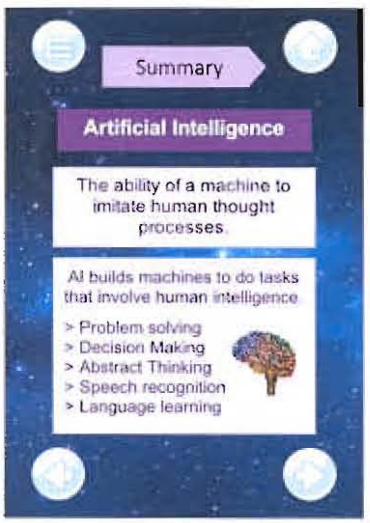

Figure 37. Summary page.

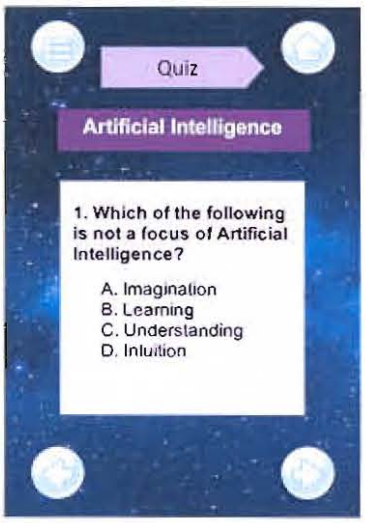

Figure 38. Quiz questions.

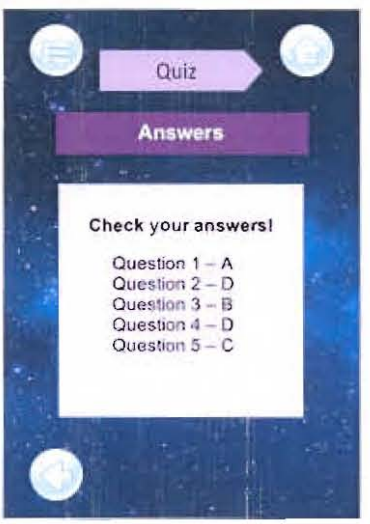

Figure 39. Quiz answers.

The Linguistics Module

Figure 40. Recap for Artificial Intelligence module.

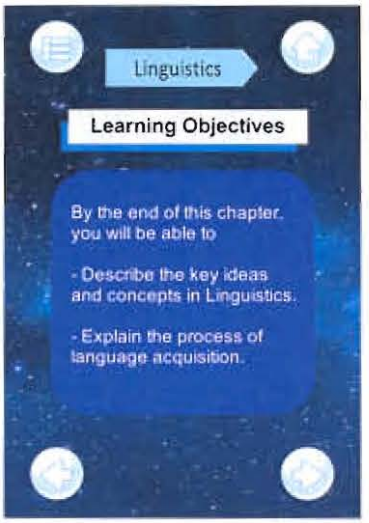

Figure 41. Learning objectives.

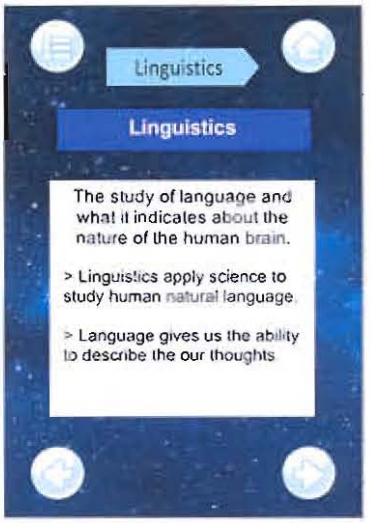

Figure 42. Learning content.

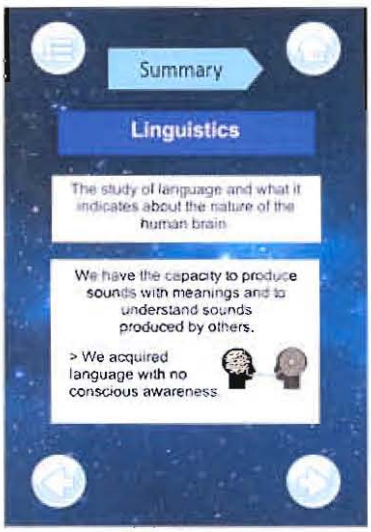

Figure 43. Summary page.

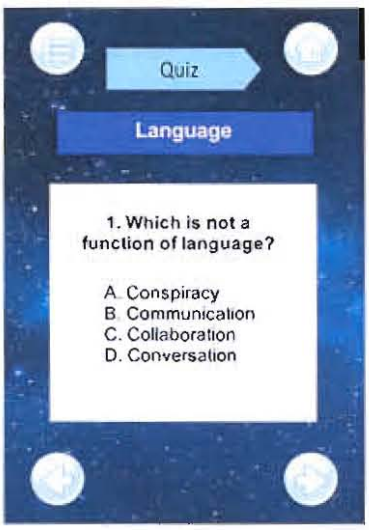

Figure 44. Quiz questions.

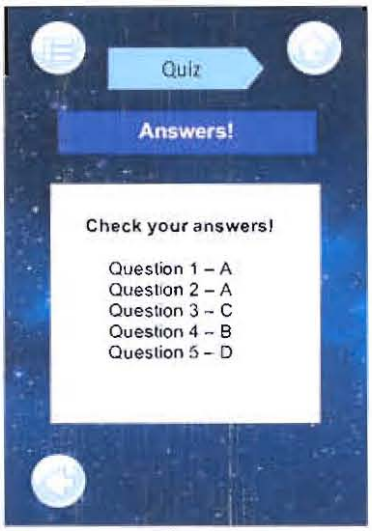

Figure 45. Quiz answers.

The Philosophy Module

Figure 46. Recap for Linguistics module.

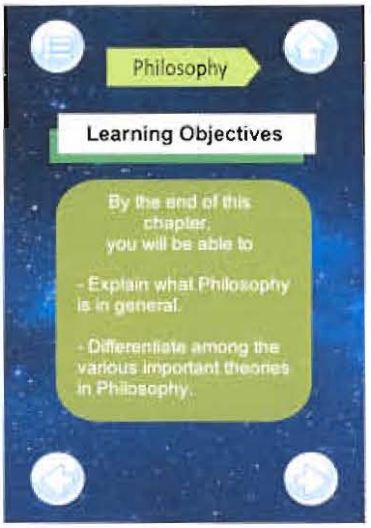

Figure 47. Learning objectives.

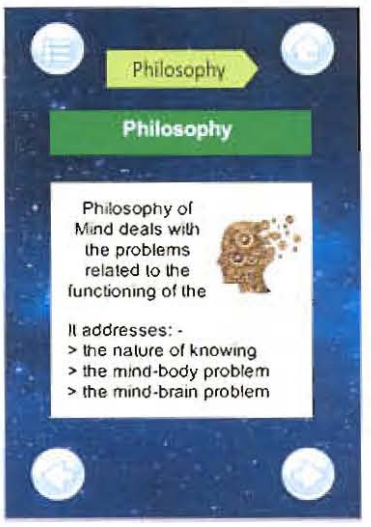

Figure 48. Learning content.

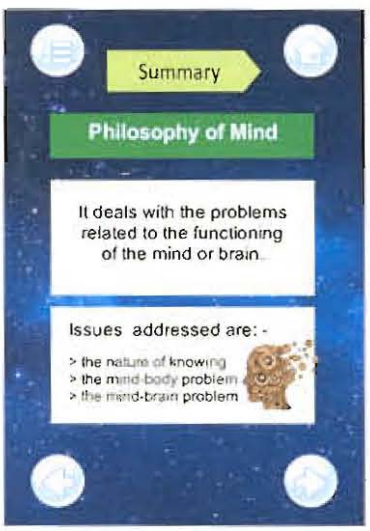

Figure 49. Summary page.

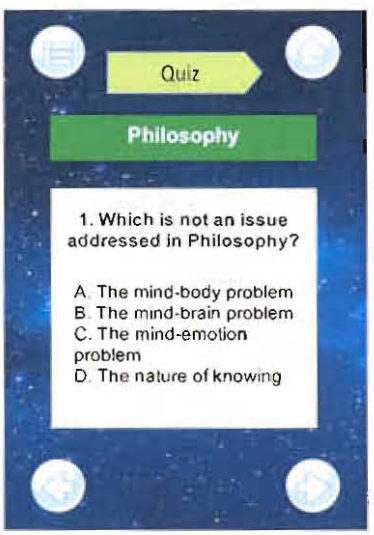

Figure 50. Quiz questions.

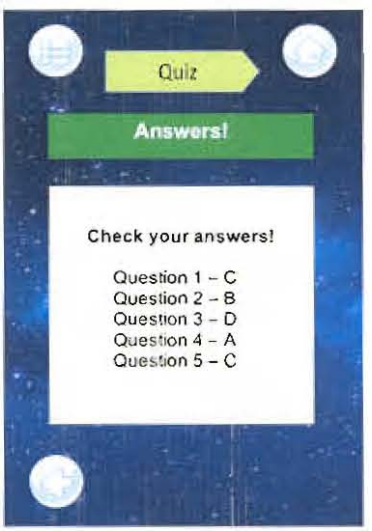

Figure 51. Quiz answers.

CHAPTER SIX

CONCLUSION

Overview

This final chapter will discuss on the overall project on the introductory content design for Cognitive Sciences. Several recommendations will also be provided for future work based on the limitations found in this project.

Research Summary

This project was conducted with the general objective to design relevant learning content for a mobile learning application to introduce Cognitive Sciences to higher secondary school students in Malaysia. The learning content for the mobile application had been designed based on the ADDIE Model and Gagné's Nine Events of Instruction Model. A think aloud protocol, questionnaire and an interview were used to conduct this project. The respondents were able to voice out their opinion and thoughts freely. Four secondary school students were chosen to participate in this project with the requirement that they are in Form Four or Form Five.

Limitation and Recommendations

There are numerous limitations related to this project. The learning content is currently only available in English which may be limited to only certain higher secondary school students in Malaysia. The content is also based solely on *The Cognitive Sciences: An interdisciplinary approach* textbook whereby some of the topics are still difficult to be comprehended by higher secondary students.

Apart from this, the respondents who underwent the think aloud session reported that at they were distracted at times as they could not concentrate while verbalizing their thoughts. This had then affected their performance to focus on the learning content thereafter.

For future work on this project, focus should be placed on placed on improving the accessibility of this content by adding more language options and to include of more sources as content resources. It is also recommended to make the content more interactive for users apart from content being displayed only to enhance their learning. By doing so, it can integrate more learning styles of the users and boost their interest while using the mobile application.

Conclusion

In general, this project has achieved its objective to introduce Cognitive Sciences through designing learning contents for a mobile application. The mobile application called 'Introduction to Cognitive Sciences' provides an exposure for higher secondary school in Malaysia to Cognitive Sciences and helps to increase their interest in this field. The learning content for this mobile application can be further improved by overcoming the limitations found as well as by adding enhancements in the future work on this project.

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APPENDIX A

THINK ALOUD PROTOCOL

Respondent ID # ___ Researcher Initials _____

Describe interaction with respondent

#1 Gain attention

___ text ___ image ___ questions

Describe interest of respondent

#2 Inform learners of objectives

___ read aloud ___ read silently ___ skipped

Describe expectation of respondent

#3 Stimulate recall of prior learning

___ answer aloud ___ answer silently ___ skipped

Describe recollection of respondent

#4 Present the content

___ text ___ image ___table ___diagram ___example

Describe learning of respondent

#5 Provide guidance

___image ___mnemonics ___acronym

Describe memorization of respondent

#6 Elicit performance

___ question ___ real life scenario

Describe application of respondent

#7 Provide feedback

___ exercise

Describe progress of respondent

#8 Assess performance

___ quiz

Describe performance of respondent

#9 Enhance retention and transfer

___ text ___ image ___ table ___ diagram

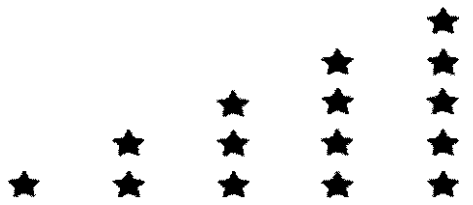
Describe expectation of respondent

*Remarks

APPENDIX B

ADAPTED LEARNING OBJECTS REVIEW INSTRUMENT V1.5 (LORI)

Scoring Sheet



1. Content Quality ➢ The clarity of ideas in conveying facts and information.					
2. Content Design ➢ Flow of the presentation of visual and worded information.					
3. Interest towards content ➢ The appeal level of the content for the users.					
4. Motivation ➢ The tendency of the users to continue looking through the content.					
5. Feedback ➢ The perception of users towards the content.					
6. Accessibility ➢ Availability of the content to accommodate users from different backgrounds.					
7. Reusability ➢ Ability to be used in varying learning contexts.					

APPENDIX C

OPEN ENDED INTERVIEW

1. Did you face any difficulties in understanding the facts and information given?

2. What do you think of the overall representation of the visual and worded information?

3. Does the content appeal to you to want to learn about Cognitive Sciences?

4. Does the content motivate you to finish all the modules in the mobile application?

5. Do you think the content is able to cater to users coming from different background?

6. Do you think you are able to apply the content that you have learnt in future?

APPENDIX D

INFORMED CONSENT FORM

PROTOCOL TITLE	: DESIGN AND EVALUATION OF A MOBILE LEARNING APPLICATION TO INTRODUCE COGNITIVE SCIENCES
PROTOCOL IDENTIFIER	: ALIXIA LEE HWEI LIH
SPONSOR	: NIL
PRINCIPAL INVESTIGATOR	: ALIXIA LEE HWEI LIH
INSTITUTION ADDRESS	: FACULTY OF COGNITIVE SCIENCES AND HUMAN DEVELOPMENT UNIVERSITI MALAYSIA SARAWAK JALAN DATUD MOHAMMAD MUSA 94300 KOTA SAMARAHAN SARAWAK.

THE NATURE AND PURPOSE OF THE STUDY

General objective:

The main objective of this project is to design relevant learning content for a mobile learning application to introduce Cognitive Sciences to higher secondary school students in Malaysia.

Specific objectives:

1. To design learning content at introductory level for a mobile application to introduce Cognitive Sciences.
2. To evaluate the learning content of a mobile application in introducing Cognitive Sciences.

STUDY DESCRIPTION

The data will be collected by using three methods: think aloud protocol, adapted LORI v1.5 model and interview. The approximate time for think aloud protocol will be 30 – 45 minutes while the adapted LORI v1.5 model and interview will take 10 – 15 minutes.

RISKS OF STUDY PARTICIPATION

There are no risks for participating in this study.

POSSIBLE BENEFITS OF STUDY PARTICIPATION

This study contributes to a better understanding on designing suitable learning content to introduce Cognitive Sciences. This study also gives exposure to the public in the field of Cognitive Science and further nurture the interest of secondary school students.

WITHDRAWAL FROM STUDY

Subsequent to your consent, you may refuse to participate or withdraw from this study any time.

TO OBTAIN FURTHER INFORMATION

Any further inquiry or clarification can be referred directly to Ms. Alixia Lee Hwei Lih via e – mail at alixia.lee.hl@gmail.com.

VOLUNTARY PARTICIPATION

The participation in this study is voluntary. Participant should not be forced in this study.

CONFIDENTIALITY

All information provided will be kept confidential and as a result, you will not be identified in any reports on this study.

CONSENT TO PARTICIPATE IN THIS STUDY

I have read, or have been read to me, in a language understandable to me, the above information. The content and meaning of this information has been fully explained to me.

I have had time and opportunity to ask any questions that I have about the study and this form, all my questions have been answered. I have read, or have been read to me, all pages of this consent form and the risks described. I voluntarily consent and offer to take part in this study.

By signing this consent form, I certify that all information I have given is true and correct to the best of my knowledge.

I understand that I will receive a copy of this signed consent form.

Printed name of subject	IC Number
Signature of subject	Date