EVALUATION OF DESIGN GUIDELINES: QUESTIONNAIRE DESIGN FOR EVALUATING CHILDREN EDUCATIONAL APP

By

TEH YEW PIN

A dissertation submitted to the
Department of Engineering and Computer Science,
Lee Kong Chian Faculty of Engineering and Science,
Universiti Tunku Abdul Rahman,
in partial fulfillment of the requirements for the degree of
Master of Information Systems
April 2015

ABSTRACT

EVALUATION OF DESIGN GUIDELINES: QUESTIONNAIRE DESIGN FOR EVALUATING CHILDREN EDUCATIONAL APP

Teh Yew Pin

More and more children are becoming frequent users of smartphones and tablets in this modern age. This research aims to evaluate design guidelines and heuristics to discover a survey method for evaluating Malaysian children's educational app. Besides, the researcher also intends to investigate the survey method's degree of applicability in evaluating Malaysian children's educational apps. In addition, the researcher plans to uncover whether the participants' age and gender have any significant effects on the survey method's degree of applicability. Out of a wide array of educational apps, three locally developed educational apps namely PiKidz ABC Play, Zap Zap Fractions and Princess Drawsalot & the Dragon, were reviewed and analyzed. Due to time and resources constraints, only one educational app (i.e., PiKidz ABC Play) was selected to be used in the evaluation study. Six key design guidelines and heuristics were identified and compiled from literature review. Based on the design principles, questionnaire statements measuring Screen, Navigation and Control, Feedback and Help, and Ease of Use were formulated. A total of 27 participants were recruited for the evaluation study. In the evaluation study, participants interact with the educational app and complete a survey questionnaire while the researcher observes. Data collected was analyzed using Statistical Package for Social Science (SPSS). The research findings revealed

that the survey method have a high degree of applicability in evaluating children's educational apps. However, participants' age and gender had no significant effect on the survey method's degree of applicability. In addition, 5 year old participants enjoyed playing the educational app more compared to 6 and 8 year old participants. Mostly all participants were reluctant to express their opinions regarding the usability of the educational app. Lastly, mostly all participants possessed good motor skills and faced no interaction issues.

ACKNOWLEDGEMENTS

First and foremost, I would like to extend my utmost gratitude to my parents for giving me an opportunity to pursue my Master's degree as a full-time student. It would not be possible for me to complete my studies if not for the continuous support and motivation from my family members and my girlfriend.

I would also like to express my utmost gratitude to my supervisor, Ms Beh Hooi Ching who provided me with valuable insight, advice, and guidance throughout this research project. Without her tireless supervision, I would not be able to complete this research project on time.

Lastly, I would like to thank all the participants and their parents for taking the time to participate in the evaluation study. Without their cooperation, the completion of this research project would not have been possible. Besides, I would also like to thank my friends and course mates who supported me along the way.

APPROVAL SHEET

This dissertation entitled "**EVALUATION OF DESIGN GUIDELINES: QUESTIONNAIRE DESIGN FOR EVALUATING CHILDREN EDUCATIONAL APP**" was prepared by TEH YEW PIN and submitted as partial fulfilment of the requirements for the degree of Master of Information Systems at Universiti Tunku Abdul Rahman.

Approved by:

_____

(Ms Beh Hooi Ching) Date: _____

Supervisor

Department of Internet Engineering and Computer

Lee Kong Chian Faculty of Engineering and Science

Universiti Tunku Abdul Rahman

LEE KONG CHIAN FACULTY OF ENGINEERING AND SCIENCE

UNIVERSITI TUNKU ABDUL RAHMAN

Date: _____

SUBMISSION OF DISSERTATION

It is hereby certified that **Teh Yew Pin** (ID No: **13UEM06777**) has completed this dissertation entitled "**EVALUATION OF DESIGN GUIDELINES: QUESTIONNAIRE DESIGN FOR EVALUATING CHILDREN EDUCATIONAL APP**" under the supervision of Ms Beh Hooi Ching (Supervisor) from the Department of Internet Engineering and Computer Science, Lee Kong Chian Faculty of Engineering and Science.

I understand that University will upload softcopy of my dissertation in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

_____

(TEH YEW PIN)

DECLARATION

I **TEH YEW PIN** hereby declare that the dissertation is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

_____

Date _____

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	
GPS	Global Positioning System
HTML	Hyper Text Markup Language
SPSS	Statistical Package for Social Science
MOE	Ministry of Education
UEM	User evaluation method
VAS	Visual Analogue Scale
PIPC	Problem Identification Picture Card
HCI	Human Computer Interaction
QUIS	Questionnaire for User Interface Satisfaction

CHAPTER 1

INTRODUCTION

1.1. Introduction

Nowadays, mobile apps have become the norm among users of smartphones and tablets. There is just about an app for everything, from news apps to free messaging apps. However, Campbell (2011) remarked the word "app" was still an uncommon word back in 2011. Campbell defines the "word 'app' as a noun, which stands for 'application' and typically refers to a software program used on a smartphone or mobile devices such as the Android, iPhone, BlackBerry or iPad." Campbell prefers to think of a mobile app as "shortened" or narrow software application that perhaps does just one function or that provides a small bit of entertainment. On the other hand, Cutlack (2013), states that "apps are basically little, self-contained programs, used to enhance existing functionality, hopefully in a simple, more user-friendly way."

Mobile apps have experienced a rapid growth over the recent years. According to Arrington (2008) and Takanashi (2008), there were merely more than 600 apps in the App Store and Android Market (currently known as Google Play) when they first launched back in 2008. Besides, Victor (2013) wrote in an article that Google Play had officially reached 1 million apps as of June 2013,

and had outgrown Apple's App Store and its 900,000 apps. As of July 2014, Google Play takes the lead again with 1.3 million available apps compared to that of Apple's App Store's 1.2 million apps (Statista Inc., 2014). Thus, mobile apps are expected to continue its growth in many years to come.

Based on a report by Common Sense Media (2011), 1,384 American children aged 0 to 8 years old participated in the survey study. One of the key finding is that more than half (52%) of the children has access to one of the newer mobile devices at home, either a smartphone (41%), a video iPod (21%) or an iPad or other tablet devices (8%). Besides, Common Sense Media reported that 29% of all parents have downloaded apps for their children to use. Figures 1.1 and 1.2 shows the mobile media use and mobile media access of the children of ages 0 to 8 years old. Hence, children are considered to be frequent users of smartphones and tablets.

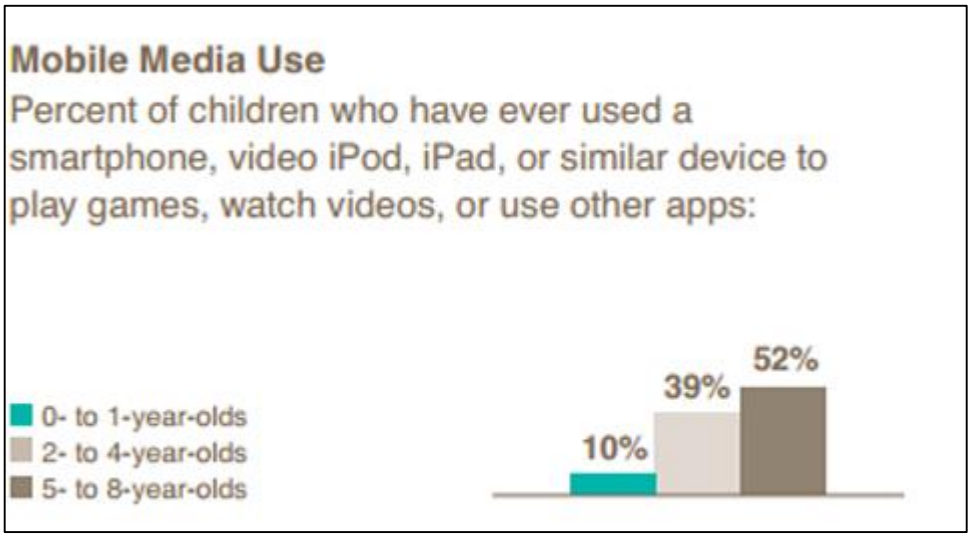


Figure 1.1: Mobile media use of children from age 0 to 8 years old

Source: Common Sense Media, 2011

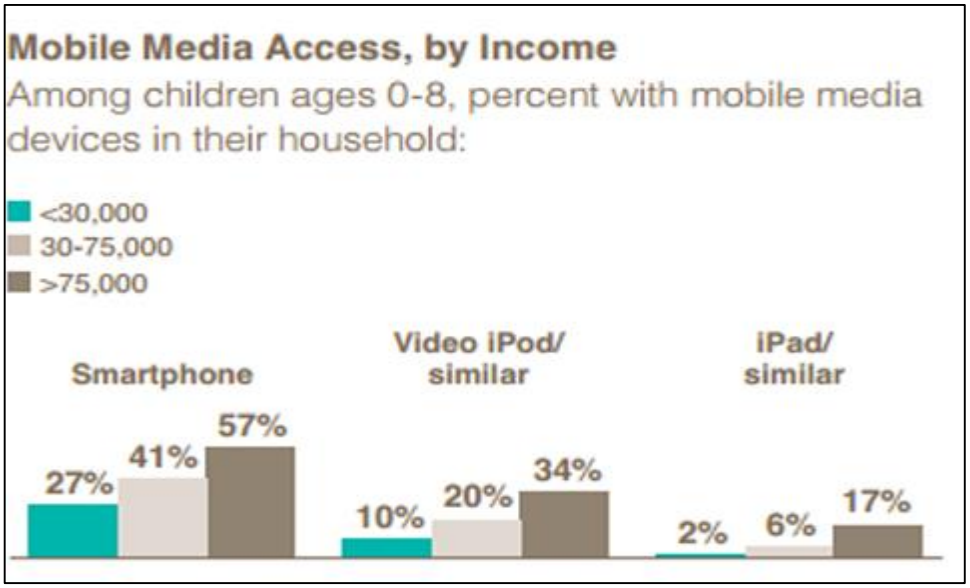


Figure 1.2: Mobile media access of the children, by parents' income

Source: Common Sense Media, 2011

1.2. Problem Statement

Parents are facing various concerns and difficulties when finding or selecting good educational apps for their children. According to Lee (2014), "parents are concerned about the educational quality, age-appropriateness of the app, and whether their children's privacy is protected." Meanwhile, McCoy (2013) states "parents are concerned with the app content and information collected when children are using the app." In addition, parents are overwhelmed with the vast amount of apps available in Apple's App Store (1.2 million) and Google Play (1.3 million) as of July 2014 (Statista Inc., 2014). Thus, this makes the process of finding good educational apps for children challenging.

Based on a survey carried out by Mom with Apps (2014), “parents feel they are wasting time looking for the right educational apps for their kids." Out of 355 respondents, 49% rated their experience in finding good apps for their children as 3, 4, or 5 based on a scale of 1 to 5, where 1 indicates “very easy” while 5 indicates “very hard”. In addition, Lee (2014) of the Joan Ganz Cooney Center wrote in an article:

> I still personally find it frustratingly difficult to find great apps for my children as there is no way to search by age range in the App Store and searching by general queries such as “spelling or “phonics” return large amount of results that are impossible to sort through.

Parents are struggling to find good educational apps for their children as conventional and tedious methods to evaluate an educational app on App Store and Google Play before purchasing or downloading include viewing screenshots and videos, examining descriptions, age ratings and user reviews, or downloading for a trial run (free apps). One alternative is to rely on third party websites that review and rate mobile apps for children such as Common Sense Media (Davis, 2013).

In addition, free apps are not often what they seem or claim as they often contain advertisements and in-app purchases. “Apps with advertisements pose a privacy risk as children’s activity via the mobile device can be shared with the advertiser or a third-party tracker (Davis, 2013)”. In-app purchase is a common feature in both free and paid apps that allow purchases to be made in within the

game. In-app purchases may include extra lives or power-ups. Children can easily pile up multiple in-app purchases that result in an expensive credit card bill especially if parental controls are not set up on the device. According to an article by BBC (2014), Apple was recently told to refund $32.5m (£19.8m) to parents whose children had made purchases without their parents' consent. Gleer (2012) and Davis (2014) emphasized that mobile apps with social sharing features that allow children to share their creations or communicate with others pose a serious privacy threat. App developers are unable to guarantee that their users are all children instead of adults looking to interact with children.

The problem faced by parents is worsened when apps are designed poorly, with various usability problems. According to Budiu and Nielsen (2010), "iPad apps are inconsistent and have low feature discoverability, with frequent errors due to accidental gestures." Besides, an overly strong print metaphor and weird interaction styles cause further usability problems. Based on a follow-up study conducted by Budiu and Nielsen (2011), "iPad apps are much improved, however, new usability problems have emerged, such as swipe ambiguity and navigation overload." Inconsistency in the user interface between multiple educational apps cause skills learnt when using one particular app to be inapplicable in another app (Budiu and Nielsen, 2010).

This research intends to address the problem by evaluating design guidelines and heuristics proposed by international to discover a useful survey method for evaluating educational apps for young Malaysian children. Besides, the researcher intends to conduct an evaluation study on Malaysian developed educational apps with children to test the effectiveness of the survey method. The survey method will be able to evaluate educational apps and contribute to tackling the problems mentioned above.

1.3. Objectives

The aim of this research is to evaluate design guidelines and heuristics to discover a survey method for evaluating children's educational app.

The objectives of the research are:

1. Study and evaluate design guidelines and heuristics proposed by international researchers to produce a consolidated children's educational apps design guideline.
2. Identify and evaluate three suitable educational apps developed by Malaysian developers to be used in the evaluation study with children aged between 4 to 8 years old.
3. Formulate a survey questionnaire based on the consolidated design guideline for evaluating educational apps identified.
4. To discover the extent of how applicable the survey questionnaire are towards the evaluation of Malaysian children's educational apps.

5. To examine the effects of age and gender of young children on the survey questionnaire's extent of applicability in the evaluation of Malaysian children's educational apps.

1.4. Research Questions and Hypothesis

The following research questions are formulated for this research:

1. What is the survey questionnaire's extent of applicability towards evaluating Malaysian children's educational apps?
2. What is the relationship between gender and age towards the survey questionnaire's extent of applicability in evaluating children's educational apps?

The following are the hypotheses derived from the research questions for this research.

H1: The survey questionnaire formulated is applicable to the evaluation of educational apps for Malaysian children.

H2: Gender of child participants has significant effect on the applicability of the survey questionnaire in the evaluation of educational apps for children.

H3: Age of child participants has significant effect on the applicability of survey questionnaire in the evaluation of educational apps for children.

1.5. Scope of Work

For this dissertation, educational apps for children are identified and evaluated in the evaluation study with young children aged between 4 to 8 years old. Then, a survey questionnaire will be administered to the children to be completed with minimal assistance from the children's parent. This research focuses on educational apps of the iOS platform. Besides, this research only focuses on educational apps designed by Malaysian app developers. Hence, the educational apps proposed in this dissertation are by no means the most useful and beneficial educational apps existing in Apple's App Store.

Due to constraints of costs, time and manpower, the sampling size for the evaluation study will be set to 20, where all participants are of Malaysian nationality, between age 4 and 8 years. The sampling method used in selecting the participants will be purposive sampling. In addition, participants must have prior experience in using smart devices, such as a smartphone or tablet.

1.6. Research Significance

There is limited published academic research in Malaysia that focuses on the design guidelines or heuristics for designing and developing good and beneficial educational apps for children. One closely related research paper is authored by Yusop and Razak (2013), which focuses on the development of i-CARES, a five-phased framework detailing proposed sequential processes of selecting, categorizing, reviewing, evaluating and synthesizing variety of mobile educational apps for children. The framework proposed focuses on helping parents and educators to make informed decision in utilizing mobile apps. This research on the other hand, proposes a survey questionnaire for evaluating the usability and overall user experience of children's educational apps.

Another closely related research paper is authored by Kamaruddin (2012), which focuses on evaluating the interface design of the Science courseware from the Malaysian Smart Project to discover its strength and weaknesses. An empirical evaluation was conducted on the courseware by comparing against the Malaysian Ministry of Education (MOE) and international literature guidelines. Although this research does focus on design guideline, its research is directed on courseware for primary and secondary students rather than educational apps for children.

Overall, this research attempts to formulate a survey questionnaire based on a consolidated design guideline for evaluating educational apps for Malaysian children. This research will make valuable academic contributions in the area of children's educational apps design and will also serve as future references for researches in this particular area. Furthermore, this research will also contribute in solving the various concerns and challenges faced by parents when searching for good and beneficial educational apps for their children.

1.7. Conclusion

This chapter identified problems faced by parents in the selection of appropriate educational apps for their children due to large amount of free and paid apps in the App Store. Besides, poor designed apps with various usability issues also contribute to the problem. This research aims to discover whether the survey method formulated is applicable in the evaluation of educational apps for Malaysian children. The research findings will make valuable academic contributions in the area of children's educational apps design and help in solving the problems faced by parents.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter presents a review of literature on various topics relevant to the research. The topics covered include a broad overview of mobile learning, mobile app, and usability as well as the design guidelines and heuristics proposed by international and local researchers. Three educational apps are selected and evaluated against the design guidelines and heuristics. Besides, this chapter includes sections on Piaget's Theory of Cognitive Development and the challenges with working with children as well as review of various research methods.

2.2. Mobile Learning

Mobile learning, otherwise known as m-learning is one of the hot topics of research in the educational area. Kukulska-Hulme (2005) defined mobile learning as being concerned with learner mobility in the sense that learners should be able to engage in educational activities without being tied to a tightly-delimited physical location. Quinn (2000) defined mobile learning as the intersection of mobile computing (the application of small, portable, and

wireless computing and communication devices) and e-learning (learning facilitated and supported through the use of information and communications technology).

The utilization of m-learning helps by enhancing the overall learning process of the learner. Evans (2008) conducted a research on the effectiveness of m-learning in the form of podcasting for business course university students. The results indicate that more students believed that they were more receptive to the material delivered as podcasts than either textbooks or traditional revision lectures. Al-Fahad (2009) has found that m-learning could increase the retention rate among undergraduate students through a study on the student's attitude and perception to the use of mobile technology in education.

According to Corbeil (2007), mobile technology such as laptops, PDAs, smartphones that are connected to wireless networks enable mobility and facilitate m-learning. Hence, this mobility allows the teaching and learning process to take place outside of the traditional classroom. Some pros of m-learning include personalized learning experience, enhancement of interaction between learners and instructors, and the access to learning materials on the go. Alternatively, some cons of m-learning include the requirement to offer learning media in several formats, contents need to be updated constantly, and non-tech savvy learners and instructors may require additional learning curve.

2.3. Mobile Apps

Mobile applications or mobile apps for short, has undergone a rapid growth over the years, where just about everyone from adults to children has apps in their smart devices such as smartphones and tablets. Mobile apps are divided into categories which are the native app, web app and hybrid app (Budiu, 2013). Native apps are installed on the smart device and are accessed through icons on the device home screen. Native apps are downloaded and installed through an application store, such as Google Play for the Android platform, and Apple's App Store for the iOS platform. These apps are often developed specifically for a single platform, and are able to fully access all the device's features, including the camera, GPS, accelerometer, contact lists, notifications and others. Ali (2013) states native apps provide fast performance and high degree of reliability. Besides, some native apps can work offline as well as online.

Although web apps are not exactly real applications, these websites look and feel like native apps in various ways. However, web apps are not implemented as native apps but instead they are run by a browser and are typically written in HTML5. According to Ali, a mobile web app uses technologies such as JavaScript or HTML5 to provide interaction, navigation, or customization capabilities. Due to the similarities in the functionality between native and web apps, the distinction between the two has become blurred, according to Budiu. Besides, web apps are also able to access the device's features.

Hybrid apps, on the other hand, are the combination of native and web apps. Similar to native apps, they are installed on the device and are able to access the device's features. At the same time, hybrid apps rely on the device's browser engine to render the HTML and process the JavaScript locally. Hybrid apps are popular because they allow cross-platform development. The same HTML code components can be reused on different mobile operating systems, hence, reducing development costs significantly.

2.4. Usability

Usability is a quality attribute that assesses how easy user interfaces are to use, or in other words, the degree of user-friendliness. The word "usability" also refers to methods for improving ease-of-use during the design process (Nielsen, 2012). On the other hand, Stone et al. (2005) states usability is concerned with the extent to which users of an application are able to work effectively, efficiently, and with satisfaction in their particular contexts.

Nielsen states usability is defined by 5 quality components which are:

- **Learnability**: How easy is it for users to accomplish basic tasks the first time they encounter the design?
- **Efficiency**: Once users have learned the design, how quickly can they perform tasks?
- **Memorability**: When users return to the design after a period of not using it, how easily can they reestablish proficiency?

- **Errors**: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
- **Satisfaction**: How pleasant is it to use the design?

Nielsen believes that a well-designed application with high usability would have the five quality components incorporated. Usability is a significant factor in the retention of mobile app users. Hence, a well-designed mobile app needs to have a good user interface design as well as high degree of usability.

Usability is essential for the survival of websites on the Web. According to Nielsen, if a website is difficult to use or if the users gets lost on a website, they leave. Besides, if a website's information is hard to read or doesn't answer users' key questions, they leave. The same situation applies to mobile apps as well. There are plenty of similar apps available in the App Store and Google Play store, so users will not waste time to trying to figure out the user interface. When users find a mobile app to be difficult to use or the user interface is poorly designed, they would just simply leave.

2.5. iPad App and Website Usability

When the 1st generation Apple iPad was launched, a preliminary study on the usability of iPad apps and websites was conducted by Budiu and Nielsen (2010) on users with at least three months of experience in using iPhone. And the first impression the users had with the iPad was that it looks like a giant

iPhone. Hence, the iPad user interface should not be an enlarged or scaled-up iPhone user interface.

Some of the key usability findings from the study include:

- Apps have wacky interfaces
- Inconsistency in the interaction design
- Touchable areas are too small and too close together
- Read-tap asymmetry
- Websites worked fairly well on the standard iPad browser
- Accidental activation due to unintended touches
- Low discoverability due to users failing to differentiate which areas are touchable and which are not
- Users disliked typing using touchscreen

Another study was conducted by Budiu and Nielsen (2011) as a follow-up to the first preliminary study to discover what has changed in the iPad apps user interface design over the course of a year. The authors recruited participants who possess at least 2 month worth of experience in using iPad.

Some of the key usability findings from the study include:

- Splash screens with long introductory segments
- Swipe ambiguity where multiple items on the screen can be swiped

- Many apps squeezed information into areas that are too small, making it harder to recognize and manipulate
- Excessive navigation where the screen is crowded with a large number of navigational options

For a good user interface design with a high degree of usability, Budiu and Nielsen (2010, 2011) suggest some user interface design guidelines. The suggested user interface design guidelines include:

1) Add dimensionality and better define individual interactive areas to increase discoverability through perceived affordances of what users can do where.
2) To achieve these interactive benefits, loosen up the etched-glass aesthetic. Going beyond the flatland of iPad's first-generation apps might create slightly less attractive screens, but designers can retain most of the good looks by making the GUI cues more subtle than the heavy-handed visuals used in the Macintosh-to-Windows-7 progression of GUI styles.
3) Abandon the hope of value-add through weirdness. It is better to use consistent interaction techniques that empower users to focus on your content instead of wondering how to get it.
4) Support standard navigation such as, including a Back feature, search, clickable headlines, and a homepage for most apps.

5) The screens on mobile devices and tablets are inherently small, so you must optimize the usage of the screen space and show things as large as possible.
6) Lengthy splash screens may be entertaining for the first time but will hinder users from using the app since users need to wait.
7) Always assume you are designing for a multi-user device, as iPads are found to be shared among family members.

Although Budiu and Nielsen (2010, 2011) has conducted extensive researches into the proper design and usability in mobile apps, the user interface guidelines that the authors came up with only applies to mobile apps in general. In fact, from the web, there are many design guidelines that are aimed at mobile apps in general such as Matzner (2012), Weevers (2011) and Gordon (2010). However, there is limited design guidelines specifically meant for educational apps for children.

2.6. Design Principle, Guideline and Heuristics

This section distinguishes the differences between design principles, guidelines and heuristics as well as how they are related to one another. Te'eni et al. (2005) provided an explanation on the differences and relations of design principles and guidelines in the book entitled “Human Computer Interaction: Developing Effective Organizational Information Systems”.

According to Te'eni et al., "design principle is a high-level and largely context-free design goals based on theories of human-computer interaction". Design principles are more fundamental and widely applicable compared to design guidelines. Design principles help facilitate a structured design process and tend to be more abstract than design guidelines.

On the other hand, design guideline is defined as "specific and usually context-dependent rules for designers to follow in order to achieve the principles" (Te'eni et al., 2005). Unlike design principles, design guidelines are best practices that are based on practical experiences or empirical studies. Design guidelines provide solutions for design problems and helpful reminders based on knowledge and experiences, and are very specific and practical.

According to Nielsen (1995), heuristics are defined as "general rules that seem to describe common properties of usable interfaces". Heuristics are broad rules of thumb and are less specific compared to design guidelines. Heuristics are often used in heuristic evaluation sessions involving evaluators going through the user interface numerous times to inspect various elements and then compares them against the heuristics (Nielsen, 1995).

Design principles, guidelines and heuristics have a common goal where they aim to strike a balance between user, technology and task (Te'eni et al., 2005). Design principles, guidelines and heuristics can help designers make efficient proven decisions as well as avoiding mistakes made in the past.

2.7. Design Guidelines and Heuristics

This section covers six design guidelines and heuristics proposed by international and local researchers. Although several of the design guidelines and heuristics were not originally proposed for the design of educational apps, the researcher found that some of the design principles applicable for the design of children's educational apps. Finally, the design guidelines and heuristics are analyzed and consolidated as one.

2.7.1. Nielsen's Ten Usability Heuristics

The user interface (UI) is an essential component of almost all mobile apps. The UI is the mechanism or tool for users to communicate or interact with the app. Thus, it is imperative to take into account the importance of good user interface design when developing mobile apps. Stone et al. (2005) defined a good user interface design as the facilitator for easy, natural, and engaging interaction between a user and a system, which allow users to carry out their required tasks.

Alternatively, poor user interface design usually leads to user frustration and dissatisfaction towards the mobile app, usually resulting in abandonment. Nielsen (1993) identified the 10 usability heuristics for user interface design. Although the principles were based on the user interface design of computer systems back in the 90s, most of them are found to be applicable to the user interface design of mobile apps. The ten usability heuristics identified by Nielsen include:

1) Visibility of system status

According to Nielsen (1993), "the system should always keep users notified about what is going on, through appropriate feedback within reasonable durations."

2) Match between system and real world

Nielsen (1993) states that the "system should avoid the use of system-oriented terms that is difficult for users to understand." Instead, the system should follow real-world conventions by presenting information in a natural and logical order while using words, phrases, and concepts that are easy to understand.

3) User control and freedom

Nielsen (1993) comments that "users will often invoke certain system functions by mistake and a clearly marked 'emergency exit' must be presented clearly for user to leave the unwanted state without having to go through an extended dialogue. Buttons such as main menu, quit or undo can help user to recover from mistakes.

4) Consistency and standards

"Users should not have to guess whether different words, situations, or actions mean the same thing (Nielsen, 1993)." Standard platform conventions should be followed. Hence, user interfaces should be consistent across all screens in the system.

5) Error prevention

Design of user interfaces should be carefully implemented to prevent common problems from occurring in the first place (Nielsen, 1993). Nielsen remarked that "designers can either eliminate error-prone conditions or present users with confirmation options before proceeding to commit."

6) Recognition rather than recall

Nielsen (1993) recommends "minimizing the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another." Instructions for use of the system should be visible or easily retrievable whenever appropriate. Icons and other screen elements should be intuitive and self-explanatory.

7) Flexibility and efficiency of use

"Accelerators - unseen by the novice user - may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users (Nielsen, 1993)." The system should allow users to tailor the system to their frequent actions.

8) Aesthetic and minimalist design

According to Nielsen (1993), "dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and reduces their relative visibility." In other words, irrelevant information increases the difficulty or likelihood of users in discovering relevant information.

9) Help users recognize, diagnose, and recover from errors

Nielsen (1993) states "error messages should be expressed in plain, understandable language in order to precisely indicate the problem, and helpfully suggest a solution." In other words, error messages should be presented as concisely and as clearly as possible to assist the users in solving the problem.

10) Help and documentation

Help and documentation are sometimes necessary to be provided although it is ideal if the system is easy to use without any documentation. Nielsen (1993) recommends that the "information provided by the documentation should be easy to search, focused on the users' task, and list simple concrete steps to be carried out."

2.7.2. Norman's Design Principles for Usability

Donald Norman introduced six basic user interface design principles and concepts in the book "The Design of Everyday Things", published in 1988. These basic user interface design principles and concepts are able to better help users to understand which designs are more useable and learnable. The six basic design principles and concepts, according to Preece et al. (2002), include:

1) Consistency

According to Preece (2002), consistency refers to designing interfaces to have similar operations and use similar elements for achieving similar tasks. In particular, a consistent interface is one that follows rules, such as using the

same operation to select all objects. For instance, a consistent operation is using the same input action to highlight any graphical object at the interface, such as always clicking the left mouse button.

On the other hand, according to Matz (2012), inconsistency in the interface creates confusion due to things not working according to the way the user expects them to work. Matz states that forcing users to memorize exceptions to the rules will increase their cognitive burden and causes resentment towards the product. The presence of consistency in the user interface reduces the number of new things for users to learn.

2) Visibility

Visibility refers to the degree of visibility of the functions shown in the user interface (Preece, 2002). Users will better understand and know what to do next if the functions are more visible in the user interface. In contrast, users will have difficulty to find and know how to use the products if the functions are hidden or placed in unexpected locations. Matz (2012) states that the principle of visibility suggests improving usability and learnability to allow the user to easily see what commands and options are available.

3) Affordance

According to Preece (2002), affordance refers to an attribute of an object that allows people to know how to use it. The affordance principle can be applied in the graphical user interface. One such application of the principle is using visual cues to make controls look clickable or touchable. One technique suggested by Matz (2012) is making buttons and other controls look "three-

dimensional" and rise off the screen by using colors to simulate light and shadows.

4) Mapping

Preece (2002) define mapping as the relationship between controls and their effects in the world. Preece suggests that mapping should be performed as clearly and explicitly as possible. Descriptive labels, icons, and menu items can be used to achieve clear and explicit mappings. Controls should be also positioned in logical ways so that they match real-world objects or general conventions. For instance, sliding the brightness slider positioned horizontally on a smartphone right increases the brightness while sliding it left decreases the brightness.

5) Feedback

According to Preece (2002), feedback refers to sending back information about what action has been done and what has been accomplished, allowing the user to continue with the task. Matz (2012) distinguishes between two types of feedback:

- **Activational feedback** refers to the evidence that the control was activated successfully. For example, pressing a button or selecting a menu option. Evidence of a successful activation can be provided along with visual feedbacks. For example, a button can be animated to give the appearance of being depressed and released.
- **Behavioral feedback** refers to the evidence that the activation or adjustments of a particular control has affected the system. For example, in a web browser, clicking "Save as" button results in a

confirmation message in a pop-up dialog, and a file may be saved onto the computer.

6) Constraints

Constraints refer to ways of restricting the kind of user interaction that can take place at a given moment or state (Preece, 2002). Constraints prevent invalid data from being entered and invalid actions from being performed. User interfaces must be designed with constraints in place to prevent the system from entering into an invalid state.

2.7.3. Shneiderman's Eight Golden Rules of Interface Design

Ben Shneiderman introduced the Eight Golden Rules of Interface Design in the book, "Designing the User Interface: Strategies for Effective Human-Computer Interaction" in 1987 based on his research done in the area of Human Computer Interaction (HCI). These design principles can help to create a well-designed user interface which in turn helps to improve the usability of most interactive systems. The design principles have been refined over the years to match technology changes. Although the design principles have limitations, they can be refined and extended for use in the design of educational apps for children. The eight golden rules of interface design proposed by Shneiderman include:

1) Strive for consistency

"Consistent sequences of actions should be required in similar situations (Shneiderman, 1987)." For instance, identical terminology should be used in prompts, menus, and help screens. Persistent commands should be employed throughout the system to ensure consistency.

2) Cater to universal usability.

Shneiderman (1987) states the "needs of diverse users should be recognized and designed for plasticity, facilitating transformation of content." The differences between novice and expert user as well as their age ranges, disabilities, and technological diversity each enhance the range of requirements that guides design. Besides, Shneiderman and Plaisant (2010) remarked that "adding features for novice users, such as explanations, and shortcuts and faster pacing features for expert users can enhance the interface design and improve perceived system quality."

3) Offer informative feedback.

System feedback needs to be provided for every user action. According to Shneiderman (1987), "the response for frequent and minor actions can be modest, whereas for infrequent and major actions, the response should be more substantial."

4) Design dialog to yield closure.

According to Shneiderman (1987), sequences of actions should be organized into groups with a beginning, middle, and end. Shneiderman commented that "informative feedback at the completion of a group of actions

give users the satisfaction of accomplishment, a sense of relief, a signal to drop contingency plans from their minds, and an indicator to prepare for the next group of actions." For instance, an e-commerce web sites move users from selecting products into shopping carts to the checkout page, and finally ending with a clear confirmation page that completes the transaction.

5) Prevent Errors

The system should be designed in a manner which prevents users from making serious errors. Shneiderman (1987) states "the interface should detect the error and provide simple, constructive, and specific instructions for recovery if an error is made." According to Shneiderman and Plaisant (2010), "erroneous actions should leave the system state unchanged, or the interface should give instructions about restoring the state." For instance, the system can disable menu items that are not used to prevent erroneous actions.

6) Permit easy reversal of actions

Actions should be reversible as often as possible. Shneiderman (1987) states "this feature relieves user anxiety as the user knows that any errors done are reversible, and encourages exploration of unfamiliar options." The units of reversibility may be a single action, a data-entry task, or a complete group of actions, such as entry of a name-address block.

7) Support internal locus of control.

According to Shneiderman (1987) and Shneiderman and Plaisant (2010), "experienced users usually intend to seek a strong sense of control over the interface and how it responds to their actions." They dislike surprises or changes in familiar behavior, and they are annoyed by tedious data-entry

sequences, difficulty in obtaining necessary information, and inability to produce their desired result.

8) Reduce short-term memory load.

According to Shneiderman (1987), "the limitation of human information processing capacity in short-term memory requires that designers avoid interfaces in which users must remember information from one screen and then recall that information to use on another screen." Multiple-page displays should be combined, and sufficient training time should be assigned for complex sequences of actions.

2.7.4. Magic or Dust Design Guidelines

Wolock et al. (2006) state that the following guidelines are essential for all software intended for young children must have. The design guideline proposed by Wolock et al. are more appropriate to the design process of educational app for children compared to heuristics proposed by Nielsen (1993) and Norman (Preece, 2002). However, the Magic or Dust design guideline is originally intended for the design of computer software for children. Table 2.1 shows the Magic or Dust design guideline.

Table 2.1: Magic or Dust Design Guideline

Source: Wolock et al. (2006)

No	Design Guidelines
D1	Clear picture menus that does not have text
D2	Simple "one layer" menus that provide direct access to activities
D3	Limited wait or loading times to match short attention spans
D4	Quick, clear responses to keystrokes
D5	Short, interruptible routines for opening sequences and animations
D6	The ability to handle "machine-gun" keyboarding without buffer problems or crashes.
D7	Deliver help via clear speech in the context of the problem (the program should not jump to a separate help sequence)
D8	Use large icons that are understandable to children in an intuitive way and easy to select. Avoid using "phantom icons", which are objects that ask to be clicked on but has no functionalities.
D9	Picture-driven printing and saving routines (not text driven). Parents or teachers should have options for disabling the printing routines.
D10	Feedback/help that goes beyond simple reinforcement messages such as "nice job" or "try again." The program may narrow the options (to increase the chance of success on a second try) or provide a hint to coach the child along.

2.7.5. Playability Heuristics

Korhonen and Koivisto (2006) proposed their own playability heuristics that are specifically designed for evaluating mobile games. Their set of playability heuristics are divided into three categories which are namely game usability, mobility and gameplay. Korhonen and Koivisto commented that a game must have a convenient, reliable, and usable user interface in order for the player to concentrate on playing and enjoying the game instead of struggling with the user interface.

Korhonen and Koivisto have subdivided the game usability heuristics into several sub-categories. Table 2.2 shows the game usability heuristics which encompasses the game controls and user interface. Heuristics GU1 to GU5 deal with visual design, presentation of information, and terminology used. Heuristics GU6 to GU8 deal with navigation and game controls design. The remaining heuristics addresses important aspects such as providing feedback and giving help or hints when needed.

Mobility heuristics are used to evaluate the mobile games in terms of mobility aspects to uncover issues affecting the mobility of the game. Korhonen and Koivisto defined mobility as how easily the game allows a player to enter to the game world and how it behaves in diverse and unexpected environments. Table 2.3 and 2.4 shows the mobility heuristics and the gameplay heuristics respectively. Gameplay heuristics are used to evaluate the mobile games in terms of gameplay in order to discover issues that affect the gameplay.

The playability heuristics is originally created as a guideline for the design of mobile games on older generation of mobile phones without an emphasis on any genre or user groups. Children's educational apps mostly consist of educational contents coupled with entertainment elements in the form of games to encourage learning while having fun. The design principles of the Playability Heuristics can be adapted for the design of educational apps for Malaysian children.

Table 2.2: Heuristics for evaluating game usability

Souce: Korhonen and Koivisto (2006)

No.	Game Usability Heuristics
GU1	Audio-visual representation supports the game
GU2	Screen layout is efficient and visually pleasing
GU3	Device UI and game UI are used for their own purposes
GU4	Indicators are visible
GU5	The player understands the terminology
GU6	Navigation is consistent, logical, and minimalist
GU7	Control keys are consistent and follow standard conventions
GU8	Game controls are convenient and flexible
GU9	The game gives feedback on the player's actions
GU10	The player cannot make irreversible errors
GU11	The player does not have to memorize things unnecessarily
GU12	The game contains help

Table 2.3: Heuristics for evaluating mobility

Souce: Korhonen and Koivisto (2006)

No.	Mobility Heuristics
MO1	The game and play sessions can be started quickly
MO2	The game accommodates with the surroundings
MO3	Interruptions are handled reasonably

Table 2.4: Heuristics in evaluating gameplay

Souce: Korhonen and Koivisto (2006)

No.	Gameplay Heuristics
GP1	The game provides clear goals or supports player-created goals
GP2	The player sees the progress in the game and can compare the results
GP3	The players are rewarded and rewards are meaningful
GP4	The player is in control
GP5	Challenge, strategy, and pace are in balance
GP6	The first-time experience is encouraging
GP7	The game story supports the gameplay and is meaningful
GP8	There are no repetitive or boring tasks
GP9	The players can express themselves
GP10	The game supports different playing styles
GP11	The game does not stagnate
GP12	The game is consistent
GP13	The game uses orthogonal unit differentiation
GP 14	The player does not lose any hard-won possessions

2.7.6. Malaysian Ministry of Education (MOE) Design Guideline

The Malaysian Ministry of Education (MOE) developed a set of design guideline with the intention of guiding interactive courseware developers in designing and developing well-designed interactive courseware for the Malaysian Smart School Project (Kamaruddin, 2012). The design guideline set consists of two sections, where the first section provides overall architectural design guidelines with a description of design criteria and principles to be followed while the second section deals with the design process and production flow.

The MOE design guideline covers various design aspects in the design guideline. Figure 2.1 shows the various design aspects as well as their respective explanations. From Figure 2.1, the ministry placed an emphasis on the user interface design compared to other aspects. The design guideline covers the design of navigation and screen elements. Screen elements covered include text, graphics, animations, audio, and video. Figure 2.2 shows the user interface design principles covered in the MOE design guideline.

One difference between MOE design guideline and other design guidelines and heuristics proposed by international researchers identified in the literature is that the MOE design guideline addresses the biases in graphical or animation elements that courseware developers should avoid in the courseware. These biases include gender, religion, ethnicity and others. Besides, the

guideline advices that narration used in the courseware should have correct pronunciation and clear intonation with neutral ethnical accent.

Design Aspect	Components	
Storyboard design	Layout	
	Navigation	
	Graphics / Animation / Video placement in the overall structure	
	Content placement in the overall structure	
	Audio Script inclusion	
Instructional design	Content / Concept / Skill Learning	
	Practice / Activity	
	Test / Assessment / Evaluation	
Interface design	Navigation	Montage with the Malaysian Government logo
	Screen elements	Text
		Graphics
		Animations
		Audio
		Video
Technical requirements	Specifications	
	Environment/ contextual requirements of the classrooms	
Language and References	Language	English : Oxford Advanced Learner's Dictionary
		Malay : Kamus Dewan Bahasa dan Pustaka
	Sign language	Malay : Kod Tangan Bahasa Melayu (KTBM)
		English: American Sign Language (ASL)

Figure 2.1: Design Aspects of MOE Design Guideline

Source: Kamarudin, 2012

design standards	Necessary Characteristics
Navigation	• Introduction section shall be a multimedia presentation, between 15-30 seconds, which shall include any combination of text, animation, graphics and/or audio. • Users shall have the flexibility to navigate to the next and previous activity, to pause and continue an activity, and to exit. • All icons must have "mouse over" effects. • Test pages should have a confirmation dialogue. • Every page should be easy to use. • Every lesson must have the same introductory montage with the Malaysian Government logo to give a standardized look.
Screen Display	Colours for the total screen area shall provide contrast between the foreground and background.
Text	• Titles should use capital letters. • Colours used for text shall contrast against the background of the screen. • Fonts: Sizes and font types shall be limited to no more than 3 variations per page.
Graphics	• All graphics must be clear. • All characters used (e.g. animal, human): 1. Must be approved by the Ministry and be used again and again for consistency 2. Shall be logical and not contradictory to real life situations and must enhance or support learning 3. Biases in graphics or animations (gender, ethnicity, religion, etc.) must be avoided. • Colours used should be suitable for the age group concerned. • Any visuals should include sound effects to sustain student interest.
Animations	Shall be used for the purpose of supporting and enhancing learning.
Audio	• Voice, music narration, sound or song if include must be appropriate and should be clear. • Voices used: 1. Voice talent should be appropriate to the gender and age of the character portrayed in the courseware. 2. Correct pronunciation and clear intonation with neutral ethnic accent must be used. • Audio icons shall be provided to enable users to choose to listen.
Video	Video frames should be at least 240 X 180 pixels

Figure 2.2: User Interface Design Principles of MOE Design Guideline

Source: Kamaruddin, 2012

2.7.7. Analysis of Mobile App Design Guideline

There are numerous design guidelines and heuristics proposed by multiple researchers to design effective user interface for computer software and systems, interactive courseware, or mobile apps. In this research, the researcher has identified and reviewed six key design guidelines and heuristics from a wide body of literature available.

The six design guidelines and heuristics identified previously will be analyzed and compared in this subsection to determine which design principles are most commonly agreed upon by the researchers. Then, redundancies in design principles of the design guidelines and heuristics are removed or consolidated into a single one.

The reason why these six design guidelines and heuristics were selected is because they were proposed by experts in the area of usability, interface design and Human Computer Interaction (HCI), such as Jakob Nielsen, Donald Norman and Ben Shneiderman. In addition, these design guidelines and heuristics are well-established as they were cited by many researchers in their research work.

According to statistics provided by Google Scholar (2015a), Nielsen's Ten Usability Heuristics has been cited by 250 researchers while Norman's design principles, introduced in the book, "The Design of Everyday Things" has

been cited by 13,220 researchers (Google Scholar, 2015b). In addition, Shneiderman's rules of interface design, introduced in the book, "Designing the User Interface: Strategies for Effective Human-Computer Interaction" has been cited by 10,536 researchers (Google Scholar, 2015c). As for the other three design guidelines and heuristics, the Magic or Dust Design Guideline covered in Wolock et al. (2006) had been cited by 9 researchers (Google Scholar, 2015d) while the Playability Heuristics by Korhonen and Koivisto (2006) has been cited by 161 researchers (Google Scholar, 2015e). Lastly, the MOE Design Guideline covered in Kamaruddin (2012) was chosen because it was closely related to this research although there were no researchers citing it.

From reviewing the literature, it is discovered that Nielsen's Ten Usability Heuristics (Nielsen, 1993), Norman's Design Principles for Usability (Preece, 2002; Matz, 2012) and Shneiderman's Eight Golden Rules of Interface Design (Shneiderman, 1987; Shneiderman and Plaisant, 2010) leaned more towards heuristics rather than design guideline. Heuristic applies to basic human behaviors and mostly used in heuristics evaluation to discover usability issues. These sets of heuristics are analyzed to identify common principles of user interface design present within the three heuristics. Principles of three heuristics are cross-checked and compared. Table 2.5 shows the principles that are most common within three sets of heuristics.

By reviewing the remaining three design guidelines and heuristics identified, one of the finding state that design principles in Magic or Dust Design Guideline (Wolock et al., 2006), Playability Heuristics (Korhonen and Koivisto, 2006) and MOE Design Guideline (Kamaruddin, 2012) are quite similar to each other. Similar to the analysis performed previously, these design guidelines and heuristics are also analyzed by cross-checking and comparing to discover common design principles of user interface design.

Upon analysis, they are categorized into four distinct categories which include Screen, Navigation and Control, Feedback and Help, and Ease of Use. Besides, these principles are numbered to enable ease of cross-reference with the source. Similar principles found are consolidated as one and their respective sources are cited. Alternatively, principles that were found to be unsuitable for design of educational apps are summarized in Table 2.5. Finally, the common principles identified in Table 2.6 are consolidated with principles identified in the three heuristics. Table 2.7 shows the results of the consolidation of common principles of all six design guidelines and heuristics.

Table 2.5: Omitted Design Principles

Design Guideline/Heuristics	Source	Reason for Omission
D4. Quick, clear responses to keystrokes	Magic or Dust Design Guideline (Wolock et al., 2006)	Educational apps do not require children to type
D6. The ability to handle "machine-gun" keyboarding without buffer problems or crashes.	Magic or Dust Design Guideline (Wolock et al., 2006)	This only applies to computers with keyboard
D9. Picture-driven printing and saving routines (not text driven). Parents or teachers should have options for disabling the printing routines.	Magic or Dust Design Guideline (Wolock et al., 2006)	Educational apps offer ways to save contents digitally to device or cloud rather than printing them out
All of the Mobility Heuristics (Table 2.3)	Playability Heuristics (Korhonen and Koivisto, 2006)	This research is not concerned with mobility factors of the educational apps
All of the Gameplay Heuristics (Table 2.4)	Playability Heuristics (Korhonen and Koivisto, 2006)	This research is not concerned with the gameplay of the educational apps

Table 2.6: Common design principles present in three heuristics (by keyword)

Keywords	Nielsen's Ten Usability Heuristics	Norman's Design Principles for Usability	Shneiderman's Eight Golden Rules of Interface Design
Consistency	Consistencies and standards	Consistency	Strive for consistency
Feedback	Visibility of system status	Feedback	Offer informative feedback
Error prevention and recovery	Error prevention	Constraints	Prevent errors

Table 2.7: Common design principles found in all six design guidelines and heuristics

Categories	Design Principles	Design Guideline/Heuristics	Source
Screen	Not applicable	Clear picture menus without text [D1]	Wolock et. al (2006)
	Not applicable	Use large, easy to select icons [D8]	
	Not applicable	Avoid phantom icons [D8]	
	Not applicable	Screen layout is efficient and visually pleasing [GU2]	Korhonen and Koivisto (2006)
	Not applicable	Audio-visual representation supports learning [GU1]	Korhonen and Koivisto (2006); Kamaruddin (2012)
Navigation and Control	Not applicable	Simple "one layer" menus with direct access [D2]	Wolock et al. (2006)
	• Nielsen's Heuristic 4 • Norman's Principle 1 • Shneiderman's Rule 1, 7	Consistent, logical, and minimalist navigations [GU6]	Korhonen and Koivisto (2006); Nielsen (1993); Preece (2002); Shneiderman (1987); Schneiderman and Plaisant (2010); Kamaruddin (2012)
	• Nielsen's Heuristic 4, 7 • Norman's Principle 1 • Shneiderman's Rule 2	Game controls are convenient and flexible [GU7, GU8]	
Feedback and Help	• Nielsen's Heuristic 1 • Norman's Principle 5 • Shneiderman's Rule 3. 4	Provide feedback to inform results of user actions [D10, GU9]	Wolock et al. (2006); Nielsen (1993); Preece (2002); Shneiderman (1987); Schneiderman and Plaisant (2010)
	• Nielsen's Heuristic 9, 10 • Shneiderman's Rule 2	Deliver help via clear speech in the context of the problem [D7, GU12]	Wolock et al. (2006)

Table 2.7 (Cont.)

	• Nielsen's Heuristic 8 • Norman's Principle 2, 3, 4 • Shneiderman's Rule 4	Clear, visible indicators [GU4]	Korhonen and Koivisto (2006)
Ease of Use	Not applicable	Limited loading time [D3]	Wolock et al. (2006)
	Not applicable	Short, interruptible routines for opening sequences and animations [D5]	
	• Nielsen's Heuristic 2	Simple and understandable terminology [GU5]	Korhonen and Koivisto (2006)
	• Nielsen's Heuristics 4, 6 • Shneiderman's Rule 8	Eliminate need to memorize things [GU11]	
	• Nielsen's Heuristics 3, 5 • Norman's Principle 6 • Shneiderman's Rule 5, 6	No irreversible errors [GU10]	Korhonen and Koivisto (2006); Nielsen (1993); Preece (2002); Shneiderman (1987); Schneiderman and Plaisant (2010)

2.8. Educational Apps Selected for Evaluation

This section covers three educational apps considered for the evaluation study with young children. The researcher intends to discover the survey questionnaire's extent of applicability in evaluating educational apps for Malaysian children. This research only considers educational apps that are developed by local developers for the iOS platform. There is limited number of Malaysian developed educational apps for children as most developers on the App Store are mostly of United States of America (USA), South Korea, and China origins, according to the Malaysian iOS top chart for kids by AppAnnie

(2015), one of the largest statistical analytics and tracking company on the App Store and Google Play.

Hence, the three educational apps selected are not the best ones available on the App Store. The three educational apps proposed for the evaluation study are PiKidz ABC Play, Zap Zap Fractions and Princess Drawsalot & the Dragon. These three educational apps are offered free on the App Store with additional option of in-app purchases. Descriptions and features of each educational app are discussed in the following subsections.

2.8.1. PiKidz ABC Play

PiKidz ABC Play is a 3D interactive scrabble spelling app for children aged 4 years and older. The app is developed by Pitrees Sdn. Bhd., a local development company based in Cyberjaya. Children will recognize and memorize better with particular words while interacting with the 3D objects on scrabble spelling environment (iTunes, 2014a). Objects portrayed as examples with words in the app are interactive and playable. Figure 2.3 shows a screenshot of PiKidz ABC Play.

PiKidz ABC Play employs interesting sound effects, music, and a female voice over to act as learning companion. According to a review by AppArcadeStore (2014), Pikidz ABC Play has cute graphics and includes two different difficulties which helps broaden the age bracket. In addition,

AppArcadeStore states that a good control scheme is a hard thing to achieve and PiKidz ABC Play is successful in doing so.

A summary of the features of PiKidz ABC Play are:

- Real life interactive gameplay
- 3D objects and scrabble letters
- Different difficulty levels
- Female voice over
- Soothing background music
- Easy and direct navigation

Figure 2.3: Screenshot of PiKidz ABC Play

Source: iTunes, 2014a

2.8.2. Zap Zap Fractions

Zap Zap Fractions is educational app designed for children aged 4 years and older to learn the basics of fractions. Zap Zap Fractions is developed by Visual Math Studio, a Math brand division of CORE Visual Learning, based in Cyberjaya. The app has two parts including lessons on fractions and challenge mode. Lessons on fractions lets children learn the basics of fractions in a quick, visually-interactive, engaging way (iTunes, 2014b). Challenge mode is a space shooter game that test children's understanding on fractions providing fraction questions for children to solve.

According to Shu (2014) of TechCrunch, Zap Zap Fraction is an iPhone and iPad Math app for children that manage to be both instructional and beautiful. In addition, Lee (2014) of Tech In Asia, an online technology media company based across Asia and the US, states that Zap Zap Fraction definitely makes learning about fractions much more fun. Figure 2.4 shows a screenshot of Zap Zap Fraction.

Figure 2.4: Screenshot of Zap Zap Fraction

Source: iTunes, 2014b

2.8.3. Princess Drawsalot & the Dragon

Princess Drawsalot & the Dragon is a drawing and story-telling educational app designed for children aged 4 years and older. Princess Drawsalot & the Dragon is developed by Measat Broadcast Network Systems Sdn. Bhd., and is part of the Astro Go Play Network of games for learning and play (iTunes, 2014c). Children's drawings come to life in this exciting, animated, drawing app that encourages creativity. This app helps children develop fine motor skills, encourages creativity and imagination through drawing and storytelling. Figure 2.5 shows a screenshot of Princess Drawsalot & the Dragon.

According to The iPhoneMom (2013), an iOS and Android apps reviewing website made up of mom reviewers, reviewed that Princess Drawsalot & the Dragon is a wonderful story-making app that is perfect for young promising artists who need a little extra help to create. Besides, The iPhoneMom remarked that the app is a fun and non-threatening way to help kids develop their creativity without having to come up with a storyline and pictures all on their own.

Additional features of Princess Drawsalot & the Dragon include:

- A shared Astro Go Play account makes it easy for kids and parents to share a device and allow parents to track the game play and learning of multiple children associated with a single account.
- In-app messaging allow children and parents send one another fun and encouraging messages.
- A curated Game Catalog suggests new apps based on your child's interests and learning levels.

Figure 2.5: Screenshot of Princess Drawsalot & the Dragon

Source: iTunes, 2014c

2.9. Evaluation of Educational Apps

In this section, the three educational apps identified, PiKidz ABC Play, Zap Zap Fractions and Princess Drawsalot & the Dragon are evaluated by the researcher. The purpose of evaluating these three educational apps is to select the most appropriate educational app to be evaluated with children. The educational apps identified are evaluated against design principles compiled in Table 2.6 to determine the most appropriate educational app. The findings of each educational app are discussed in upcoming subsections.

Findings for each educational app are categorized into four categories. The four categories are Screen, Navigation and Control, Feedback and Help, and Ease of Use. Each design principle in Table 2.6 is used to check against

each educational app to discover whether any principles are implemented or violated.

2.9.1. Findings of PiKidz ABC Play

PiKidz ABC Play is evaluated by the researcher by checking against design principles in Table 2.6. Each principle is listed together with corresponding findings. The findings for PiKidz ABC Play are summarized as follows:

Screen

a) Clear picture menu without text
   - The menu in the app is clear and intuitive with minimal amount of text.

b) Use large, easy to select icons
   - Icons used in the app are large and easy to touch.

c) Avoid phantom icons
   - All touchable icons in the app present some functionality.

d) Screen layout is efficient and visually pleasing
   - Screen layout is easy to understand and attractive without the presence of distracting elements.

e) Audio-visual representation supports learning
   - Graphics, animations, sound effects, music, and voice narration enhances the learning experience of children.

Navigation and Control

a) Simple “one layer” menus with direct access

- Menus used in the app are simple “one layer” menus. These menus do not open on top of one another.
- Every screen in the app follows standard conventions. For instance, each screen has a main menu button for children to quit at any time.

b) Consistent, logical, and minimalist navigations

- The designs of navigational elements in this app are consistent in each screen.
- Navigation of the app is well designed as navigational elements are placed on the top portion of the screen.
- Simple and easy to understand icons are used as buttons.

c) Game controls are convenient and flexible

- Spelling words in the app is convenient and easy.
- Spelling words in the app forbid children from arranging one letter in the middle and another at the end. Alternatively, each letter in a word must be spelt one by one from left to right.

Feedback and Help

a) Provide feedback to inform results of user actions

- The app provides feedback for every action performed. For instance, a letter arranged wrongly bounces off and narrator informs that a mistake has been made.

b) Deliver help via clear speech in the context of the problem

- Instructions are repeated in short intervals when user performs actions wrongly a few times in a row.
- A preview of the spelling of a word is available at the bottom portion of the screen

c) Clear, visible indicators

- User status, location and system state is clear and visible.

Ease of Use

a) Limited loading time

- The loading time of the app is very short.

b) Short, interruptible routines for opening sequences and animations.

- Opening sequences of the app is short.
- Animations used in the app are continuous but interruptible.

c) Simple and understandable terminology

- Terminology used in this app is simple and easily understood.

d) Eliminate need to memorize things

- The app does not expect children to memorize anything.

e) No irreversible errors

- Errors made in this app are always reversible and does not cause the app to enter an irreversible state.

2.9.2. Findings of Zap Zap Fractions

Zap Zap Fractions is evaluated by the researcher by checking against design principles in Table 2.6. Each principle is listed together with corresponding findings. The findings for Zap Zap Fractions are summarized as follows:

Screen

a) Clear picture menu without text

- The menu in the app is clear and intuitive with a moderate amount of text.

b) Use large, easy to select icons

- Icons used in the app are large and easy to touch.

c) Avoid phantom icons

- All touchable icons in the app present some functionality.

d) Screen layout is efficient and visually pleasing

- Screen layout is easy to understand and attractive without the presence of distracting elements.

e) Audio-visual representation supports learning

- Graphics, animations, sound effects, music, and voice narration enhances the learning experience of children.

Navigation and Control

a) Simple “one layer” menus with direct access

- Menus used in the app are simple “one layer” menus. These menus do not open on top of one another.
- Every screen in the app follows standard conventions. For instance, each screen has a main menu button for children to return to main menu at any time.

b) Consistent, logical, and minimalist navigations

- The designs of navigational elements in this app are consistent in each screen.
- Navigation of the app is well designed as navigational elements are placed on the top and bottom portions of the screen.
- Simple and easy to understand icons are used as buttons.

c) Game controls are convenient and flexible

- In the Challenge mode, controls for answering quizzes are convenient.
- The flexibility of controls in Challenge mode (quiz game) is low as they are limited to four buttons (answers).

Feedback and Help

a) Provide feedback to inform results of user actions

- The app provides feedback for every action performed. For instance, a correct answer selected will causes it to flash green while wrong answer causes it to flash red. At the end of the quiz game, a summary of results is provided.

b) Deliver help via clear speech in the context of the problem

- During lessons on fractions, answering a question wrongly will result in an explanation given to clarify why the answer is wrong.
- However, there is no help provided in Challenge mode.

c) Clear, visible indicators

- User status, location and system state is clear and visible.

Ease of Use

a) Limited loading time

- The loading time of the app is very short.

b) Short, interruptible routines for opening sequences and animations.

- Opening sequences of the app is short.
- Animations used in the app are short but uninterruptible.

c) Simple and understandable terminology

- Terminology used in this app is relevant and difficulty to understand is moderate.

d) Eliminate need to memorize things

- The app does not require children to memorize anything.

e) No irreversible errors

- Errors made in this app always reversible and does not cause the app to enter an irreversible state.

2.9.3. Findings of Princess Drawsalot & the Dragon

Princess Drawsalot & the Dragon is evaluated by the researcher by checking against design principles in Table 2.6. Each principle is listed together with corresponding findings. The findings for Princess Drawsalot & the Dragon are summarized as follows:

Screen

a) Clear picture menu without text

- The menu in the app is clear and intuitive with minimal amount of text.

b) Use large, easy to select icons

- Icons used in the app are large and easy to touch.

c) Avoid phantom icons

- Most buttons in the app present some functionality
- The “Kiddoodle” button at the top left of the screen is a phantom icon that looks touchable but actually has no functionality.

d) Screen layout is efficient and visually pleasing

- Screen layout is easy to understand and attractive without the presence of distracting elements.

e) Audio-visual representation supports learning

- Graphics, animations, sound effects, music, and voice narration enhances the learning experience of children.

Navigation and Control

a) Simple “one layer” menus with direct access

- Menus used in the app are simple “one layer” menus. These menus do not open on top of one another
- Every screen in the app follows standard conventions. For instance, each screen has a back button for children to stop playing at any time and return to main menu.

b) Consistent, logical, and minimalist navigations

- The designs of navigational elements in this app are consistent in each screen.
- Navigation of the app is designed logically as navigational elements are placed on the bottom portions of the screen.
- Simple and easy to understand icons are used as buttons.

c) Game controls are convenient and flexible

- Controls for drawing and colouring are convenient and flexible. Tap once brings down a palette of colours to choose from and tap once more to select a colour or change from a pencil to brush tool
- Children can either choose to erase small portions of their drawing by tapping once or tapping twice on the eraser tool to erase the whole drawing.
- Photos of the drawing can be taken and saved by tapping once on take photo button.

Feedback and Help

a) Provide feedback to inform results of user actions

- The app provides feedback for every action performed. For instance, each brush stroke performed is immediately reflected in the drawing.

b) Deliver help via clear speech in the context of the problem

- No help is provided in the app.

c) Clear, visible indicators

- User status, location and system state is clear and visible.

Ease of Use

a) Limited loading time

- The loading time of the app is very short.

b) Short, interruptible routines for opening sequences and animations.

- Opening sequences of the app is short.
- Animations used in the app are short but interruptible.

c) Simple and understandable terminology

- Terminology used in this app is relevant and difficulty to understand is moderate.

d) Eliminate need to memorize things

- The app does not require children to memorize anything.

e) No irreversible errors

- Errors made in this app always reversible and does not cause the app to enter an irreversible state. For instance, mistakes made during

drawing can always be erased. Besides, children can always start over by erasing the whole drawing as well.

2.9.4. Summary of Findings

Findings of evaluation conducted on the three educational apps are summarized and shown in Table 2.7. Due to lack of space, PiKidz ABC Play, Zap Zap Fractions and Princess Drawsalot & the Dragon are represented as App 1, App 2 and App 3 instead. Comparison between three educational apps is made to decide which educational apps to be used in the evaluation study with children. The educational app with the least amount of violations of design principles identified in Table 2.6 will be selected to be used in the evaluation study. The reason behind why only one educational app will be used in the evaluation study is primarily due to time and resource constraints. There is simply not enough time and resources to allow the researcher to evaluate all three educational apps with every child participant.

The method used to compare the three educational apps is to calculate the amount of violations and then compare their numbers. Partial fulfillments of any single design principle are considered as violations. Based on the summary shown in Table 2.7, App 1 (PiKidz ABC Play) has the least amount of violations of design principles compared to App 2 (Zap Zap Fractions) and App 3 (Princess Drawsalot & the Dragon). App 1 has a total of three violations out of 16 design principles with App 2 and App 3 tied at five violations out of 16 design

principles. Hence, App 1 (PiKidz ABC Play) is selected to be used in the evaluation study with children.

Table 2.8: Summary of Findings for PiKidz ABC Play, Zap Zap Fractions and Princess Drawsalot & the Dragons

Design Guideline/Heuristics	**App 1**	**App 2**	**App 3**
Category 1: Screen			
Clear picture menus without text	Yes - Little amount of text	Yes - Moderate amount of text	Yes - Little amount of text
Use large, easy to select icons	Yes	Yes	Yes
Avoid phantom icons	Yes	Yes	No - One phantom icon ("Kiddoodle" button)
Screen layout is efficient and visually pleasing	Yes	Yes	Yes
Audio-visual representation supports learning	Yes	Yes	Yes
Category 2: Navigation and Control			
Simple "one layer" menus with direct access	Yes	Yes	Yes
Consistent, logical, and minimalist navigations	Yes	Yes	Yes
Game controls are convenient and flexible	Yes - Low flexibility	Yes - Low flexibility	Yes - Moderate flexibility
Category 3: Feedback and Help			
Provide feedback to inform results of user actions	Yes	Yes	Yes
Deliver help via clear speech in the context of the problem	Yes	Yes - Moderate amount of help	No help

Table 2.8 (Continued)

Clear, visible indicators	Yes	Yes	Yes
Category 4: Ease of Use			
Limited loading time	Yes	Yes	Yes
Short, interruptible routines for opening sequences and animations.	Yes - Continuous animation	Yes - Short, uninterruptable animation	Yes - Short, interruptible animation
Simple and understandable terminology	Yes	Moderate difficulty	Moderate difficulty
Eliminate need to memorize things	Yes	Yes	Yes
No irreversible errors	Yes	Yes	Yes

2.10. Piaget's Theory of Cognitive Development

According to Piaget (1932) and Cherry (2014a), "Piaget's theory describes the cognitive development of children across four distinct stages, which include, the sensorimotor stage, the preoperational stage, the concrete operational stage, and the formal operational stage." Cognitive development refers to the changes in the children's cognitive process and abilities. Cherry (2014a) states that "Piaget came to a conclusion that children were not less intelligent compared to adults" as they just think differently, based on his observation on children.

McLeod (2009) states cognitive development is the progressive restructuring of mental processes in children as a result of biological maturation and environmental experience. Children construct an understanding of the world around them and then experience discrepancies between what they

already know and what they discover in their environment. McLeod states that Piaget views early cognitive development as the "involvement of processes based upon actions which later progresses into changes in mental actions."

2.10.1. Stages of Cognitive Development

The four stages of cognitive development in children are as follows:

1) **Sensorimotor Stage** (birth to age 2)**:** According to Cherry (2014a), infants and toddlers obtain knowledge through sensory experiences and manipulation of objects during this stage.
2) **Preoperational Stage** (age 2 to 7)**:** In this stage, Cherry states that children learn through pretend play but still struggle with logic and taking the point of view of other people.
3) **Concrete Operational Stage** (age 7 to 11)**:** Cherry mentioned that children in this stage start to develop logical thoughts, however their thoughts can also be very inflexible. Hence, they tend to struggle with abstract and hypothetical concepts.
4) **Formal Operational Stage** (age 11 to adulthood)**:** According to Cherry, children in the final stage indicate an increase in logical thinking, the ability to employ deductive reasoning, and an understanding of abstract ideas.

2.10.2. Key Concepts

There are a few key concepts in Piaget's Theory of Cognitive Development. The descriptions of each key concept are as follows.

1) Schemas

According to Cherry (2014a), "a schema describes both the mental and physical actions involved in understanding and knowing. Schemas are categories of knowledge that help us to interpret and understand the world." Besides, Piaget explains that a schema consist of both a category of knowledge and the process of obtaining that knowledge, according to Cherry. The new information gained is used to modify, add to, or change previously existing schemas as new experiences occur.

For instance, a child may have a schema about a dog, a furry animal that have four legs. Hence, when a child encounters a horse, he or she is able to conclude that the horse is not a dog, but instead, a horse. The child then takes in the new information, modifying the previously existing schema to include these new observations.

2) Assimilation

Cherry (2014a) state that "assimilation is the process of taking in new information into our previously existing schemas." The process is subjective in nature, as we tend to modify experiences and information in a way that fit in with our existing beliefs. For instance, a child seeing a dog and calling it a

"dog" is an example of assimilation taking place, where the child assimilates the animal into the child's dog schema.

3) Accommodation

Cherry (2014a) define accommodation as a process involving changes or modification made on existing schemas, or ideas, in order to deal with new information or new experiences. In addition, new schemas may also be developed in the accommodation process.

4) Equilibration

According to McLeod (2009), Piaget believed that a state of equilibrium can be achieved through a process called equilibration. Equilibration occurs when a child's schema is able to deal with new information through assimilation. However, a state of disequilibrium occurs when new information cannot be fitted into existing schemas or assimilated. Hence, a child will attempt to learn or master the new information by modifying existing schemas through accommodation, eventually leading back to a state of equilibrium through equilibration.

2.11. Challenges in Working with Children

According to McKnight and Read (2011), conducting studies with children is more difficult compared to adults. There are many challenges in conducting studies with children. One of them is fitting the study into children's busy school schedule. Besides, children tend to have short attention span, hence, often leading the studies to be relatively short. In addition, children also require

some motivation or reward for participating, such as making the studies to be fun for them. On the other hand, schools involved usually want to see perceived benefits for their students, such as tasks associated with the studies carry educational or skill-based value.

Conducting studies with children requires more careful planning and considerations since working with children is harder than working with adults. Most studies are often conducted by experts in usability and user experience, education, or child psychology. Since children have their own distinct needs and requirements, newcomers who are not familiar with working with children can find the process to be an overwhelming experience.

Many standard evaluation methods may not be appropriate to be used for children. Horton and Read (2008) identified many flaws with using survey methods on children. The issues include children misunderstanding questions, politeness, or simply a different understanding of the world. Observation methods are often used as an alternative. However, the method requires trained observers and subjected to bias. Besides, surveys are subjected to satisficing and suggestibility issues.

According to Read (2008), "satisficing occurs when the children provide a more or less superficial, but reasonable or acceptable response to a question. Satisficing is a result of some of the steps of the question-answer process having been missed." Hence, questions formulated need to be understood and

completed easily in order to reduce the impact of satisficing. On the other hand, Read defined suggestibility as influence of social and psychological factors on the children's encoding, storage, retrieval and reporting of events. Read further added that one of the major influences in a survey is the interviewer or researcher as it is difficult for researchers to not intervene when children are the respondents.

2.12. Review of Literature on Research Methods

This section presents the review of literature on research methodology and participatory design approaches when conducting research studies with children.

2.12.1. Adapted Heuristic Evaluation for Children

There are four basic methods for evaluating user interfaces, according to Nielsen and Mollich (1990). The four methods for evaluating user interfaces mentioned by Nielsen and Mollich include formal evaluation using some analysis techniques, automatic evaluation using computerized procedure, empirically by testing users while performing experiments, and heuristically.

Nielsen (1992) defined that heuristic evaluation is a user evaluation method (UEM) where evaluators inspect a user interface against a guideline to identify usability problems that violate any items on the guideline. Heuristic evaluation is said to be less reliable compared to formal evaluation. However,

heuristic evaluation is often used compared to formal evaluation as it is more costly and time consuming.

Heuristic evaluation is usually carried out by a team of experts on usability. However, there are cases where the evaluation is carried out by double experts who are both usability and domain experts. Since this research is evaluating educational apps for children, using children as evaluators have the advantage where the children has a better understanding of which aspects are of utmost importance to them. The heuristic evaluation method has been widely applied using adult evaluators.

However, it is possible to adapt the heuristic evaluation method to be used with children as evaluators instead of experts. Based on studies by MacFarlane et al. (2005), children aged 7 or 8 years are able to reliably differentiate between constructs such as ease of use and fun. MacFarlane and Pasiali (2005) conducted a heuristic evaluation with 15 children aged 13 to 14 years to evaluate a web-based French learning tutorial.

2.12.2. Fun Toolkit v3

According to Read (2008), "the Fun Toolkit v3 is a survey instrument that has been developed to assist researchers and developers in gathering children's opinion about technology." The Fun Toolkit was originally developed by Read as a concept in 2000 before undergoing multiple iterations of reviews and refinement. As a result, the Fun Toolkit v2 was developed and

presented in Read and McFarlane (2006). Based on studies conducted previously, the Fun Toolkit is useful for gathering opinions from children with acceptable degrees of confidence and has the potential to be used for other user experiences.

The toolkit is developed with the intention of fun, fast, and fair and is suited for use with children as young as 4 years old. In addition, the toolkit exhibits acceptable use with teenagers. The Fun Toolkit v3 is made up of three instruments that can be used to "pass opinions" on technological products. The three instruments mentioned are the Smileyometer, Fun Sorter, and Again Again table.

a) Smileyometer

According to Read (2008) and Read and MacFarlane (2006), the Smileyometer is a Visual Analogue Scale (VAS) based around a 1 - 5 Likert scale, and uses pictorial representations of smiley faces for each scale from 1 - 5 as shown in Figure 2.6. The Smileyometer is presented to children in a horizontal row with descriptions or labels under each smiley faces. The smiley faces in the Smileyometer was co-designed with children aged 8 and 9 years and had led to informative discoveries. Children are required to tick one of the smiley faces to indicate their opinion.

Read states that the Smileyometer can be used before and after the children have experienced the technology being evaluated. By using the Smileyometer before the evaluation, the expectations of the children can be measured. On the other hand, by using it after the evaluation, the children are assumed to be reporting their experienced feelings or fun. When several technologies are to be evaluated at the same time, it is preferable to use a single Smileyometer for each technology evaluated. The key features of the Smileyometer include quick and ease of completion, requiring limited reading ability, and no writing is necessary. However, data gathered using Smileyometer alone is limited and it is problematic when used to measure multiple technology products as it is preferable to

Figure 2.6: Smileyometer

Source: Read, 2008

b) Fun Sorter

Read (2008) and Read and MacFarlane (2006) state that the Fun Sorter is used to compare a set of related technologies or products. According to Read and MacFarlane, "the Fun Sorter is made up of n + 1 columns and m + 1 rows, where n is the number of items being compared while m is the number of constructs being used." One of the merits of Fun Sorter is the ability to

measure fun and others when different constructs are used. Figure 2.7 shows an example of the Fun Sorter measuring four different input technologies with two constructs.

Read and Read and MacFarlane state that "the Fun Sorter involve children interpreting the constructs and then writing a description of the technology in blank spaces, or placing picture cards on an empty grid." However, the latter is much preferable for children with reading or writing difficulties. The ranking or placement of the cards can assign a ranked score to each of the constructs. However, Read suggests "paying special attention on the use of constructs in the Fun Sorter" as children are known to take things literally and their understanding of words are often unpredictable.

Read and McFarlane recommend that researchers should present each construct individually, especially for young children aged 8 and below. The Fun Sorter can be designed in a way which requires no writing, quick and fun to complete. However, Read and MacFarlane comment that "when several constructs are used, the Fun Sorter becomes difficult for children to understand" as the ability to read, understand and differentiating constructs is required.

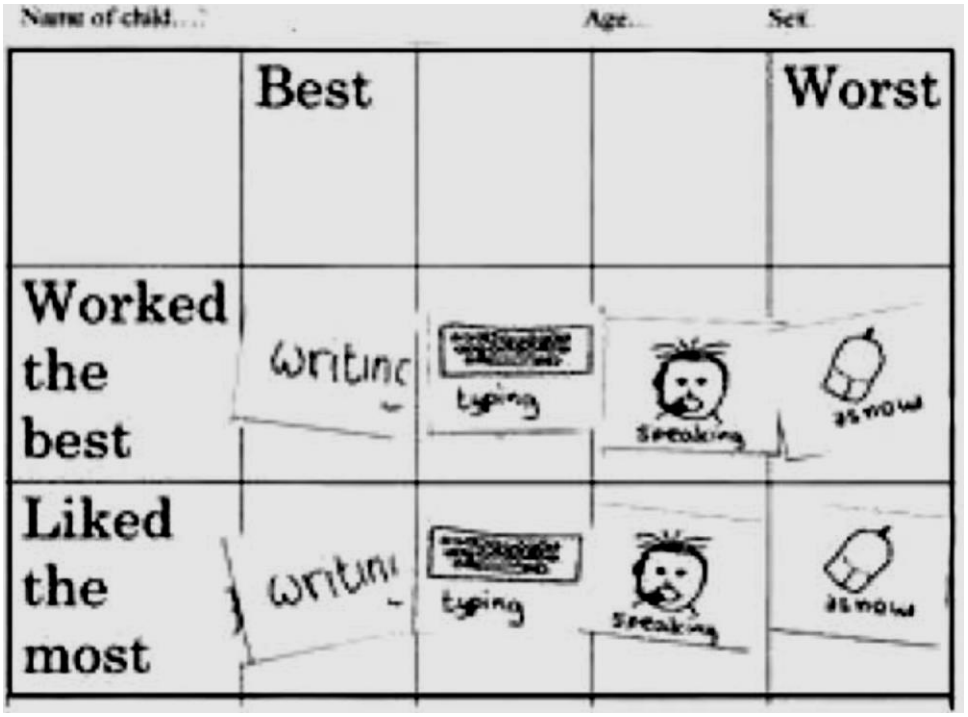


Figure 2.7: Fun Sorter measuring 4 input technologies with 2 constructs

Source: Read, 2008

c) Again Again Table

According to Read (2008) and Read and MacFarlane (2006), "the Again Again table is a simple table that requires the children to tick either 'yes', 'maybe', or 'no' for each activity or product", when asked "Would you would like to do this again?" The table comprises of four columns and n + 1 rows, where n is the number of activities being compared. Figure 2.8 shows an example of the Again Again table with images of different products or activities and columns labeled "yes", "maybe" and "no". Ratings of three, two, and one can be applied to the responses.

Read states that the Again Again table is based on work on psychology that indicates that we would most likely want to return to an activity that we liked. However, Read remarked that "the Again Again table cannot be used to evaluate a single product or technology. Alternatively, it is most useful when comparing three or more products or activities." The products or activities need to be presented on a single sheet of paper after the evaluation has been conducted. However, Read suggests that it is not recommended to not compare too many items at one time as children may get impatient.

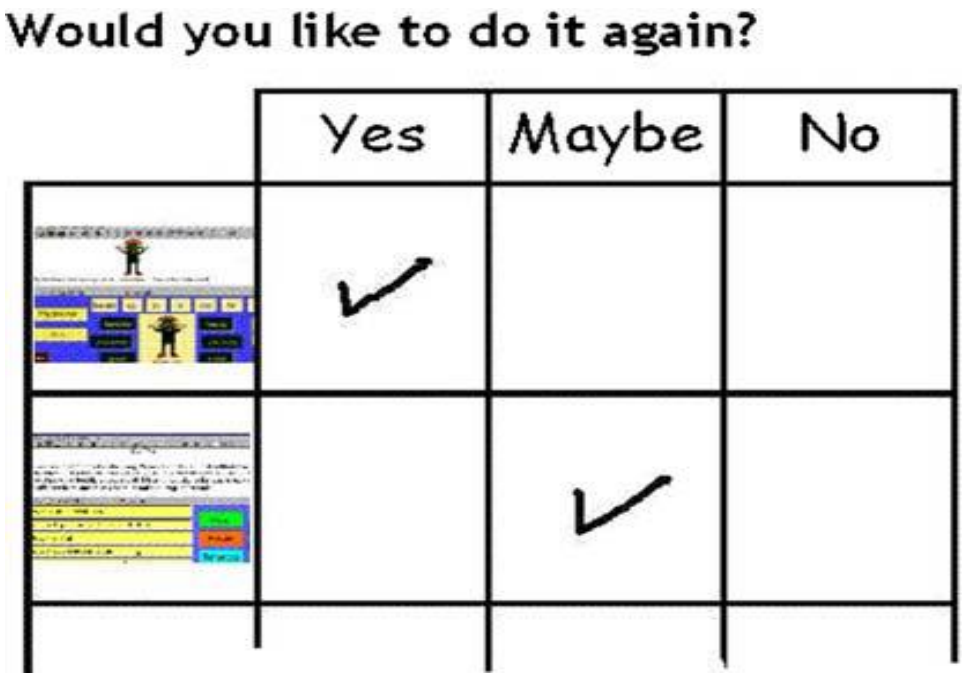


Figure 2.8: Completed Again Again table

Source: Read, 2008

2.12.2.1. Application of Fun Toolkit in Other Research Studies

The Fun Toolkit has been adapted for use in many studies by other researchers other than Read (2008) and Read and MacFarlane (2006). In a research study conducted by Barendregt et al. (2006), Smileyometer was used with 25 children aged between 5 and 7 year old after their first play session with a game and after their last play session. The paired Smileyometers were used to track children's changing satisfaction levels over time as opposed to the original application of measuring before and after scores. Children were found to show greater appreciation for the game after their last session compared to their first session (Barendregt et al., 2006).

Metaxas et al. (2005) conducted a study with 12 children aged between 8 and 12 to rate a mixed reality game using paired Smileyometers before and after play. Before playing, children were given a description of the game and then asked to complete the first Smileyometer. After playing, the children were asked what they liked about the game. The same question was asked again at a later time to measure the game's endurability. The Fun Toolkit measures endurability using Again Again table instead (Read, 2008; Read and MacFarlane, 2006). The use of paired Smileyometer found the children's had high expectations and the game fulfilled that expectation.

In addition, Metaxas et al. (2005) also used an adaption of the Again Again table. This adapted Again Again table, however, does not compare any technology products or activities. Metaxas et al. used the adapted Again Again table to discover whether the children would like to play the game again. Although all children responded "yes" to the question, this adaption of the Again Again table provides limited information regarding the reason behind the children's response.

2.12.3. Problem Identification Picture Card Method

According to Barendregt et al. (2008), the Problem Identification Picture Card (PIPC) method allows young children to express both usability and fun problems while playing a computer game. Barendregt et al. commented that the PIPC method is a combination of the traditional thinking-aloud method with picture cards. Children then place the picture cards in a box to indicate the types of problem discovered. Based on the experiment conducted by the authors, children may express more problems with the PIPC method than the conventional think-aloud method.

a) Choosing the Pictures

Based on a recommendation by Barendregt et al. (2008), it is wise to limit the use of pictures to a maximum number of eight to prevent overloading the children with too many different concepts to remember. These pictures have to represent the feelings or experience that the children may have when encountering different kinds of problems or when they really enjoy the game.

Barendregt et al. categorized usability problems into three distinct categories namely perception, cognition, and action problems. Alternatively, for fun problems, they are categorized according to the taxonomy by Malone and Lepper (1987). Malone and Lepper identified four types of fun problems which include challenge problems, fantasy problems, curiosity problems, and control problems. For each usability and fun problem, one or more possible expressions or feelings experienced by the children can be represented with a picture card.

b) Application of the PIPC method

At the beginning of the PIPC method, the children are given a brief explanation of each picture and the different situations where they can use a particular picture. According to Barendregt et al. (2008), the picture card box and picture cards representing each problem category are placed on the table next to the computer on which the game is played at the beginning of the session. Children are allowed to place as many picture cards as they like in the box. An explanation regarding the picture cards should be provided again in case the children forget. The method does not concern itself with whether the children use the correct picture card for a particular problem.

The researcher or facilitator can ask the children for an explanation if he/she does not understand why a certain picture card is used for a particular problem. Finally, the behavior of the children playing with the game together

with the picture cards is used to do the actual analysis of the test session. Figures 2.9 and 2.10 shows the picture cards used in the method and the box containing the picture cards.

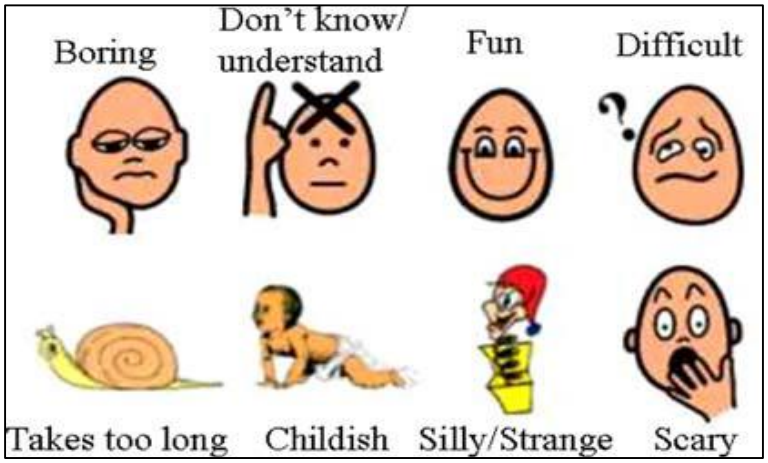


Figure 2.9: The picture cards used for PIPC method

Source: Barendregt et al., 2008

Figure 2.10: The box with compartments to store picture cards

Source: Barendregt et al., 2008

2.13. Conclusion

Mobile learning or m-learning has proven to be effective and beneficial toward learners through multiple studies conducted by researchers (i.e. Evans, 2008; Al-Fahad, 2009). Therefore, in this modern age, parents are trying to replicate the results by allowing their children to learn through educational apps. Design principles of several design guidelines and heuristics proposed by international and local researchers are reviewed and consolidated into Table 2.6 to be used in the formulation of a survey questionnaire for evaluating children's educational apps. The purpose of literature review is to evaluate and formulate a consolidated design guideline based on other design guidelines and heuristics proposed by international researchers. Then, the consolidated design guideline will be used to formulate statements for the survey questionnaire.

CHAPTER 3

RESEARCH METHODOLOGY

3.1. Introduction

This chapter discusses the methodology used to carry out the research. The topics covered include research method, research participants and sampling, data collection methods and procedures, and data analysis techniques.

3.2. Research Method

The research approach used in this dissertation is the Mixed Method Research. Creswell and Clark (2007) define mixed method research as a research design with philosophical assumptions as well as methods of inquiry which can be used both as a research methodology or method. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis of data and the mixture of qualitative and quantitative approaches in many phases in the research process. As a method, it focuses on collecting, analysing, and mixing both quantitative and qualitative data in a single study or series of studies. The main advantage of using mixed method research is the combination of quantitative and qualitative approaches are able

to provide a better understanding of research problems compared to using either one approach only.

Creswell and Clark mentioned quantitative data are closed-ended information found on attitude, behaviour or performance instruments. Quantitative data gathered from survey instruments are analysed statistically to answer research questions or test hypotheses formed. On the other hand, qualitative data refers to open-ended information gathered through interviews conducted with research participants. Besides, qualitative data can be collected from observation, gathering documents from private or public sources, and collecting audio-visual materials (Creswell and Clark, 2007). The analysis of qualitative data typically involves aggregating the data (words or images) into categories of information and presenting the diversity of ideas gathered during data collection.

According to Creswell and Clark, there are three methods of mixing or combining the quantitative and qualitative data gathered. The first method is merging the two datasets by combining them together to produce a clearer result. The second method is connecting the two datasets by allowing one dataset to build upon another. The final method is embedding one dataset within the other so that one dataset acts as a supporter for that other dataset.

The primary reason for selecting mixed method research approach is neither quantitative nor qualitative approach are sufficient in addressing the research problem when used alone. In order to discover the extent of the survey questionnaire's applicability in evaluating children's educational apps, the researcher will conduct an evaluation study with children as participants using the survey questionnaire formulated to evaluate PiKidz ABC Play. Therefore, both quantitative and qualitative data will be gathered using the survey questionnaire and direct observation. Lastly, in order to test the validity of the hypotheses formulated, both quantitative and qualitative data gathered will be analysed and compared to discover any significant findings.

3.3. Research Participants and Sampling Size

The sampling method used for the research is non-probability sampling method. Zikmund and Babin (2006) state in non-probability sampling, the probability of any particular member of the population being chosen is unknown. Therefore, samples are gathered in a manner where there is no equal chance for each member of the population to be selected. In addition, selection of samples relies heavily on the personal judgment of the researcher.

Non-probability sampling method is selected mainly due to resources constraints such as cost and time as well as the inability of the researcher to identify the members of the population precisely. Besides, Adler and Clark (2007) commented that non-probability sampling is useful when the researcher has limited resources or an inability to identify members of the population.

There are four types of non-probability sampling which are purposive, quota, convenience and snowball sampling.

Purposive sampling is used in this study because the researcher has a clear purpose and certain selection criteria in the selections of respondents. The researcher intends to collect data from respondents regarding the usability and overall user experience while using the educational app. Adler and Clark commented that in purposive sampling, the researcher selects sampling units by relying on his or her judgment of units that will facilitate an investigation.

Since the researcher was unable to obtain a comprehensive list of children in a particular state or area of the country, it is impractical to use probability sampling methods. Limited resources such as time and cost restrain the researcher to use probability sampling methods as they are more costly and time consuming. Besides, since the research employs the mixed mode research approach, it is difficult for the researcher to gather vast amount of data from large sample size due to constraints on time and resources.

The sampling size intended for the evaluation study is 20 children. The sampling size was set at 20 participants because other related research studies such as McFarlane et al. (2005) and Revelle and Reardon (2009) had successfully conducted their researches with 25 and 19 children respectively. There are three criteria for selecting participants for the evaluation study. First, participant must be a Malaysian citizen. Second, participants must be between

the age of 4 and 8 year old. Lastly, participants must have at least two months of experience interacting with smartphone or tablet devices.

Children aged 4 to 8 years old are selected as participants in the evaluation of educational apps because they are able to understand simple instructions and questions although their ability to comprehend matters is still limited. In addition, the children selected as participants are homogenous in nature where they all had prior experience interacting with smart devices.

According to Piaget's Theory of Cognitive Development, young children aged between 2 and 7 years old are in the preoperational stage (Piaget, 1932). McLeod (2010) states that children in the preoperational stage are able to mentally represent events and objects (the semiotic function), and engage in symbolic play. Cherry (2014b) said children in the preoperational stage are not yet able to understand concrete logic, unable to mentally manipulate information, and are unable to take the point of view of other people, which Piaget termed egocentrism.

According to McLeod (2010) and Cherry (2014b), Martin Hughes demonstrated that children as young as four years were able to understand situations from multiple points of view in an experiment involving dolls. Thus, this demonstrates that children become less egocentric at an earlier age than Piaget believed (McLeod, 2010; Cherry, 2014b). Hence, children aged as young

as 4 years and older are able to understand various situations which make them suitable to participate in the evaluation study.

3.4. Data Collection Methods

In order to evaluate the extent of the survey questionnaire's applicability in evaluating children's educational app, the researcher conducts an evaluation study involving children aged 4 to 8 years old. First, the researcher uses direct observation method to observe and take notes on findings regarding children's reactions, behavior, and interactions with the educational app.

According to Stone et al. (2005), direct observation is always worth doing as it is an easy activity to undertake and always yields interesting data, but it does have some limitations. One limitation mentioned by Stone et al. is direct observation only allow a single pass at the information gathering. This means although the observer takes notes, there may be things missed out and there is no possible way of reviewing. Another limitation is direct observation can be intrusive and alter the behavior and performance of person being observed.

After that, the researcher uses survey questionnaire to collect data based on the participants' interaction with the educational app. According to Trochim (2006), survey questionnaires are relatively inexpensive to administer, ease of dissemination to a wide number of respondents, and enable respondents to

complete at their own convenience. Although survey questionnaire usually suffers from low rate of response, it will not seriously affect this research as each participant of the evaluation study is almost guaranteed a response for the questionnaire except for those who wishes to quit midway.

3.4.1. Questionnaire Design

In order to discover a useful survey method to evaluate Malaysian children's educational apps, the researcher formulated questionnaire statements based on the consolidated design guideline (see Table 2.6). Besides, the researcher also reviewed reputable questionnaires from the Human Computer Interaction (HCI) community such as the Questionnaire for User Interface Satisfaction (QUIS) (Chin et al., 1988) and USE Questionnaire (Lund, 2001) in the formulation of questionnaire statements. The questionnaire is made of both closed-ended and open-ended questions. The questionnaire consists of four sections and a total number of 30 questions (kindly refer to Appendix B).

In Section A, data is collected in regards to the usability of the PiKidz ABC Play. Questions in this section are used to evaluate whether the educational app have violated any of the design principles related to Screen, Navigation and Control, and Feedback and Help. In Section B, data is collected in regards of ease of using the educational app. Questions in this section are used to check whether the educational app have violated any of the design principles related to ease of using the educational app. Both sections A and B collect data using a combination of 3-point Likert scale and Visual Analogue Scale (VAS)

consisting of responses of 1 = “Like”, 2 = “Not Sure” and 3 = “Dislike” that are represented by smiley faces. The use of the pictorial smiley faces is an adaptation of the Fun Toolkit v3’s Smileyometer (Read, 2008; Read and McFarlane, 2006). Section C collects data regarding types of smart devices in the household and how children gain access to these devices while Section D collects demographic information such as age and gender of children.

3.4.2. Questionnaire Validation

In order to ensure the validity of the questionnaire developed, Radhakrishna (2007) suggested carrying out readability tests such as Gunning-Fog Index, Flesch Reading Ease, and Flesch-Kinkaid Readability Formula. Therefore, the researcher has selected to conduct a Gunning-Fog Index readability tests on every question formulated in the questionnaire. According to Landau (2011), “the Gunning-Fog Index number indicates the numbers of years of formal education that a person requires in order to easily understand the text on his or her first reading.” In addition, Landau suggests that texts designed for a wide audience generally require a Gunning-Fog index of 12 or less while texts that require a close-to-universal understanding require an index of 8 or less.

All of the questions in the survey questionnaire are tested using two Gunning-Fox Index calculators from "www.readability-score.com" and "www.gunning-fog-index.com" to ensure reliability and validity of the results. The results produced by both calculators are slightly different. Thus, to ensure the most accurate indexes, the results obtained from both calculators are compiled and the average mean values of each statement is calculated and presented in Table 3.1.

Since the researcher intends to disseminate the questionnaire formulated to child respondents, each question are iteratively tested and modified to ensure that a mean index of 8 or less is achieved. Hence, out of 30 questions, only Q23 and Q30 have a mean index of 8 or more. After reviewing Q23 and Q30, it appears that the words "remember" and "education" is made up of three syllables resulting in a high Gunning-Fog Index, 8.0 and 10.0 respectively. Since "remember" and "education" are common English words, it is tolerable not to modify Q23 and Q30.

Table 3.1: Gunning-Fog Index for Questionnaire

No.	Question statement	Gunning-Fog Index (Mean)
Q1	Design of menu is simple.	2.0
Q2	Screen design is pretty and simple.	2.4
Q3	Buttons are large and easy to select.	2.8
Q4	Buttons in the app works when tapped.	2.8
Q5	Animation and picture used makes learning fun.	5.7
Q6	Sound used in the app makes learning easy.	3.2
Q7	Using menus to go to other screens is simple.	3.6
Q8	Using menus and buttons to go to other screens is easy.	4.4
Q9	Buttons such as next and back buttons are placed in the same place for each screen.	6.4
Q10	Learning using the app is easy.	2.4
Q11	Using the app to play games is simple.	3.2
Q12	Response given by app is clear and helpful.	3.2
Q13	Help given by app is useful.	5.75
Q14	Clues given are clear and helpful.	2.4
Q15	I know where I am now and where to go next.	4.4
Q16	I am clear of what tasks to do complete and how to complete them.	5.2
Q17	Loading time is short.	1.6
Q18	Animations in the app can be skipped or stopped.	5.8
Q19	Use of simple words	1.6
Q20	Wording and terms used is simple.	1.6
Q21	Mistakes made can be undone with ease.	2.8
Q22	Learning to how to use the app is easy.	3.8
Q23	I can remember how to use the app with ease.	8.0
Q24	I feel happy learning with the app.	2.8
Q25	It is fun to learn using the app.	3.2

Table 3.1 (Continued)

Q26	Which of the following smart devices do you have in your home? (Please tick ALL that apply)	6.5
Q27	How does your child gain access to smart devices? (Please tick only ONE)	3.6
Q28	Please specify the age of your child. (Please tick only ONE)	2.2
Q29	Please specify the gender of the child. (Please tick only ONE)	2.2
Q30	What is the highest level of education you have completed? (Please tick only ONE)	10.0

3.4.3. Pilot Testing

Prior to the actual conduct of the evaluation study, a pilot test was carried out with three children in order to discover whether the questions are too difficult to complete. The children involved in the pilot test were two male participants aged 5 and 7 year old and one female participant aged 4 years old.

According to van Teijlingen and Hundley (2001), one benefit of conducting a pilot study is that it might give advance warning about where the main research project could fail, where research protocols may not be followed, or whether proposed methods or instruments are inappropriate or too complicated. Hence, the researcher is able to make amends on the questionnaire based on participants' feedback by conducting pilot test.

As a result, some questionnaire statements were found to be difficult for participants to answer. Hence, various amendments were made to the survey questionnaire. First, questionnaire statements were rephrased using simpler vocabulary and grammar and then tested using Gunning-Fog Index to ensure a high readability for young children.

Second, a combination of 3-point Likert scale and Visual Analogue Scale (VAS) was used instead of a 5-point Likert scale. This was due to participants of the pilot testing had difficulty understanding the distance between "strongly agree" and "agree". Therefore, the scaling was reduced to a 3-point Likert scale and scale labels were represented with smiley faces instead. Lastly, order of the questions were reconsidered to ensure a smooth flow in completing the survey questionnaire (refer Appendix A and B for detailed changes).

3.5. Data Collection Procedure

The evaluation study was conducted from 10th February 2015 to 10th March 2015 where the researcher visited two kindergartens and one participant's house. First, the researcher hands the survey questionnaire to the participant and parent to go through briefly at the beginning of the evaluation study. However, only the parent goes through the questionnaire if the participant is too young (i.e. six years old and below).

Then, the parent is encouraged to clarify any uncertainties with the researcher. An iPad 4th generation loaded with the educational app, PiKidz ABC Play is handed to the child participant. The researcher allowed five minutes for the participant and parent to interact with the app. During this period, the researcher observed the participant while taking notes on behaviors, feedback and interaction with the educational app.

The researcher then asked the participant to complete the questionnaire. Average time taken to complete the questionnaire is approximately 20 to 30 minutes and depending on the age of participants. Alternatively, the parent is asked to complete the questionnaire based on the participant's responses if the participant is too young to be able to answer.

3.6. Data Analysis

For the analysis of observational data, Taylor-Powell and Renner (2003) states "there are two common approaches to focus your analysis. The two approaches include focusing by question or topic, time and event or focusing by case, individual and group." Hence, the researcher opted to focus the analysis by group, where the participants' observational data are sorted according to their age and gender. Then, the data are organized into three categories which are behavior, feedback and interaction with the educational app. Finally, the researcher analyzes the data to discover patterns and connections within or between each category and presents them.

Data analysis involving the coding and interpretation of results of the survey questionnaire is done using Statistical Package for Social Science (SPSS). Both descriptive and inferential statistics are used to analyze the data collected from the evaluation study through survey questionnaire to test the hypotheses formulated previously in Chapter 1. According to Lund Research Ltd (2013), "descriptive statistics is the analysis of data that helps describe, show or summarize data in a meaningful way." However, descriptive statistics do not allow conclusions to be made beyond the data that the researcher has analyzed. Hence, both descriptive and inferential statistics are used to test the hypotheses formulated previously in Chapter 1.

Descriptive statistics were used to analyze and present data regarding the number and type of devices in the household and the participants' demographic information (i.e. gender and age). Besides, descriptive statistics are also used to test hypothesis 1 to discover the extent of the survey questionnaire's applicability in evaluating educational apps for Malaysian children.

On the other hand, inferential statistics such as independent samples t-test and one way ANOVA test are used in testing hypotheses 2 and 3. The independent samples t-test is used to test for significance between participants' gender and the survey questionnaire's extent of applicability in evaluating Malaysian children's educational apps. On the other hand, the one way ANOVA test is used to test for significance between the participants' age and the survey

questionnaire's extent of applicability in evaluating Malaysian children's educational apps.

Table 3.2 summarizes the null hypotheses and their respective statistical analysis methods used to test them. According to Richardson et al. (2005), "there is a general agreement that outcomes associated with probabilities of 5 times out of 100 (i.e., p = 0.05) if the null hypotheses were true are said to be statistical significant." Therefore, the hypotheses are tested at the 0.05 level of significance.

Table 3.2: Summary of Statistical Analysis methods used in hypotheses testing

Null Hypotheses	**Statistical Analysis Method**
$H_0$1: The survey questionnaire formulated is not applicable to the evaluation of educational apps for Malaysian children.	Descriptive Statistics
$H_0$2: Gender of child participants has no significant effect on the applicability of the survey questionnaire in the evaluation of educational apps for children.	Independent samples t-test
$H_0$3: Age of child participants has no significant effect on the applicability of the survey questionnaire in the evaluation of educational apps for children.	One-way Analysis of variance (ANOVA) test

3.7. Conclusion

This chapter presented the research methods used in conducting the research. This chapter identified the research methods, research participants and samples, data collection method and procedures, and the appropriate statistical analysis methods to perform data analysis. The sections covered in this chapter leads to the discussion of findings in Chapter 4.

CHAPTER 4

RESEARCH FINDINGS

4.1. Introduction

This chapter presents the research findings after analyzing the data collected during the evaluation study using survey questionnaire and direct observation. The initial expected number of participants was 20 young children aged between 4 and 8 years old. In the end, a total of 27 participants were able to be recruited which is above the initial estimated number of participants. Data collected during the evaluation study were coded and analyzed using Statistical Package for Social Science (SPSS). The results of descriptive statistics and inferential statistics as well as the analysis of observational data findings are discussed in the following sections:

- Results of data analysis on participants' demographics
- Results of data analysis using descriptive analysis
- Results of observational data analysis
- Results of hypotheses testing

4.2. Results of Data Analysis on Participants' Demographics

This section presents an overview of the participants' demographic data. The demographic data collected include participants' gender and age as well as the education level of the participants' parent.

4.2.1. Participants' Gender

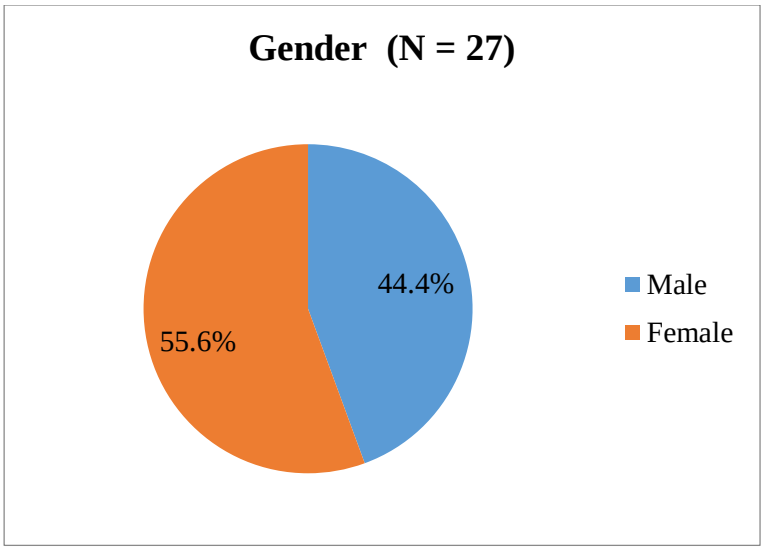


Figure 4.1: Participants' Demographic Data – Gender

In the evaluation study conducted, female participants made up a majority of the sample. The pie chart in Figure 4.1 shows that out of 27 participants, 55.6% (15 participants) are female while 44.4% (12 participants) are male.

4.2.2. Participants' Age

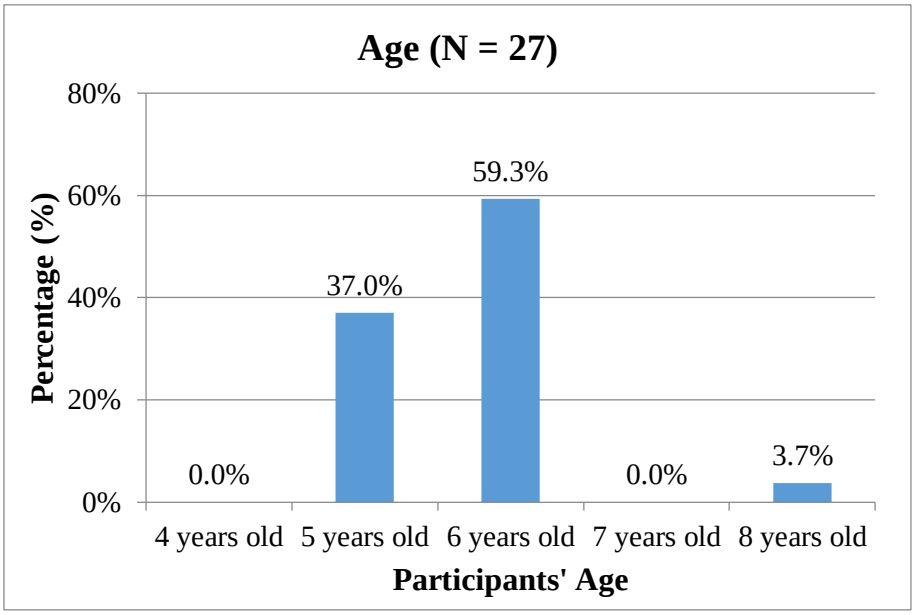


Figure 4.2: Participants' Demographic Data – Age

The column chart in Figure 4.2 shows the demographic data on the participants' age. The participants of the evaluation study are young Malaysian children aged between 4 and 8 years old. According to the pie chart, it is revealed that age 6 makes up the majority of the participants with 59.3% (16 participants) followed up by the age of 5 with 37.0% (10 participants) and the age of 8 with 3.7% (1 participant).

4.2.3. Parent's Education Level

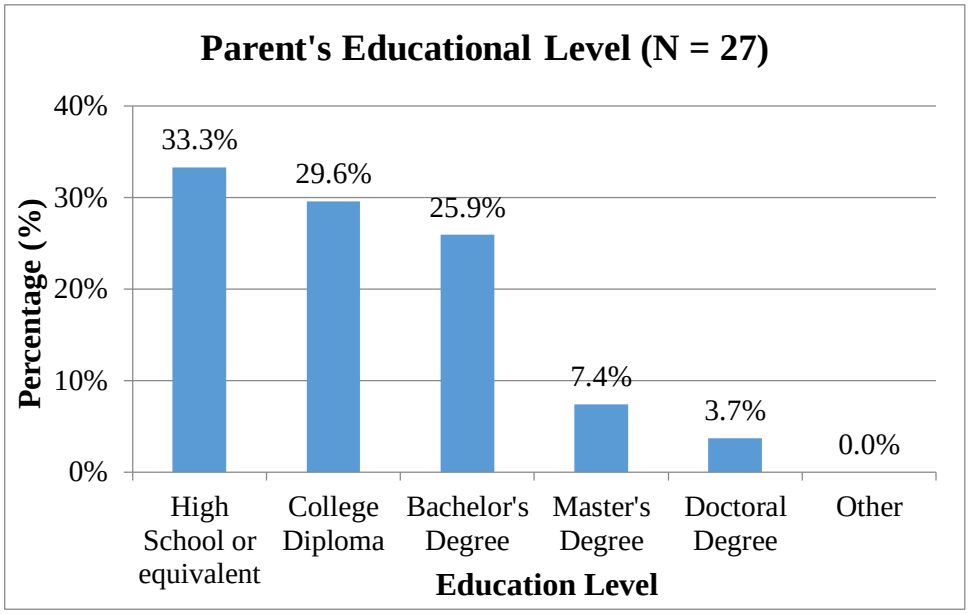


Figure 4.3: Participants' Demographic Data – Parent's Education Level

The column chart in Figure 4.3 shows the demographic information regarding the education level of the participants' parent. Based on Figure 4.3, majority of the parents completed high school or equivalent which makes up 33.3% (9 parents) of the overall number of participants. The second highest level of education completed is college diploma at 29.6% (8 parents) followed by bachelor's degree at 25.9% (7 parents). The fourth highest level of education completed is the master's degree at 7.4% (2 parents) followed by doctoral degree at 3.7% (1 parent).

4.3. Results of Data Analysis using Descriptive Analysis

This section presents the results of descriptive analysis on the data collected regarding the participants' responses in the survey questionnaire. The results are categorized into three sections (i.e., Section A, B and C). For each statement in the survey questionnaire, three smiley faces are provided for participants to tick. The smiley faces from left to right represents 1 = "like", 2 = "not sure" and 3 = "dislike". However, the participants' responses are recoded as 3 = "like", 2 = "not sure" and 1 = "dislike" during data analysis in SPSS. Henceforth, these statements are referred by their respective numbers for ease of presentation.

4.3.1. Section A: Usability of the Educational App

Section A presents the data regarding the usability of the educational app. The statements in this section are separated into three constructs which measures the level of usability of the educational app. The three constructs measured are Screen, Navigational and Control, and Feedback and Help.

4.3.1.1. Screen

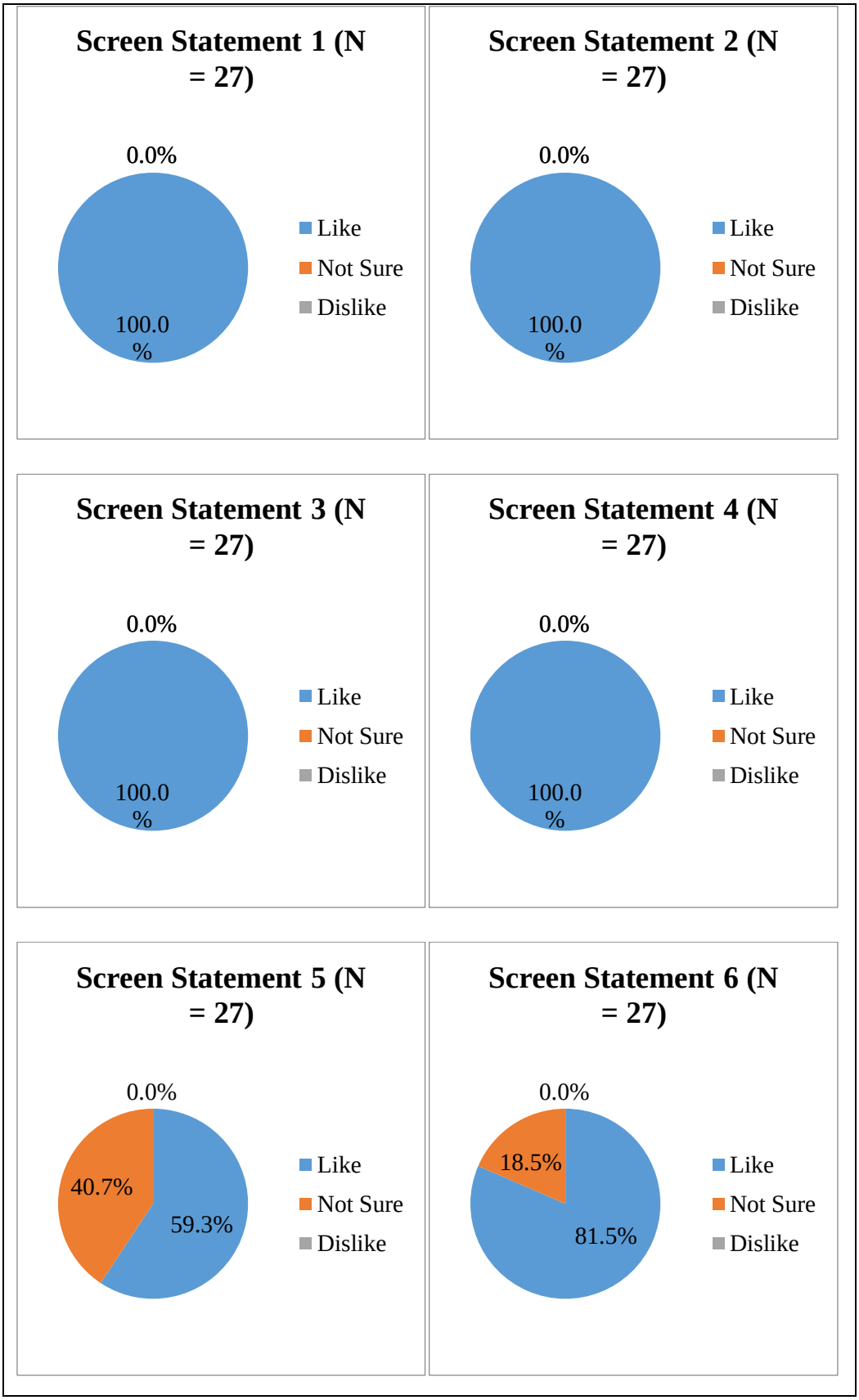


Figure 4.4: Participants' Responses - Screen

Table 4.1: Screen statements

Screen				
No.	**Statement**			
1.	Design of menu is simple			
2.	Screen design is pretty and simple			
3.	Buttons are large and easy to select			
4.	Buttons in the app works when touched			
5.	Animation and picture used makes learning fun			
6.	Sound used in the app makes learning easy			

Participants were asked for their level of agreement with the following statements relating to screen design as shown in Table 4.1 by ticking any one of the smiley faces. Based on the results in Figure 4.4, most participants completely agree with statements 1 through 4 resulting in 100% (27 participants) response for 1 = “like”. However, for statement 5, 59.3% or 16 participants ticked 1 = “like” while 40.7% or 11participants ticked 2 = “not sure”. Lastly, for statement 6, majority of the participants (81.5%, 22 participants) ticked 1 = “like” while 18.5% or 5participants ticked 2 = “not sure”.

4.3.1.2. Navigation and Control

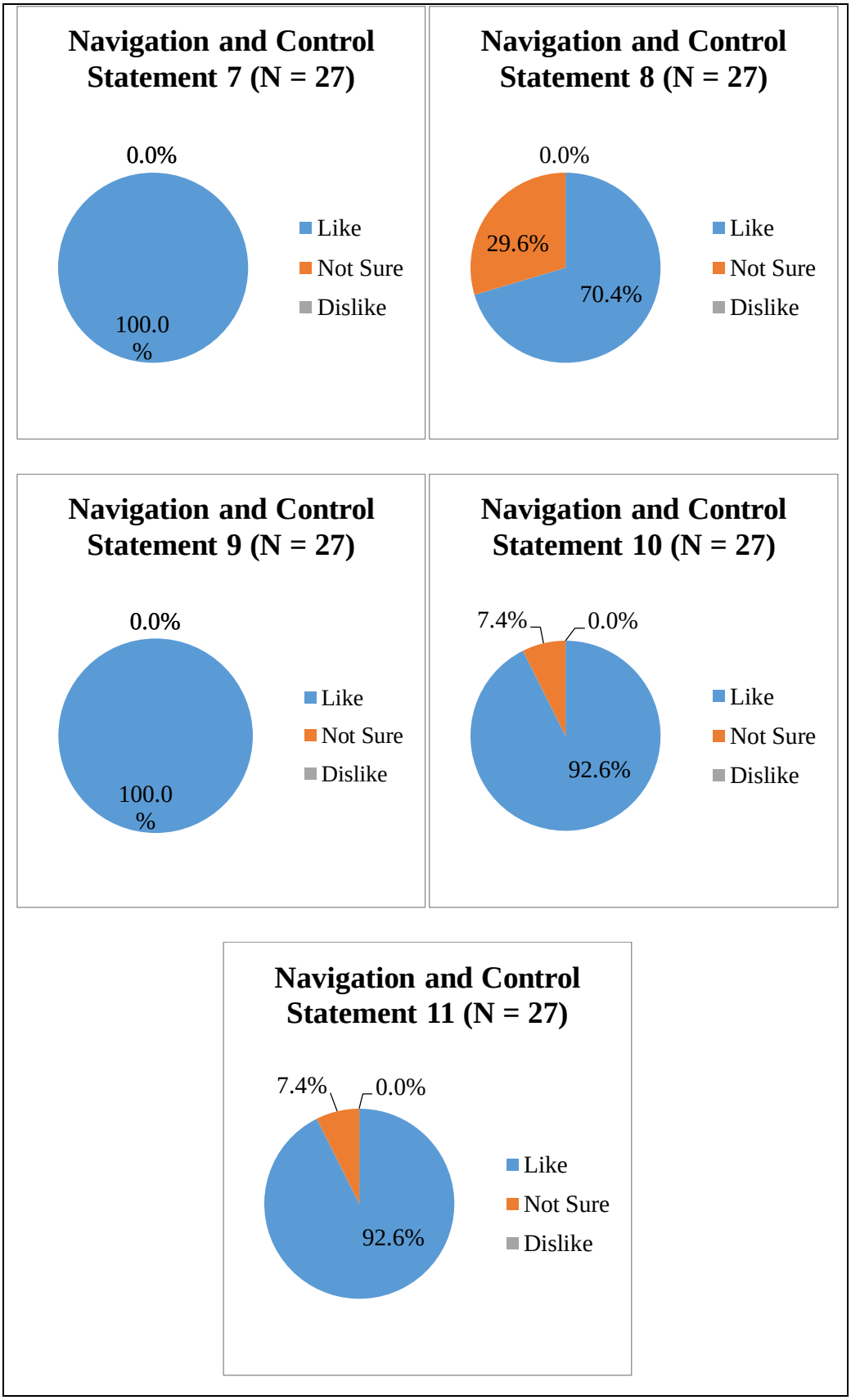


Figure 4.5: Participants' Responses - Navigation and Control

Table 4.2: Navigation and Control statements

Navigation and Control				
No.	**Statement**			
7.	Using menus to go to other screens is simple			
8.	Using menus and buttons to go to other screens is easy			
9.	Buttons such as next and back buttons are placed in the same place for each screen			
10.	Learning using the app is easy			
11.	Using the app to play games is simple			

Participants were asked to indicate their level of agreement for each statement relating to navigation and control as shown in Table 4.2 by ticking one of the three smiley faces. Based on the results in Figure 4.5, the participants shown complete agreement with statements 7 and 9 (100%, 27 participants). There were 19 participants (70.4%) who ticked 1 = “like” for statement 8 while 8 participants (29.6%) ticked 2 = “not sure”. For statement 10, there were 25 participants (92.6%) who selected 1 = “like” while 2 participants (7.4%) selected 2 = “not sure”. Lastly, for statement 11, 92.6% participants (25) responded with 1 = “like” while 7.4% participants (2) responded with 2 = “not sure”.

4.3.1.3. Feedback and Help

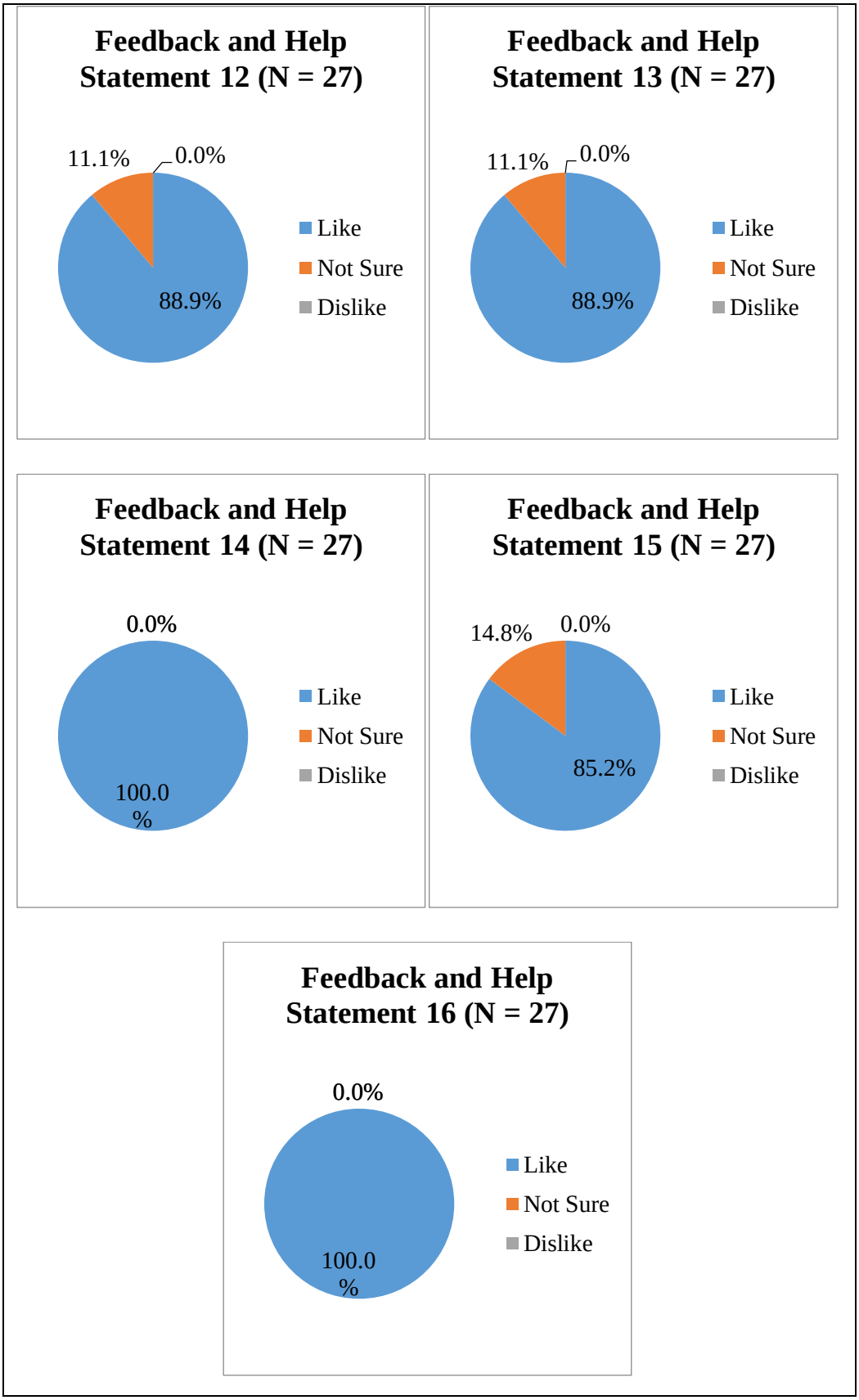


Figure 4.6: Participants' Responses - Feedback and Help

Table 4.3: Feedback and Help statements

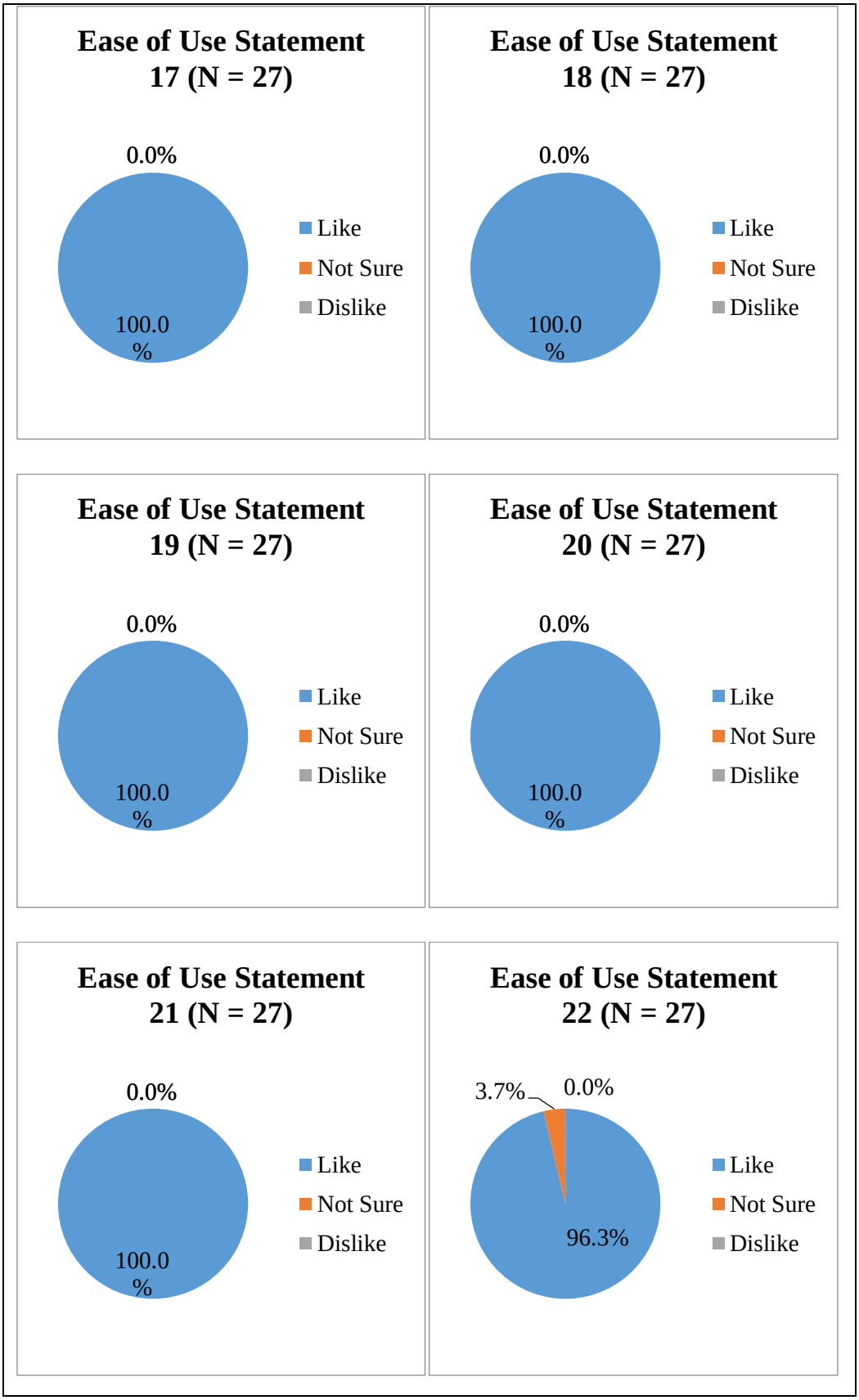
Feedback and Help				
No.	**Statement**			
12.	Responses given by app is clear and helpful			
13.	Help given is useful to me.			
14.	Clues given are clear and helpful.			
15.	I know where I am now and where to go next			
16.	I am clear of what tasks to finish and how to finish them			

Participants were asked to indicate their level of agreement for each statement relating to feedback and help as shown in Table 4.3 by ticking one of the three smiley faces. Based on the results shown in Figure 4.6, 88.9% (24 participants) ticked 1 = “like” while 11.1% (3 participants) ticked 2 = “not sure” as their response for statements 12 and 13. Meanwhile, participants are in complete agreement (100%, 27 participants) for statements 14 and 16. Lastly, 85.2% (23 participants) ticked 1 =“like” while 14.8% (4 participants) ticked 2 = “not sure” for statement 15.

4.3.2. Section B: Overall User Experience

Section B presents the data regarding the overall user experience while using the educational app. This section consists of statements that measure the user satisfaction when interacting with the app.

4.3.2.1. Ease of Use



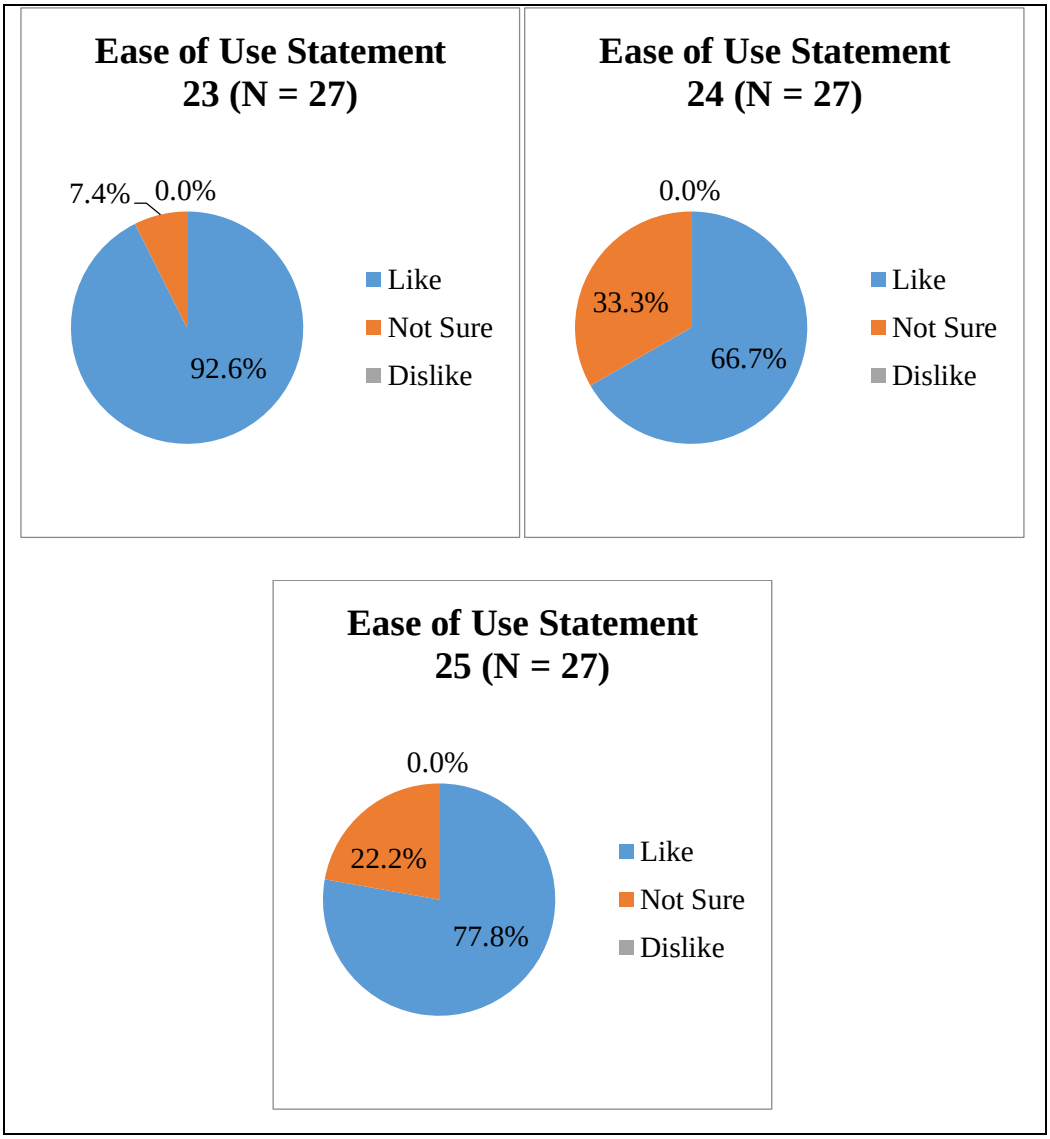


Figure 4.7: Participants' Responses - Ease of Use

Table 4.4: Ease of Use statements

Ease of Use				
No.	**Statement**			
17.	Loading time is short			
18.	Animations in the app can be skipped or stopped			
19.	Use of simple words			
20.	Language used is simple			
21.	Mistakes made can be easily recovered			
22.	Learning how to use the app is easy			
23.	I can remember how to use the app with ease			
24.	I feel happy learning with the app			
25.	It is fun to learn using the app			

Participants were asked to indicate their level of agreement with the statements as shown in Table 4.4 regarding the ease of using the educational app based on their experience. Based on the results shown in Figure 4.7, 100% of the participants seem to agree with each statement from 17 to 21. However, for statement 22, 96.3% participants (26) ticked 1 = “like” while only 3.7% participant (1) ticked 3 = “not sure”. Besides, 92.6% participants (25) selected 1 = “like” while 7.4% participants (2) selected 2 = “not sure” for statement 23. Furthermore, for statement 24, 66.7% participants (18) selected 1 = “like” while 33.3% participants (9) selected 2 = “not sure”. Lastly, for statement 25, majority of the participants (77.8%, 21 participants) selected 1 = “like” while only 22.2% (6 participants) selected 2 = “not sure”.

4.3.3. Section C: Devices in the Household

This section presents an overview of the data regarding the types of smart device owned in the household and how children in the household gain access to these smart devices.

4.3.3.1. Types of Smart Devices in the Household

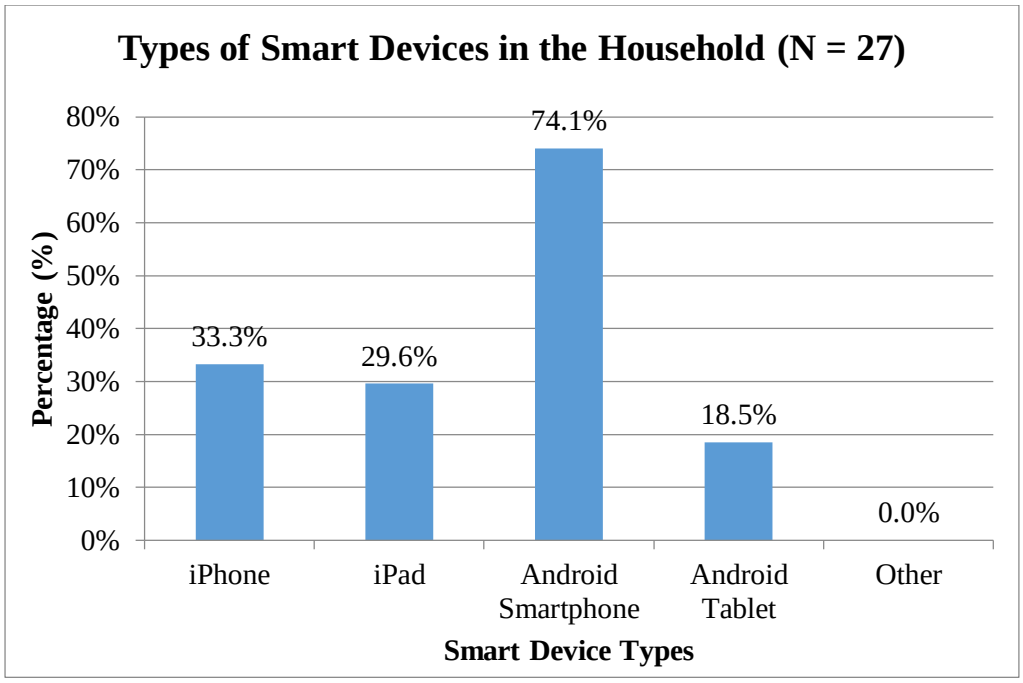


Figure 4.8: Type of smart devices in the household

The column chart in Figure 4.8 shows the data collected regarding the types of smart devices owned in the participants' households. The data collected also provide hints regarding the participants' smart device preferences. Based on Figure 4.8, it is revealed that Android smartphone was the most preferred smart device with 74.1% households (20), and then followed by iPhone at 33.3% households (9). Meanwhile, iPad ranked third with 29.6% households (8) and followed by Android Tablet in fourth place with 18.5% households (5). The reason why the sum of percentage exceeds 100% is because participants were

allowed to tick multiple types of devices as they may own several different types of smart devices.

4.3.3.2. Means of Accessing Smart Devices

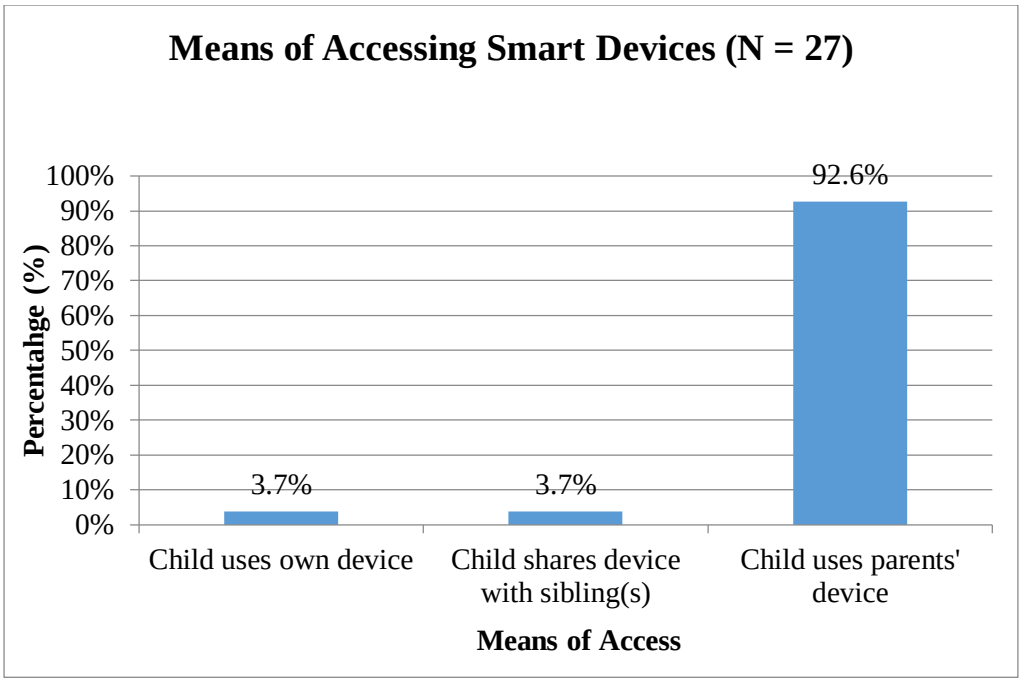


Figure 4.9: Means of Accessing Smart Devices in the Household

The column chart in Figure 4.9 shows the data regarding the means of how children gain access to smart devices in the household. Based on Figure 4.9, 92.6% or 25 parents responded that their children use smart devices belonging to them or their spouse while the percentage of parents selecting 1 = "child uses own device" and 2 = "child shares device with sibling(s)" is tied at 3.7% (1 parent) each respectively. This point out that majority of the child participants do not have their own devices and only gains access to smart devices should their parents allow them to play with their device.

4.4. Results of Observational Data Analysis

This section presents the results of the observational data collected during the evaluation study. As discussed in Chapter 3, the researcher focused the analysis of the observational data by group. Therefore, the observational data was sorted according to the participants' age and gender. After that, the data was organized according to three separate groups which include behavior, feedback and interaction with the educational app. Lastly, findings of the analysis of the observational data are presented.

Out of a total 27 participants, 55.6% participants (15) of the participants are female while 44.4% participants (12) are male participants (kindly refer to Table 4.1). Based on an age perspective, participants aged 6 years made up the majority of the sample with 59.3% (7 male and 9 female participants) followed by 5 years old participants at 37% (4 male and 6 female participants) and only one 8 years old participant at 3.7% (1 male participant) (kindly refer to Table 4.2). The findings for each category are presented in the following sections.

4.4.1. Behavior

During the conduct of the evaluation study, the researcher took note of each participant's behavior when interacting with the educational app. The findings are sorted by participants' gender while information regarding participants' age is described as follows.

Numerous behaviors were observed and recorded by the researcher during the evaluation study. Behaviors shown by the participants that were similar to one another were sorted, merged and represented by synonyms. Table

4.5 shows a list of behavior exhibited by the participants and their synonyms representations.

Table 4.5: Behavior observed and their synonyms

Behavior shown	**Synonym**
Shy	Shy
Absorbed in playing, intrigued, focused	Interested
Laughs happily, smiles	Happy
Enthusiastic, eager to play more	Excited
Slightly bored, distracted	Bored
Not so enthusiastic	Not excited

4.4.1.1. Male Participants

The total number of male participants is 12 where four of them are aged 5, seven of them are aged 6 and only one of them is aged 8. These participants were grouped according to their age. Among the 5 year old group, half of the participants were interested in playing with the educational app. Three out of four participants showed signs of happiness and excitement while playing the educational app while one participant was feeling bored playing the app.

For the 6 year old group, two participants were shy and hesitant to interact with the app during the evaluation study. One of the participants was excited and eager to play after some interaction with the app while the other participant was not so enthusiastic compared to the first. Most participants were interested in playing the app. Three participants were happy playing the app while three other participants lost some enthusiasm later during the evaluation study. In addition, one participant was slightly bored playing the app. Lastly, the 8 year old participant was feeling bored playing the app.

Based on the observational data, most participants of the 5 year old group enjoyed playing the app. However, the 6 year old group and the 8 years old participant did not enjoy the app as much as the 5 year old group. This may be due to the fact that the educational content of the app was too simple, and the animation and graphical elements used may be too childish.

4.4.1.2. Female Participants

The total number of female participants in the evaluation study is 15 where six of them are aged 5 and nine of them are aged 6. These female participants were grouped according to their age. Among the 5 year old group, most of the participants were interested and happy playing with the educational app. Besides, half of the participants were excited and eager to play more. However, one female participant was slightly bored playing the app and appear to be distracted.

For the 6 year old group, all of them find the educational app interesting as they were absorbed in playing. Besides, the participants were focused in spelling words. All the participants were happy playing the app as some had smiles across their faces while some laughed happily.

Based on the observational data, mostly all female participants of the 5 year old group were satisfied playing the educational app while one participant was bored. On the other hand, all the female participants of the 6 year old group were satisfied playing the app. This finding was contrary to the finding of the 6 year old and the 8 year old male participants as they were not as satisfied with the educational app as the 6 years old female participants.

4.4.2. Feedback

During the conduct of the evaluation study, the researcher took note of each participant's feedbacks regarding the educational app. The findings are sorted by participants' gender while information regarding participants' age is described as follows.

Both male and female participants provided little feedback during the evaluation study. Majority of the participants kept quiet during their interaction with the educational app. This may be due to participants being shy or uncomfortable in the presence of the researcher to express their opinions. The recorded feedback was presented in Table 4.6.

Table 4.6: Feedback from participants

No.	Feedbacks
1.	Likes the animation of the example
2.	Likes the animation of the app
3.	Feel it is too simple
4.	Likes the app overall

4.4.2.1. Male Participants

The total number of male participants is 12 where four of them are aged 5, seven of them are aged 6 and only one of them is aged 8. These participants were grouped according to their age. Out of 12 participants, half of participants kept quiet during the evaluation study and were all 6 year old.

All of the 5 year old participants stated they "like the animation of the example". One 6 year old participant said he "like the animation in the app". Lastly, the 8 year old participant mentioned he "feels that the app is too simple" but "overall, he likes the app".

Since there was not much feedback from the male participants, it is difficult to tell whether they were satisfied with the app or not. However, based on the feedback from the participants who responded, they did like and enjoyed the educational app.

4.4.2.2. Female Participants

The total number of female participants in the evaluation study is 15 where six of them are aged 5 and nine of them are aged 6. These female participants were grouped according to their age. Similar to the male participants, most of the female participants also kept quiet during the evaluation study. Only five out of 15 participants expressed their opinions regarding the educational app. These participants consist of six 6 year old participants and one 5 year old participant.

One 6 year old participant stated she "like the animation of the app". On the other hand, four 5 year old participants mentioned they "like the animation of the example". Due to the shortage of feedback provided, it is also difficult to conclude whether the female participants were satisfied with the educational app or not. However, based on the small amount of feedback recorded, the participants were satisfied and enjoyed the educational app.

4.4.3. Interaction with the Educational App

During the conduct of the evaluation study, the researcher observed how the participants interacted with the educational app as well as any problems faced during the interaction session. The findings are sorted by participants' gender while information regarding participants' age is described as follows.

Numerous observations were made by the researcher on the interaction between the participants and the educational app. The observed manner of interaction and problems faced by the participants are summarized in Table 4.7 below and discussed in the following sections.

Table 4.7: Observed manner of interaction and problems faced

Observed Manner of Interaction	**Observed Problems**
Good motor skills	Struggles slightly to change screens
Moderate motor skills	Accidentally rotated spelling area
No issues with touch screen interaction	Did not discover word definition example
Able to change screens easily	Slightly struggled at main menu
Able to select alphabets easily in the alphabets menu	Slightly struggled at alphabets selection menu
No issues spelling words	Struggled spelling long words - "Ferris Wheel", "Helicopter", and "Music Box"

4.4.3.1. Male Participants

Out of 12 male participants, four of them are aged 5, seven of them are aged 6 and only one of them is aged 8. These participants were grouped according to their age. Majority of the male participants in the evaluation study were observed to possess good motor skill. The participants were able to master the educational app in a short duration. In addition, all participants had no issue with touch screen interaction.

Although mostly all the participants had no issue spelling words, all four 5 year old participants slightly struggled in spelling longer words such as “helicopter” and “music box” while the 8 year old participant struggled spelling “Ferris wheel” on hard difficulty. Besides, majority of the 6 year old participants and the 8 year old participant had no problems changing screens. However, half of the 5 year old participants slightly struggled in changing screens.

Out of the 7 participants of the 6 year old group, only one participant slightly struggled at the main menu. For the 5 year old group, all of them faced no problem at the main menu. Besides, all the male participants were able to select alphabets easily at the alphabets menu. Three 6 year old and one 8 year old participant accidentally rotated the spelling area while spelling a word. Three participants including two 6 year old and one 8 year old recovered quickly while one 6 year old participant required guidance.

Unfortunately, mostly all male participants were not aware of the word definition example button located at the spelling completion menu except for one 6 year old participant who discovered it by accident. Based on the observational data, most male participants had no serious issues interacting with the educational app. Most participants were able to navigate through the app and spell words with ease.

4.4.3.2. Female Participants

Out of 15 female participants, six of them are aged 5 and nine of them are aged 6. These female participants were grouped according to their age. Similar to the male participants, mostly all the female participants were observed to possess good motor skills while three female participants had moderate motor skills. All female participants were able to master the educational app in a short time and had no problems interacting using touch screen.

Mostly all female participants faced no problems with spelling words. However, three 5 year old participants and two 6 year old participants slightly struggled in spelling longer words such as “Ferris wheel”. Based on the observational data, most female participants faced no problem changing screens except for one 6 year old participant who slightly struggled.

Regarding navigating the main menu and the alphabets selection menu, only one 6 year old female participant slightly struggled while eight other participants had no issue. The issue of accidentally rotating the spelling area occurred with female participants as well. The issue happened to three female participants including two 5 year old and one 6 year old who recovered quickly on their own.

The female participants were also not aware of the word definition example button located at the spelling completion menu. Based on the observational data, majority of the female participants also faced no alarming problems using the educational app. Mostly all female participants were able to navigate through the app and spell words with ease.

4.5. Results of Hypothesis Testing

Previously in Chapter 1, three hypotheses were formulated in order to validate the research objectives. The results of each hypothesis testing are presented in this section.

4.5.1. Hypothesis 1 (H1)

The following null hypothesis was tested:

$H_0$1: The survey questionnaire formulated is not applicable to the evaluation of educational apps for Malaysian children.

As discussed in Chapter 3, descriptive statistics were used to test the validity of $H_0$1. Mean, standard deviation, frequency and percentage are used to measure the extent of the survey questionnaire's applicability in evaluating children's educational apps by determining the number of participants who agreed or disagreed with each statement in Section A (S1 - S6; NC1 - NC5; FH1 - FH5) and Section B (EoU1 - EoU9).

4.5.1.1. Testing Null Hypothesis 1 ($H_0$1)

Table 4.8 shows the means and standard deviation computed for each of the statements in Section A and B of the survey questionnaire. Section A includes statements pertaining to the educational app's Screen design, Navigation and Control design, and Feedback and Help provided. On the other hand, section B consists of statements pertaining to participants' overall satisfaction.

Based on the results shown in Table 4.8, the mean score range for Screen statements are from 2.59 to 3.00. As for Navigation and Control statements, the mean score ranges from 2.70 to 3.00. The mean score range for Feedback and Help statements are from 2.85 to 3.00. Lastly, the mean score range for Ease of Use statements range from 2.67 to 3.00. The mean scores projected for each of the four constructs' statements are above the midpoint (1.5) of the 3-point Likert scale.

Table 4.9 presents the frequency and percentages of participants' responses for each statement in Section A and B. Majority of the statements received positive responses (1 = "like") from the participants. Based on the results in Table 4.8, the findings indicate that the formulated survey questionnaire possess a high degree of applicability toward the evaluation of the educational app, PiKidz ABC Play. Hence, there is sufficient evidence to reject $H_0$1.

Table 4.8: Descriptive statistics of statements in Section A and B (N = 27)

Screen	**Mean**	**Std. Deviation**
S1: Design of menu is simple	3.00	0.00
S2: Screen design is pretty and simple	3.00	0.00
S3: Buttons are large and easy to select	3.00	0.00
S4: Buttons in the app works when touched	3.00	0.00
S5: Animation and picture used makes learning fun	2.59	0.50
S6: Sound used in the app makes learning easy	2.81	0.40
Navigation and Control	**Mean**	**Std. Deviation**
NC1: Using menus to go to other screens is simple	3.00	0.00
NC2: Using menus and buttons to go to other screens is easy	2.70	0.47
NC3: Buttons such as next and back buttons are placed in the same place for each screen	3.00	0.00
NC4: Learning using the app is easy	2.93	0.27
NC5: Using the app to play games is simple	2.93	0.27
Feedback and Help	**Mean**	**Std. Deviation**
FH1: Responses given by app is clear and helpful	2.89	0.32
FH2: Help given is useful to me.	2.89	0.32
FH3: Clues given are clear and helpful.	3.00	0.00
FH4: I know where I am now and where to go next	2.85	0.36
FH5: I am clear of what tasks to finish and how to finish them	3.00	0.00
Ease of Use	**Mean**	**Std. Deviation**
EoU1: Loading time is short	3.00	0.00
EoU2: Animations in the app can be skipped or stopped	3.00	0.00
EoU3: Use of simple words	3.00	0.00
EoU 4: Language used is simple	3.00	0.00
EoU5: Mistakes made can be easily recovered	3.00	0.00
EoU6: Learning how to use the app is easy	2.96	0.19

Table 4.8 (Continued)

EoU7: I can remember how to use the app with ease	2.93	0.27
EoU8: I feel happy learning with the app	2.67	0.48
EoU9: It is fun to learn using the app	2.78	0.42

Table 4.9: Frequency and Percentage of responses for Section A and B (N= 27)

Screen	**Response**	**Frequency**	**Percentage (%)**
S1: Design of menu is simple	Like	27	100
	Not Sure	0	0
	Dislike	0	0
S2: Screen design is pretty and simple	Like	27	100
	Not Sure	0	0
	Dislike	0	0
S3: Buttons are large and easy to select	Like	27	100
	Not Sure	0	0
	Dislike	0	0
S4: Buttons in the app works when touched	Like	27	100
	Not Sure	0	0
	Dislike	0	0
S5: Animation and picture used makes learning fun	Like	16	59.3
	Not Sure	11	40.7
	Dislike	0	0
S6: Sound used in the app makes learning easy	Like	22	81.5
	Not Sure	5	18.5
	Dislike	0	0
Navigation and Control	**Response**	**Frequency**	**Percentage (%)**
NC1: Using menus to go to other screens is simple	Like	27	100
	Not Sure	0	0
	Dislike	0	0

Table 4.9 (Continued)

NC2: Using menus and buttons to go to other screens is easy	Like	19	70.4
	Not Sure	8	29.6
	Dislike	0	0
NC3: Buttons such as next and back buttons are placed in the same place for each screen	Like	27	100
	Not Sure	0	0
	Dislike	0	0
NC4: Learning using the app is easy	Like	25	92.6
	Not Sure	2	7.4
	Dislike	0	0
NC5: Using the app to play games is simple	Like	27	92.6
	Not Sure	0	7.4
	Dislike	0	0
Feedback and Help	**Response**	**Frequency**	**Percentage (%)**
FH1: Responses given by app is clear and helpful	Like	24	88.9
	Not Sure	3	11.1
	Dislike	0	0
FH2: Help given is useful to me.	Like	24	88.9
	Not Sure	3	11.1
	Dislike	0	0
FH3: Clues given are clear and helpful.	Like	27	100
	Not Sure	0	0
	Dislike	0	0
FH4: I know where I am now and where to go next	Like	23	85.2
	Not Sure	4	14.8
	Dislike	0	0
FH5: I am clear of what tasks to finish and how to finish them	Like	27	100
	Not Sure	0	0
	Dislike	0	0
Ease of Use	**Response**	**Frequency**	**Percentage (%)**
EoU1: Loading time is short	Like	27	100
	Not Sure	0	0
	Dislike	0	0

Table 4.9 (Continued)

EoU2: Animations in the app can be skipped or stopped	Like	27	100
	Not Sure	0	0
	Dislike	0	0
EoU3: Use of simple words	Like	27	100
	Not Sure	0	0
	Dislike	0	0
EoU4: Language used is simple	Like	27	100
	Not Sure	0	0
	Dislike	0	0
EoU5: Mistakes made can be easily recovered	Like	27	100
	Not Sure	0	0
	Dislike	0	0
EoU6: Learning how to use the app is easy	Like	26	96.3
	Not Sure	1	3.7
	Dislike	0	0
EoU7: I can remember how to use the app with ease	Like	25	92.6
	Not Sure	2	7.4
	Dislike	0	0
EoU8: I feel happy learning with the app	Like	18	66.7
	Not Sure	9	33.3
	Dislike	0	0
EoU9: It is fun to learn using the app	Like	21	77.8
	Not Sure	6	22.2
	Dislike	0	0

4.5.2. Hypothesis 2 (H2)

The following null hypothesis was tested:

$H_0$2: Gender of child participants has no significant effect on the applicability of the survey questionnaire in the evaluation of educational apps for children.

As discussed in Chapter 3, independent samples t-test was used to test the validity of $H_0$2. An independent samples t-test was conducted to compare the effect of the participants' gender on survey questionnaire's extent of applicability in the evaluation of educational apps for Malaysian children. The results of the independent samples t-test are presented in Table 4.11.

4.5.2.1. Testing Null Hypothesis 2 (H_20)

Based on the results of the independent samples t-test obtained in Table 4.11, the gender of male participants (M = 2.89, SD = 0.15) and female participants (M = 2.91, SD = 0.11) had no effect on the applicability extent of the Screen statements, t(27) = 0.654. Besides, the participants' gender, male (M = 2.92, SD = 0.10) and female (M = 2.91, SD = 0.15) did not had no effect on the applicability extent of the Navigation and Feedback statements, t(27) = 0.845.

As for Feedback and Help statements, the gender of male participants (M = 2.98, SD = 0.06) and female participants (M = 2.88, SD = 0.25) had no effect toward its applicability extent in evaluating educational apps, t(27) = 0.139. The reason behind Feedback and Help's t(27) = 0.139 instead of t(27) = 0.172 was because it had violated the assumption of equal variance by failing Levene's test, where its significant value (p = 0.001) is larger than 0.05.

Lastly, gender of male (M = 2.93, SD = 0.99) and female (M = 2.93, SD = 0.14) participants also had no effect on the Ease of Use statements toward the evaluation of educational apps. t(27) = 1.000. The values obtained for all four constructs were larger (p > 0.05) than the statistical significance level. The results suggest that the participants' gender had no significant effect on the survey questionnaire's extent of applicability in evaluating educational apps. Hence, there was insufficient evidence to reject $H_0$2.

Table 4.10: Descriptive statistics for Screen, Navigation and Control, Feedback and Help, and Ease of Use statements (N = 27)

	Participant Gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Screen	Male	12	2.8889	.14794	.04271
	Female	15	2.9111	.10666	.02754
Navigation and Control	Male	12	2.9167	.10299	.02973
	Female	15	2.9067	.14864	.03838
Feedback and Help	Male	12	2.9833	.05774	.01667
	Female	15	2.8800	.24842	.06414
Ease of Use	Male	12	2.9259	.09863	.02847
	Female	15	2.9259	.14344	.03704

Table 4.11: T-test results for gender and Screen, Navigation and Control, Feedback and Help, and Ease of Use statements (N = 27)

		Levene's Test for Equality of Variance		T-test for Equality of Means		
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
Screen	Equality assumed	3.181	0.087	-0.454	25	0.654
	Equality not assumed			-0.437	19.413	0.667
Navigation and Control	Equality assumed	1.539	0.226	0.198	25	0.845
	Equality not assumed			0.206	24.579	0.839
Feedback and Help	Equality assumed	12.909	0.001	1.406	25	0.172
	Equality not assumed			1.559	15.862	0.139
Ease of Use	Equality assumed	0.641	0.431	0.000	25	1.000
	Equality not assumed			0.000	24.532	1.000

4.5.3. Hypothesis 3 (H3)

The following null hypothesis was tested:

$H_0$3: Age of child participants has no significant effect on the applicability of the survey questionnaire in the evaluation of educational apps for children.

As previously discussed in Chapter 3, one-way Analysis of Variance (ANOVA) test was used to test the validity of $H_0$3. A one-way between subjects of ANOVA was conducted to compare the effect of participants' age on the survey questionnaire's extent of applicability in the evaluation of educational apps. The results of the independent samples t-test are presented in Table 4.12.

4.5.3.1. Testing Null Hypothesis 3 ($H_0$3)

From the results of the one-way between subjects ANOVA test presented in Table 4.12, participants' age had no effect on the Screen statements' extent of applicability in evaluating educational apps [$F(2, 24) = 0.50$, $p = 0.613$]. In addition, age of participants had no effect on the Navigation and Control statements' extent of applicability in evaluating educational apps [$F(2, 24) = 0.26$, $p = 0.771$].

Besides, there was no significant effect of participants' age on the Navigation and Control's extent of applicability in evaluating educational apps [$F(2, 24) = 1.41$, $p = 0.265$]. Lastly, there was also no significant effect of participants' age on the applicability extent of Ease of Use statements [$F(2, 24) = 2.60$, $p = 0.097$]. The values obtained for all four constructs were larger ($p > 0.05$) than the statistical significance level. The results obtained suggest that participants' age had no significant effect on the survey questionnaire's extent of applicability in evaluating educational apps for children. Hence, there was insufficient evidence to reject $H_0$3.

Table 4.12: ANOVA test results for age and Screen, Navigation and Control, Feedback and Help, and Ease of Use statements (N = 27)

		Sum of Squares	df	Mean Square	F	Sig.
Screen	Between Groups	0.016	2	0.008	0.500	0.613
	Within Groups	0.387	24	0.016		
Navigation and Control	Between Groups	0.009	2	0.005	0.263	0.771
	Within Groups	0.418	24	0.017		
Feedback and Help	Between Groups	0.102	2	0.051	1.405	0.265
	Within Groups	0.870	24	0.036		
Ease of Use	Between Groups	0.070	2	0.035	2.580	0.097
	Within Groups	0.325	24	0.014		

4.6. Summary of Hypotheses Testing

Based on the results of the hypotheses testing presented in the previous sections, only one out of three null hypotheses tested (i.e., $H_0$1) was successfully rejected. Since $H_0$1 was tested using descriptive analysis, it was successfully rejected because the mean score range for each statements of the four constructs (i.e., Screen, Navigation and Control, Feedback and Help, and Ease of Use) were larger than the midpoint (1.5) of the 3-point Likert scale.

On the other hand, the two other hypotheses ($H_0$2 and $H_0$3) were not able to be rejected. This is due to the fact that the p-values obtained for $H_0$2 (Screen = 0.654; Navigation and Control = 0.845; Feedback and Help = 0.139; Ease of Use = 1.000) and $H_0$3 (Screen = 0.613; Navigation and Control = 0.771; Feedback and Help = 0.265; Ease of Use = 0.097) were all larger than the 0.05 significance level. Therefore, there was not enough evidence for the researcher

to reject the null hypotheses. The results of the hypotheses testing were summarized in Table 4.13 below.

Table 4.13: Summary of the results of hypotheses testing

Null Hypothesis	**Decision**
$H_0$1: The survey questionnaire formulated is not applicable to the evaluation of educational apps for Malaysian children.	**Rejected $H_0$1** The findings showed that the survey questionnaire formulated is applicable to the evaluation of educational apps for Malaysian children.
$H_0$2: Gender of child participants has no significant effect on the applicability of the survey questionnaire in the evaluation of educational apps for children.	**Failed to reject $H_0$2** The findings showed that participants' gender had no significant effect on the survey questionnaire's applicability to the evaluation of educational apps for children.
$H_0$3: Age of child participants has no significant effect on the applicability of the survey questionnaire in the evaluation of educational apps for children.	**Failed to reject $H_0$3** The findings showed that participants' age had no significant effect on the survey questionnaire's applicability to the evaluation of educational apps for children.

4.7. Conclusion

In conclusion, this chapter presented all the major findings of this research resulting from the analysis of data collected during the evaluation study using survey questionnaire and direct observation. The major findings resulting from the data analysis include the results of analysis on the participants' demographic data, the results of descriptive analysis performed on the data collected, and the results of observational data analysis as well as the results of hypotheses testing using descriptive and inferential analysis methods. From the results of hypotheses testing, only one null hypothesis was successfully rejected while there was no sufficient evidence to reject the other two null hypotheses. The major findings in this chapter are further discussed in the next and final chapter of this research.

CHAPTER 5 DISCUSSION AND CONCLUSIONS

5.1. Introduction

This chapter discusses the following sections:

- Discussion on research outcomes
- Research contributions
- Limitations and recommendations for future work

5.2. Discussion on Research Outcomes

Five objectives were formulated for this research previously in Chapter 1. Overall, all the objectives shown below were achieved successfully and discussed in the following subsections.

1. Study and evaluate design guidelines and heuristics proposed by international researchers to produce a consolidated children's educational apps design guideline.
2. Identify and evaluate three suitable educational apps developed by Malaysian developers to be used in the evaluation study with children aged between 4 to 8 years old.
3. Formulate a survey questionnaire based on the consolidated design guideline for evaluating educational apps identified.
4. To discover the extent of how applicable the survey questionnaire are towards the evaluation of Malaysian children's educational apps.

5. To examine the effects of age and gender of young children on the survey questionnaire's extent of applicability in the evaluation of Malaysian children's educational apps.

Besides, research outcomes obtained from the analysis of data collected and testing of hypotheses in Chapter 4 are further discussed in the following subsections.

5.2.1. Objective 1

Through a study of literature in Chapter 2, six key design guidelines and heuristics for the design of Malaysian children's educational apps are identified. The six identified design guidelines and heuristics include three heuristics (i.e., Nielsen's Ten Usability Heuristics, Norman's Design Principle for Usability and Shneiderman's Eight Golden Rule of Interface Design) and three design guidelines (i.e., Magic or Dust Design Guideline, Playability Heuristics and MOE Design Guideline).

After studying and evaluating these six design guidelines and heuristics, the researcher consolidated the design guidelines and heuristics into a single design guideline with four categories of design principles (see Table 2.6). The four categories are Screen, Navigation and Control, Help and Feedback, and Ease of Use. The reason behind the consolidation of the design guidelines and heuristics was because all six design guidelines and heuristics proposed by international researchers did not suit the design of children's educational apps as three heuristics (i.e., Nielsen's Ten Usability Heuristics, Norman's Design

Principle for Usability and Shneiderman's Eight Golden Rule of Interface Design) were originally proposed for the design of computer software. Although these heuristics were proposed nearly 30 years ago, most design principles were found to be adaptable to the design of educational apps

Besides, the remaining three design guidelines also did not suit the design of children's educational apps. The Magic or Dust design guideline was also originally proposed for the design of children's computer software. Alternatively, the Playability Heuristics was proposed for the design of mobile games while the MOE design guideline was proposed for the design of interactive courseware for Malaysian primary and secondary students. However, the design principles were also found to be adaptable in the design of educational apps for Malaysian children.

5.2.2. Objective 2

The second objective of this research was to identify and evaluate three locally developed educational apps to be used in the evaluation study. After an extensive search for locally developed educational apps for young children on the App Store and the web, the researcher reviewed and considered multiple educational apps for Malaysian children and chose three educational apps, which included an alphabet learning app, PiKidz ABC Play, a basic fractions teaching app, Zap Zap Fractions, and a drawing and storytelling app, Princess Drawsalot & the Dragon. All three apps are offered free on the App Store with in-app purchases.

The researcher evaluated the three educational apps and found that PiKidz ABC Play was most suited to be used in the evaluation study compared to the other two educational apps. Out of 16 design principles compiled in Table 2.6, PiKidz ABC Play had the least violation with only three violations compared to Zap Zap Fractions and Princess Drawsalot & the Dragon with five violations each. Hence, PiKidz ABC Play was selected to be used in the evaluation study with the participants. A summary of the evaluation is presented in Table 2.7.

5.2.3. Objective 3

The third objective of this research was to formulate a survey questionnaire to evaluate children's educational apps based on the consolidated design guideline (see Table 2.6). Through reviewing other reputable questionnaires such as Questionnaire for User Interface Satisfaction (QUIS) and USE Questionnaire, the researcher had formulated a survey questionnaire consisting of both closed-ended and open-ended questions, with a total of 30 questions grouped in four sections (see Appendix B).

Section A measures the educational app's usability pertaining to Screen, Navigation and Control, and Feedback and Help statements. Meanwhile, Section B measures the user's overall experience interacting with the educational apps with Ease of Use statements. Statements in sections A and B are formulated using a combination of 3-point Likert scale and Visual Analogue Scale (VAS) consisting of responses 1 = "Like", 2 = "Not Sure" and 3 = "Dislike" that are represented by smiley faces.

On the other hand, section C collects data regarding the type of smart devices owned in the household and how children gain access to these devices. Lastly, section D collects the participants' demographic data such as participants' age and gender. In order to ensure the validity of the statements formulated, Gunning-Fog Index readability test was conducted on the questionnaire statements. Furthermore, the survey questionnaire was pilot tested with three children. The researcher made amendments to the statements according to the participants' feedback.

5.2.4. Objective 4

The fourth objective of this research was to discover the extent of how applicable the formulated survey questionnaire is to the evaluation of educational apps for Malaysian children. In order to achieve this objective, $H_0 1$ was formulated and tested. A summary of the results is presented in Table 4.8 and 4.9.

Based on the results of the hypothesis testing using descriptive statistics, the average mean score obtained for each Screen, Navigation and Control, Feedback and Help, and Ease of Use statements were all above the midpoint (1.5) of the 3-point Likert scale (see Table 4.8). The results indicate that the survey questionnaire had a high degree of applicability in the evaluation of educational apps for Malaysian children. Table 5.1 shows the average mean score and the standard deviation of all four constructs' statements. Thus, there was sufficient evidence to reject $H_0$1.

Table 5.1: Mean score and standard deviation of Screen, Navigation and Control, Feedback and Help, and Ease of Use statements

Construct	Mean	Std. Deviation
Screen	2.90	0.12
Navigation and Control	2.91	0.13
Feedback and Help	2.93	0.19
Ease of Use	2.93	0.12

5.2.5. Objective 5

The fifth objective formulated for this research was to examine the effects of participants' age and gender towards the survey questionnaire's degree of applicability in evaluating Malaysian children's educational apps. Hence, two null hypotheses, $H_0$2 and $H_0$3 were formulated and tested using independent t-test and one-way ANOVA.

The results of $H_0$2 testing using independent t-test is shown in Table 5.2. The p-values obtained from the test were all larger than the significance level of 0.05. Screen statements had a p-value of 0.654 while Navigation and Control statements had a p-value of 0.845. Meanwhile, Feedback and Help statements had a p-value of 0.139 while Ease of Use statements had a p-value of 1.000. Hence, there was insufficient evidence to reject $H_0$2.

The results of H03 testing using one way ANOVA is shown in Table 5.3. The p-values obtained from the test were also larger than the significance level of 0.05. Screen statements had a p-value of 0.651 while Navigation and Control statements had a p-value of 0.771. Feedback and Help statements had a p-value of 0.265 while Ease of Use statements had a p-value of 0.097. Hence, there was not enough evidence to reject $H_0$3.

Based on the results of the hypothesis testing, it was discovered that the age and gender of participants did not had any significant effects on the survey questionnaire's degree of applicability. Thus, the results point out that the survey questionnaire formulated is applicable towards the evaluation of Malaysian children's educational apps regardless of the age and gender of the end users.

Table 5.2: Results of $H_0$2 testing using independent t-test

Construct	Significance (2-tailed)
Screen	0.654
Navigation and Control	0.845
Feedback and Help	0.139
Ease of Use	1.000

Table 5.3: Result of $H_0$3 testing using one way ANOVA

Construct	Significance (2-tailed)
Screen	0.481
Navigation and Control	0.791
Feedback and Help	0.210
Ease of Use	0.151

5.3. Research Contributions

This research study will be able to make several potential contributions to the area of development of children's educational apps. First, the research findings would potentially contribute towards the development of better educational apps for Malaysian children. The formulation of the survey questionnaire based on the consolidated design guideline would potentially be able to help evaluate and help differentiate well designed educational apps from the poorly designed ones.

Second, the findings of this research will be able to contribute to the process of addressing the various concerns faced by parents when selecting suitable educational apps for their children (see Section 1.2). Besides, this research would be able to potentially contribute to the body of literature on the area regarding design guidelines and heuristics as well as the evaluation of educational apps for children.

Lastly, this research would serve as reference for other further researchers in their researches in this area. Furthermore, future researchers could use this research as a base to further expand the scope and scale of their research.

5.4. Limitations and Recommendations

As previously mentioned in Chapter 3, this research is heavily constrained by time and resources. Therefore, this current research had multiple limitations to be addressed. In addition, recommendations for future researches are also provided.

First, the sampling method used for this research is purposive sampling. Purposive sampling is a type of non-probability sampling method that does not ensure every individual of a population an equal chance of being selected. Since this research utilized non-probability sampling method, it will cause other researchers to question the validity and the generalizability of this research.

Thus, it is recommended to employ probability sampling methods to greatly enhance the validity and generalizability of the research study.

Second, the age of the participants leaned more towards 5 and 6 year old in the evaluation study. There is only one 8 year old participant while there are no 4 year old and 7 year old participants (kindly refer to figure 4.2). The outcome of this research study may greatly differ if there was an equal distribution of participants aged between 4 to 8 years old. Therefore, it is recommended for future researchers to allocate equal amount of participants of different age to ensure equal distribution of samples.

Third, the researcher may not be adept at recording data through the direct observation method. As previously mentioned by Stone et al. (2005), direct observation only allows a single pass at the information gathering. Thus, the researcher may have missed vital information during the evaluation study.

Fourth, the outcome of this research may be subjected to bias of the parents and the researcher. During the completion of the survey questionnaire, parents may have interpreted and explained the statements to the participants according to their biases. Alternatively, the researcher may also have taken observational notes of the participants with a certain degree of bias.

Lastly, the presence of the researcher may have also influenced how the participants behaved throughout the evaluation study. Hence, it is recommended to have two or more observers observing a single participant. This would allow the observers to be able to compare observational notes to ensure and increase the validity of the data gathered.

5.5. Conclusion

The field of mobile app development has experienced a rapid growth over the recent years. As of July 2014, Google's Play Store had approximately 1.3 million apps compared to 1.2 million apps in the Apple's App Store (Statista Inc., 2014). Hence, mobile app development is expected to sustain its growth in many future years to come. Besides, statistics from Common Sense Media (2011) indicate that more than 5 out of 10 American children have access to smart devices at home. Thus, young children nowadays have become a part of proficient users of smart devices.

Six key design guidelines and heuristics were identified and analyzed. Then, the design principles from the six identified design guidelines and heuristics were compiled and consolidated into a single design guideline (see Table 2.6). Based on the consolidated design guideline, a survey questionnaire was formed based on the design principles. A total of 27 participants were surveyed, observed and their responding data collected.

This research intended to discover the extent of the survey questionnaire's applicability as well as the effects of participants' gender and age toward the evaluation of Malaysian children's educational apps. The findings indicate that the survey questionnaire had a high degree of applicability towards the evaluation of Malaysian children's educational apps. Thus, there was sufficient evidence to reject $H_0$1. On the other hand, the findings indicate that the participants' gender and age had no significant effect on the survey questionnaire's degree of applicability in evaluating children's educational apps. Hence, $H_0$2 and $H_0$3 were failed to be rejected due to insufficient evidence.

Other findings of the research include:

- Most participants' parents are high school graduates (33.3%) followed by college diploma holders (29.6%), bachelor degree graduates (25.9%), master's degree graduates (7.4%) and doctoral degree graduates (3.7%).
- Majority of the participants (74.1%) owned Android smartphone followed by iPhone (33.3%), iPad (29.6%) and Android tablet (18.5%).
- Majority of the participants (92.6%) use smart devices belonging to their parents while 3.7% of the participants have their own smart device and 3.7% of the participants share a smart device with their sibling(s).
- From observing the male participants, 5 year old participants enjoy playing the educational app but 6 year old participants found it less enjoyable. Lastly, the 8 year old participant liked the app, however was bored as he found the app to be too simple.

- Based on observation on female participants, both 5 and 6 year old participants enjoyed playing the educational app.
- Mostly all male and female participants were reluctant in expressing their opinions regarding the educational app.
- Majority of the male participants possessed good motor skills and had no issue with touch screen interaction. Besides, mostly all participants were able to navigate the app with ease. However, a minor amount of participants slightly struggled with spelling long words.
- Mostly all female participants had good motor skills and faced no issue with touch screen interaction. In addition, mostly all participants were able to navigate the app with ease. However, a minor amount of participants slightly struggled with spelling long words.

In conclusion, children in this modern age are regular users of smart device. Based on the findings of this research, children as young as 5 year old are already proficient in the usage of smart devices. Therefore, parents need to be informed in order to be able to protect their children from the problems mentioned earlier. The findings of this research may potentially contribute to solving the problems faced as well as contributing to the development of better quality educational apps. App developers should aim to develop high quality educational apps for Malaysian children.

REFERENCES

Adler, E. and Clark, R. 2007. *An invitation to social research*. 3rd ed. Belmont, CA: Wadsworth.

Al-Fahad, F. N., 2009. Students' attitudes and perceptions towards the effectiveness of mobile learning in King Said University, Saudi Arabia. *Turkish Online Journal of Educational Technology, 8(2)*.

Ali, S. N., 2013. *What is a mobile application!* [Online]. Available at: http://www.socialhunt.net/blog/types-of-mobile-app/ [Accessed: 21 March 2014]

AppAnnie, 2015. *iOS Top App Charts Malaysia - Kids*. [Online]. Available at: http://www.appannie.com/apps/ios/top/malaysia/kids/?device=ipad [Accessed: 18 January 2015].

AppArcadeStore, 2014. *App Store Arcade | Pikidz ABC Play (iOS)*. [Online]. Available at: http://www.appstorearcade.com/2014/11/13/pikidz-abc-play-ios/ [Accessed: 19 January 2015].

Apple Inc., 2014. *App Store Review Guidelines - App Store Resource Center*. [Online].
Available at: https://developer.apple.com/appstore/resources/approval/guidelines.html#functionality [Accessed: 19 Aug. 2014].

Arlington, M., 2008. *iPhone App Store has launched (Updated).* [Online]. Available at: http://techcrunch.com/2008/07/10/app-store-launches-upgrade-itunes-now/ [Accessed: 8 March 2014]

BBC, 2014. *Parents unaware of smartphone danger*. [Online]. Available at: http://www.bbc.com/news/technology-26121434 [Accessed: 3 January 2015].

Barendregt, W., Bekker, M.M., Bouwhuis, D.G., & Baauw, E. (2006). Identifying usability and fun problems in a computer game during first use and after some practice. *International Journal of Human-Computer Studies, 64*(9), 830-846.

Barendregt, W., Bekker, M., and Baauw, E., 2008. Development and evaluation of the problem identification picture cards method. *Cognition, Technology & Work, 10(2), pp.95--105.*

Budiu, R., 2013. *Mobile: Native apps, web apps, and hybrid apps*. [Online]. Available at: http://www.nngroup.com/articles/mobile-native-apps/ [Accessed: 21 March 2014].

Budiu, R, and Nielsen, J., 2010. *iPad usability: first findings from user testing.* [Online]. Available at: http://www.nngroup.com/articles/ipad-usability-first-findings/ [Accessed: 8 March 2014]

Budiu, R, and Nielsen, J., 2011. *iPad usability: Year one.* [Online]. Available at: http://www.nngroup.com/articles/ipad-usability-year-one/ [Accessed: 8 March 2014]

Campbell, A., 2011. *What the heck is an "app"?* [Online]. Available at: http://smallbiztrends.com/2011/03/what-is-an-app.html [Accessed: 8 March 2014]

Cherry, K., 2014a. *The 4 stages of cognitive development in children*. [Online]. Available at: http://psychology.about.com/od/piagetstheory/a/keyconcepts.htm [Accessed: 15 Oct. 2014].

Cherry, K., 2014b. *What Is the Preoperational Stage of Cognitive Development?* [Online] Available at:http://psychology.about.com/od/piagetstheory/p/preoperational.htm [Accessed: 31 December 2014].

Chin, J.P., Diehl, V.A., and Norman, K.L., 1988. Development of an Instrument Measuring User Satisfaction of the Human-Computer Interface. *Proceedings of ACM CHI'88 Conference on Human Factors in Computing Systems,* 1988, p.213-218

Common Sense Media, 2011. *Zero to eight: Children's media use in America* [Online]. Available at: http://www.commonsensemedia.org/sites/default/files/research/zerotoeightfinal2011.pdf [Accessed: 8 March 2014]

Corbeil, J. R., 2007. *Are you ready for mobile learning?* [Online]. Available at: http://www.educause.edu/ero/article/are-you-ready-mobile-learning [Accessed: 20 March 2014]

Creswell, J. and Clark, V.L.P., 2007. Designing and conducting mixed methods research. *Thousand Oaks, Calif.: SAGE Publications.*

Cutlack, G., 2013. *What are apps and how do they work with your smartphone?* [Online]. Available at: http://www.techradar.com/news/phone-and-communications/mobile-phones/what-are-apps-and-how-do-they-work-with-your-smartphone--1141429 [Accessed: 8 March 2014]

Davis, C., 2013. *Is That App-propriate? How to Protect Kids on Mobile Devices - ParentMap.* [Online] Available at: https://www.parentmap.com/article/is-that-app-propriate-how-to-protect-kids-on-mobile-devices [Accessed: 3 January 2015].

Evans, C., 2008. The effectiveness of m-learning in the form of podcast revision lectures in higher education. *Computers & education*, 50(2), 491-498.

Gauchet, S., 2014. *App Store Optimization (ASO): Improve Your App Ratings*. [Online]. Available at: http://www.apptamin.com/blog/app-store-optimization-app-ratings/ [Accessed: 19 Aug. 2014].

Google Scholar, 2015a. *Google Scholar - Iterative user-interface design* [Online] Available at:https://scholar.google.com/citations?view_op=view_citation&hl=en&user=h-2JebwAAAAJ&citation_for_view=h-2JebwAAAAJ:5nxA0vEk-isC [Accessed: 2 May 2015].

Google Scholar, 2015b. *Google Scholar Citations - The design of everyday things* [Online] Available at: https://scholar.google.com/citations?view_op=view_citation&hl=en&user=h-2JebwAAAAJ&citation_for_view=h-2JebwAAAAJ:5nxA0vEk-isC [Accessed: 2 May 2015].

Google Scholar, 2015c. *Google Scholar Citations - Designing the user interface-strategies for effective human-computer interaction* [Online] Available at: https://scholar.google.com/citations?view_op=view_citation&hl

=en&user=h4i4fh8AAAAJ&citation_for_view=h4i4fh8AAAAJ:q09DtPQ_434C [Accessed: 2 May 2015].

Google Scholar, 2015d. *Google Scholar Citations - Child development 101 for the developers of interactive media* [Online] Available at: https://scholar.google.com/citations?view_op=view_citation&hl=en&user=lpk2HgoAAAAJ&citation_for_view=lpk2HgoAAAAJ:zYLM7Y9cAGgC

Google Scholar, 2015e. *Google Scholar Citations - Playability heuristics for mobile games* [Online] Available at: https://scholar.google.com/citations?view_op=view_citation&hl=en&user=RFFDEu4AAAAJ&citation_for_view=RFFDEu4AAAAJ:b0M2c_1WBrUC [Accessed: 2 May 2015].

Gordon, J, 2010. *Useful design tips for your iPad app.* [Online]. Available at: http://mobile.smashingmagazine.com/2010/04/16/design-tips-for-your-ipad-app/ [Accessed: 24 March 2014]

iTunes, 2014a. *Pikidz ABC Play*. [Online] Available at: https://itunes.apple.com/us/app/pikidz-abc-play/id895336932?mt=8 [Accessed: 19 January 2015].

iTunes, 2014b. *Zap Zap Fractions: Virtual Fraction Tutor*. [Online]. Available at: https://itunes.apple.com/us/app/zap-zap-fractions- virtual/id865942865?mt=8 [Accessed: 19 January 2015].

iTunes, 2014c. *Princess Drawsalot & the Dragon*. [Online]. Available at: https://itunes.apple.com/my/app/princess-drawsalot-dragon/id768249259?mt=8 [Accessed: 19 January 2015].

Kamaruddin, N., 2012. Interface design in interactive science courseware for the Malaysian Smart School Project. *Basic Research Journal of Education Research and Review,* pp. 140-127.

Korhonen, H., and Koivisto, E.M., 2006. Playability heuristics for mobile games. In: *Proceedings of the 8th conference on Human-computer interaction with mobile devices and services* (pp. 9-16). ACM.

Kukulska-Hulme, A., 2005. Mobile usability and user experience. *Mobile Learning: A handbook for educators and trainers,* 45-56.

Lee, M., 2014. *Parents ask: Why is it so hard to find good apps?* [Online]. Available at: http://www.joanganzcooneycenter.org/2014/12/09/parents-ask-why-is-it-so-hard-to-find-good-apps/ [Accessed: 30 December 2014].

Lund, A.M., 2001. Measuring Usability with the USE Questionnaire. *STC Usability SIG Newsletter, 8:2.*

Lund Research Ltc, 2013. *Understanding Descriptive and Inferential Statistics*. [Online]. Available at: https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php [Accessed: 28 January 2015].

Malone, T. W., and Lepper, M. R., 1987. Making learning fun: A taxonomy of intrinsic motivations for learning. *Aptitude, learning, and instruction*, 3, 223-253.

MacFarlane, S., Sim, G. and Horton, M., 2005. Assessing usability and fun in educational software. *Proceeding of the 2005 conference on Interaction design and children - IDC '05*.

MacFarlane, S., and Pasiali, A., 2005. *Adapting the heuristic evaluation method for use withchildren.* [Online]. Available at:http://chici.uclan.ac.uk/references/adapting_the_heuristic_evaluation.pdf [Accessed: 14 November 2014]

McCoy, A, 2013. How to protect your kids' safety when choosing apps. [Online]. Available at: http://specialsections.suntimes.com/education/prek12/17266560-555/how-to-protect-your-kids-safety-when-choosing-apps.html [Accessed: 30 December 2014].

McKnight, L., and Read, J. C., 2011. PLU-E: a proposed framework for planning and conducting evaluation studies with children. *Proceedings of the 25th BCS Conference on Human-Computer Interaction,* pp. 126-131. *British Computer Society*.

McLeod, S., 2010. *Preoperational Stage - Egocentrism. | Simply Psychology*. [Online]. Available at: http://www.simplypsychology.org/preoperational.html [Accessed 31 Dec. 2014].

McLeod, S., 2009. *Concrete Operational Stage | Simply Psychology*. [Online]. Available at: http://www.simplypsychology.org/concrete-operational.html [Accessed: 22 Aug. 2014].

Metaxas, G., Metin, B., Schneider, J., Shapiro, G., Zhou, W., & Markopoulos, P., 2005. SCORPIODROME: an exploration in mixed reality social gaming for children. *Proceedings of the 2005 ACM SIGCHI International Conference on Advances in computer entertainment technology* (pp. 229-232). ACM.

Matz, K., 2012. *Donald Norman's design principles for usability*. [Online]. Available at: http://architectingusability.com/2012/06/28/donald-normans-design-principles-for-usability/ [Accessed 4 September 2014].

Matzner, R., 2012. *Designing a mobile app? Don't make these 10 mistakes.* [Online]. Available at: http://mashable.com/2012/04/11/mobile-app-design-tips/ [Accessed: 24 March 2014]

Nielsen, J, and Molich, R., 1990. Heuristic evaluation of user interfaces. *Proceedings of the SIGCHI conference on Human factors in computing systems*. *ACM*.

Nielsen, J., 1993. Iterative user-interface design. *Computer,* 26(11), 32-41.

Nielsen, J., 2012. *Usability 101: introduction to usability* [Online]. Available at: http://www.nngroup.com/articles/usability-101-introduction-to-usability/ [Accessed: 21 March 2014]

Piaget, J., 1932. *The moral judgment of the child.* [Online]. Available at: http://www.archive.org/stream/moraljudgmentoft005613mbp#page/n5/mode/2up [Accessed: 15 October 2014].

Preece, J., Rogers, Y., and Sharp, H., 2002. Interaction Design: Beyond Human-Computer Interaction, *New York: Wiley*, p.21

Quinn, C., 2000. *mLearning: Mobile, wireless in-your-pocket learning.* [Online]. Available at: http://www.linezine.com/2.1/features/cqmmwiyp.htm [Accessed: 20 March 2014]

Radhakrishna, R.B., 2007. *Tips for Developing and Testing Questionnaires/Instruments*. [Online] Available at: http://www.joe.org/joe/2007february/tt2.php [Accessed: 25 January 2015].

Read, J. C., 2008. Validating the Fun Toolkit: an instrument for measuring children's opinions of technology.*Cognition, Technology & Work,* Volume 10, Number 2, pp. 119-128(10)

Read, J. C. and S. J. MacFarlane, 2006. Using the Fun Toolkit and other survey methods to gather opinions in child computer interaction. *Interaction Design and Children, IDC2006, Tampere, Finland, ACM Press.*

Revelle, G, and Emily R. 2009. Designing and testing mobile interfaces for children. *Proceedings of the 8th International Conference on Interaction Design and Children*, pp. 329-332.

Richardson, S., Guru, B.K., Yu, C.M., Wei, K.K. and Pointon, L., 2005. *How to research: A guide for undergraduate and graduate students*. Connecticut: Thomson Learning.

Schutt, R., 2012. *Investigating the social world*. Thousand Oaks, Calif.: Sage Publications.

Shneiderman, B., 1987. Designing the user interface: Strategies for effective human-computer interaction: First Edition, *UK: Addison Wesley.*

Shneiderman, B. and Plaisant, C., 2010. Designing the User Interface: Strategies for Effective Human-Computer Interaction: Fifth Edition, *UK: Addison Wesley.*

Shu, C., 2014. *Zap Zap Fractions Makes Learning Math Fun*. [Online]. Available at: http://techcrunch.com/2014/06/30/zap-zap-fractions-makes-learning-math-fun/ [Accessed: 19 January 2015].

Statista Inc., 2014. *Number of apps available in leading app stores 2014*. [Online]. Available at: http://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/ [Accessed: 31 December 2014].

Stone, D., Jarrett, C., Woodroffe, M., and Minocha, S., 2005. User interface design and evaluation. *Amsterdam: Elsevier.*

Takanashi, D., 2008. *Google releases details on Android Market launch.* [Online]. Available at: http://venturebeat.com/2008/10/22/google-releases-details-on-android-market-launch/ [Accessed: 8 March 2014]

Te'eni, D., Carey, J.M., and Zhang, P., 2005. Human-computer interaction: Developing effective organizational information systems. *John Wiley & Sons.*

Taylor-Powell, E. and Renner, M., 2015. Analyzing Qualitative Data. *Program Development & Evaluation*. [Online] Available at: http://learningstore.uwex.edu/assets/pdfs/g3658-12.pdf [Accessed 12 Mar. 2015].

The iPhoneMom, 2013. *Princess Drawsalot and the Dragon Review*. [Online]. Available at: http://www.theiphonemom.com/princess-drawsalot-and-the-dragon-review/ [Accessed 19 Jan. 2015].

Trochim, W, 2006. *Types of Surveys*. [Online]. Available at:http://www.socialresearchmethods.net/kb/survtype.php [Accessed: 21 January 2015].

van Teijlingen, E. and Hundley, V., 2001. *Social Research Update 35: The importance of pilot studies*. [Online]. Available at: http://sru.soc.surrey.ac.uk/SRU35.html [Accessed: 6 February 2015].

Victor, H., 2013. *Android's Google Play beats App Store with over 1 million apps, now officially largest.* [Online]. Available at: http://www.phonearena.com/news/Androids-Google-Play-beats-App-Store-with-over-1-million-apps-now-officially-largest_id45680 [Accessed: 8 March 2014]

Weevers, I, 2011. *Seven guidelines for designing high-performance mobile user experiences.* [Online]. Available at: http://uxdesign.smashingmagazine.com/2011/07/18/seven-guidelines-for-designing-high-performance-mobile-user-experiences/ [Accessed: 24 March 2014]

Wolock, E., Orr, A., and Buckleitner, W., 2006, Child development 101 for the developers of interactive media. *Active Learning Associates*.

Yusop, F. D., and Razak, R. A., 2013. Mobile educational apps for children: Towards development of i-CARES framework. *Annual International Conference on Management and Technology in Knowledge, Service, Tourism & Hospitality 2013 (SERVE 2013), Jakarta, Indonesia.*

Zikmund, W. and Babin, B., 2006. *Exploring marketing research*. 9th ed. Stanford: Cengage Learning.

APPENDIX A

Survey Questionnaire Before Amendments

UNIVERSITI TUNKU ABDUL RAHMAN

Department of Internet Engineering and Computer Science
Lee Kong Chien Faculty of Engineering and Science
Universiti Tunku Abdul Rahman
Jalan Genting Kelang, 53300 Setapak,
Kuala Lumpur, Malaysia.

Dear valued respondent,

My name is Teh Yew Pin, a postgraduate student currently pursuing my Master of Information System at Universiti Tunku Abdul Rahman (UTAR). In partial fulfillment of my dissertation entitled "Evaluation of Design Guidelines: Questionnaire Design for Evaluating Children Educational App", I am required to conduct a survey questionnaire to discover the extent of this questionnaire's applicability in evaluating Malaysian children's educational apps.

The participating respondents for this study must be **Malaysian children aged between 4 to 8 years old.** In addition, I would be extremely grateful if you could spend 20 minutes of your precious time to complete this survey questionnaire. Parental guidance is required for completion of this survey. The validity of this research highly depends on your truthful response. Hence, it is of utmost important for you to fully complete the survey questionnaire.

Please rest assured that information collected in this survey questionnaire will strictly be kept confidential and would be used for academic purposes only. Your time and cooperation is highly appreciated. Thank you.

Yours sincerely,

yewpin

Teh Yew Pin
Email: yewpin@hotmail.com
H/P No: 017-5787892

Section A: Usability of the Educational App

This section of the questionnaire captures the level of usability of the educational app based on the hands-on experience of your child.

Instructions: Indicate the extent that you agree with each statement in Section A. Please refer to the ratings provided and tick [✓] the most appropriate option in the relevant column for each statement below.

Ratings:

1 = Strongly Disagree
2 = Disagree
3 = Neutral (Neither Agree nor Disagree)
4 = Agree
5 = Strongly Agree

Screen Design						
No.	**Statement**	**1**	**2**	**3**	**4**	**5**
1.	Menus are simple and easy to understand					
2.	Screen layout is pleasant and intuitive					
3.	Buttons are large and easy to select					
4.	Animation, sound, and graphic used makes learning fun					
5.	Animation, sound, and graphic makes learning easier					

Navigation and Control						
No.	**Statement**	**1**	**2**	**3**	**4**	**5**
6.	Using menus to choose activities is easy					
7.	Using menus and buttons to go to an activity is simple and convenient					
8.	Buttons such as next and previous are always in the same place in every screen					
9.	Doing activities or playing games is convenient					
10.	Doing activities or playing games is easy					

Feedback and Help						
No.	**Statement**	**1**	**2**	**3**	**4**	**5**
11.	Response given by app is clear and informative					
12.	Help given is easy to understand and useful					
13.	Clues given is clear and useful					
14.	Status, goals, and location are clearly indicated					
15.	I am clear of what I am currently doing and what to do next					

Section B: Overall User Experience

This section of the questionnaire collects information regarding the overall user experience when using the educational app.

Instructions: Indicate the extent that you agree with each statement in Sections B. Please tick [✓] the most appropriate option in the relevant column for each statement below.

Ratings:

1 = Strongly Disagree
2 = Disagree
3 = Neutral (Neither Agree nor Disagree)
4 = Agree
5 = Strongly Agree

Ease of Use						
No.	**Statement**	**1**	**2**	**3**	**4**	**5**
16.	Loading time is short					
17.	Animations can be skipped or interrupted					
18.	Simple terms are used					
19.	Language used is easy to understand					
20.	Mistakes made can be easily recovered					
21.	Learning to use the app is easy					
22.	I can easily remember how to use the app					
23.	It is satisfying to use the app					
24.	It is fun to learn using the app					

Section C: Devices in the Household - To be filled in by **PARENTS ONLY**

This section of the questionnaire explores the type of smart device(s) you own and how your child gains access to them.

Instructions: Please tick [✓] the most appropriate options for each of the questions.

25. Which of the following smart devices do you have in the household? (Please tick **ALL** that apply)
    - ❑ iPhone
    - ❑ iPad
    - ❑ Android smartphone
    - ❑ Android tablet

26. How does your child gain access to smart devices? (Please tick only **ONE**)
    - ❑ My child uses his or her own smart device
    - ❑ My child shares a smart device with his or her sibling(s)
    - ❑ My child uses smart device belonging to me or my spouse

Section D: Demographic Information – To be filled in by **PARENTS ONLY**

This section of the questionnaire refers to background or biographical information. Although we are aware of the sensitivity of the questions in this section, the information will allow us to combine your responses with those of the other people taking part in this study. Once again, rest assured that your response will remain anonymous and will be kept strictly confidential.

27. Please specify the age of your child. (Please tick only **ONE**)
    - ❑ 4 years
    - ❑ 5 years
    - ❑ 6 years
    - ❑ 7 years
    - ❑ 8 years

28. Please specify the gender of the child. (Please tick only **ONE**)
    - ❑ Male
    - ❑ Female

APPENDIX B

Survey Questionnaire After Amendments

UNIVERSITI TUNKU ABDUL RAHMAN

Department of Internet Engineering and Computer Science
Lee Kong Chien Faculty of Engineering and Science
Universiti Tunku Abdul Rahman
Jalan Genting Kelang, 53300 Setapak,
Kuala Lumpur, Malaysia.

Dear valued respondent,

My name is Teh Yew Pin, a postgraduate student currently pursuing my Master of Information System at Universiti Tunku Abdul Rahman (UTAR). In partial fulfillment of my dissertation entitled "Evaluation of Design Guidelines: Questionnaire Design for Evaluating Children Educational App", I am required to conduct a survey questionnaire to discover the extent of this questionnaire's applicability in evaluating Malaysian children's educational apps.

The participating respondents for this study must be **Malaysian children aged between 4 to 8 years old.** In addition, I would be extremely grateful if you could spend 20 minutes of your precious time to complete this survey questionnaire. Parental guidance is required for completion of this survey. The validity of this research highly depends on your truthful response. Hence, it is of utmost important for you to fully complete the survey questionnaire.

Please rest assured that information collected in this survey questionnaire will strictly be kept confidential and would be used for academic purposes only. Your time and cooperation is highly appreciated. Thank you.

Yours sincerely,

yewpin

Teh Yew Pin
Email: yewpin@hotmail.com
H/P No: 017-5787892

Section A: Usability of the Educational App

This section of the questionnaire captures the level of usability of the educational app based on the hands-on experience of your child.

Instructions: Please refer to the ratings provided and tick [✓] an option that you think is correct for each statement below.

Ratings:

1 = Like

2 = Not Sure

3 = Dislike

Screen				
No.	**Statement**			
1.	Design of menu is simple			
2.	Screen design is pretty and simple			
3.	Buttons are large and easy to select			
4.	Buttons in the app works when touched			
5.	Animation and picture used makes learning fun			
6.	Sound used in the app makes learning easy			

Navigation and Control				
No.	**Statement**			
7.	Using menus to go to other screens is simple			
8.	Using menus and buttons to go to other screens is easy			
9.	Buttons such as next and back buttons are placed in the same place for each screen			
10.	Learning using the app is easy			
11.	Using the app to play games is simple			

Feedback and Help				
No.	**Statement**			
12.	Responses given by app is clear and helpful			
13.	Help given is useful to me.			
14.	Clues given are clear and helpful.			
15.	I know where I am now and where to go next			
16.	I am clear of what tasks to finish and how to finish them			

Section B: Overall User Experience

This section of the questionnaire collects information regarding the overall user experience when using the educational app.

Instructions: Please refer to the ratings provided and tick [✓] an option that you think is correct for each statement below.

Ratings:

1 = Like

2 = Not Sure

3 = Dislike

Ease of Use				
No.	**Statement**			
17.	Loading time is short			
18.	Animations in the app can be skipped or stopped			
19.	Use of simple words			
20.	Language used is simple			
21.	Mistakes made can be easily recovered			
22.	Learning how to use the app is easy			
23.	I can remember how to use the app with ease			
24.	I feel happy learning with the app			
25.	It is fun to learn using the app			

Section C: Devices in the Household - To be filled in by **Parents Only**

This section of the questionnaire explores the type of smart device(s) you own and how your child gains access to them.

Instructions: Please tick [✓] the most appropriate options for each of the questions.

26. Which of the following smart devices do you have in the household? (Please tick **ALL** that apply)
    - ❑ iPhone
    - ❑ iPad
    - ❑ Android smartphone
    - ❑ Android tablet
    - ❑ Other:_____

27. How does your child gain access to smart devices? (Please tick only **ONE**)
    - ❑ My child uses his or her own smart device
    - ❑ My child shares a smart device with his or her sibling(s)
    - ❑ My child uses smart device belonging to me or my spouse

Section D: Demographic Information - To be filled in by **Parents Only**

This section collects information regarding background and personal information. Please rest assured that the information collected are for academic purposes and will be kept strictly confidential.

Instructions: Please tick [✓] the most appropriate options for each of the questions.

28. What is your child's age? (Please tick only **ONE**)
    - ❑ 4 years
    - ❑ 5 years
    - ❑ 6 years
    - ❑ 7 years
    - ❑ 8 years

29. What is your child's gender? (Please tick only **ONE**)
    - ❑ Male
    - ❑ Female

30. What is the highest level of education you have completed? (Please tick only **ONE**)
    - ❑ High school or equivalent
    - ❑ College Diploma
    - ❑ Bachelor's degree
    - ❑ Master's degree
    - ❑ Doctoral degree
    - ❑ Other: _____

APPENDIX C

RESULTS OF INDEPENDENT SAMPLES T-TEST

T-Test

[DataSet1] C:\Users\Power-User\Desktop\Project\Evaluation Study (N = 27).sav

Gender

	Participant Gender	N	Mean	Std. Deviation	Std. Error Mean
Screen	Male	12	2.8889	.14794	.04271
	Female	15	2.9111	.10666	.02754
Navigation	Male	12	2.9167	.10299	.02973
and Control	Female	15	2.9067	.14864	.03838
Feedback and	Male	12	2.9833	.05774	.01667
Help	Female	15	2.8800	.24842	.06414
Ease of Use	Male	12	2.9259	.09863	.02847
	Female	15	2.9259	.14344	.03704

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Screen	Equal variances assumed	3.181	.087	-.454	25	.654	-.02222	.04899	-.12312	.07867
	Equal variances not assumed			-.437	19.413	.667	-.02222	.05082	-.12843	.08398
Navigation and Control	Equal variances assumed	1.539	.226	.198	25	.845	.01000	.05056	-.09412	.11412
	Equal variances not assumed			.206	24.579	.839	.01000	.04855	-.09007	.11007
Feedback and Help	Equal variances assumed	12.909	.001	1.406	25	.172	.10333	.07351	-.04807	.25473
	Equal variances not assumed			1.559	15.862	.139	.10333	.06627	-.03726	.24392
Ease of Use	Equal variances assumed	.641	.431	.000	25	1.000	.00000	.04869	-.10027	.10027
	Equal variances not assumed			.000	24.532	1.000	.00000	.04672	-.09631	.09631

APPENDIX D

RESULTS OF ONE-WAY ANOVA TEST

One-way

[DataSet1] C:\Users\Power-User\Desktop\Project\Evaluation Study (N = 27).sav

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Screen	Between Groups	.016	2	.008	.500	.613
	Within Groups	.387	24	.016		
	Total	.403	26			
Navigation and Control	Between Groups	.009	2	.005	.263	.771
	Within Groups	.418	24	.017		
	Total	.427	26			
Feedback and Help	Between Groups	.102	2	.051	1.405	.265
	Within Groups	.870	24	.036		
	Total	.972	26			
Ease of Use	Between Groups	.070	2	.035	2.580	.097
	Within Groups	.325	24	.014		
	Total	.395	26			