Keyboard Design for Pre-School Children

by

Alyssa Izzati Binti Amir Hamzah

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Technology (Hons)
(Information & Communication Technology)

MAY 2011

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Computer Information Science Programme
Universtiti Teknologi PETRONAS
in partial fulfilment of the requirements for the
Bachelor of Technology (Hons)
(Information & Communication Technology)

Approved by,

____
Assoc Prof Dr Wan Fatimah Wan Ahmad

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
MAY 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have been undertaken or done by unspecified sources or persons.

ALYSSA IZZATI BINTI AMIR HAMZAH

ABSTRACT

Computers are being used by children as a learning instrument at an incredibly young age. Many children embark on the adventure of using the keyboard while still preliterate and unfamiliar with the keyboard. Due to this reason they are unable to interpret the conventional keyboard configuration or the symbolic representations used on the keyboard. This would result the child to use up a significant amount of time locating the keys and correcting unintended strokes which may lead to frustration. Thus, the conventional computer keyboard design for adults is not suitably or exclusively designed for the young user. The research is concentrated to design a computer keyboard which is more suitable for young children. To carry out the study, the research methodology used for the project would be the Iterated Waterfall Model. The effects of color in the visual preferences of pre-school children is examined in a series of experiments conducted with kindergarten and elementary school students in Malaysia. The results from the experiments are that children prefer intense colors such as red, blue and yellow. The study also adds if larger font of the characters would aid the pre-literate children in recognizing, identifying and distinguishing characters on the computer keyboard. Apart from that, as children does not fully utilize all the keys on the keyboard, it may be more reasonable to remove certain keys on the keyboard to help children identifying and distinguishing the characters on the keyboard better. The results of the study concluded that children's learning curve is expedited when color, font size and utilization of keys are put into prospect in the design of the computer keyboard.

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, my utmost gratitude to Assoc Prof Dr Wan Fatimah Wan Ahmad, whose sincerity and encouragement I will never forget. Dr Wan Fatimah has been my inspiration as I hurdle all the obstacles in the completion this research work.

The students and children from various kindergartens around the Petaling Jaya area that participated in the survey and the study.

The Administrators of the Faculty of Computer and Science Department of Universiti Teknologi PETRONAS, for their untiring effort in encouraging the students to pursue professional growth. Likewise the staff of the Dean's Office for their relaying every communication sent in my behalf.

Last but not the least, my family and the one above us all, the omnipresent Allah, for answering my prayers for giving me the strength to plod on despite my constitution wanting to give up and throw in the towel, thank you so much Allah.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The computer at this age and time is no longer a tool used only by the adults. Due to the ubiquity of personal computers, together with more reasonably priced and proliferation of educational and entertainment software, the computer is progressively more relied on as a device to educate young children. Haugland (1992) said that children who use computer have a significantly greater developmental gain when compared to children without computer experiences. He refines the developmental gains in intelligence, nonverbal skills, structural knowledge, long-term memory, manual dexterity, verbal skills, problem solving, abstraction and conceptual skills.

Computers in general are broadly used by children of a very young age. Evidently some software is designed for children as young as two years old such as the *Alphabet, Shapes and Colors 1.00*. A large amount children's first contact with a computer is for educational and entertainment use. Computer keyboards currently provide the most common means of communication with computers and advanced technologies.

1. 2 Problem Statement

1.2.1 Problem Identification

1) Many young children begin using the computer keyboard at the early stages of learning how to read. The problems of the conventional computer keyboard have caused frustration to the users and would eventually destructive learning process. Thus, the conventional computer keyboard designed for adults is not suitable or specifically designed for young user and would discourage, delay or obstruct the child's interest in using the computer as a learning tool. The following difficulty

has been identified in the learning process: Unable to interpret the conventional computer keyboard configuration

In addition to being preliterate, children are also unfamiliar and unable to interpret the conventional keyboard configuration of the symbolic representations used on the keyboards. The unfamiliarity of the computer keyboard has resulted in the young users spending an inordinate amount of learning time to locate the keys on the computer keyboard and correct unintended keystrokes.

2) Unable to distinguish the characters on the keyboard

The conventional computer keyboard design is typically monocolor. Due to this factor, children are unable to distinguish the characters on the keyboard. This would also contribute to the user spending time to locate the keys on the keyboard.

3) Unable to make the intended keystroke

The error-free zone is defined as the distance between the two closer edges of the top surfaces of two opposite sided neighboring keys to that key. The conventional keyboard has a smaller error-free zone as depicted in the Figure 1.1 below. Due to this reason, the conventional computer keyboard design is less tolerant to error. The small error-free zone makes the conventional computer keyboard design unsuitable for young users as young users, being preliterate would want to explore the keyboard characters and functions.

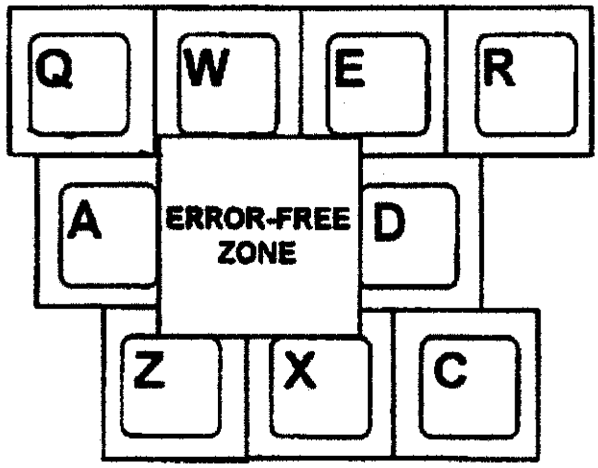

Figure 1.1: Error-Free Zone Depicted by Kuhlenschmidt (1997)

1.2.2 Significance of the Project

The use of computer keyboard by young children began even before they have fully developed hand-to-eye coordination. Due to the size of the keys on the conventional keyboards, the monochromatic color scheme, and the small characters on the conventional keyboard keys, children have an enormous difficulty in making the intended keystroke. The proposed invention is a children's computer keyboard with significantly larger keys than those of a conventional keyboard and color-coded keys according to the correct finger-association for touch typing. The invention is an aid for learning to locate, conceptualize and distinguish finger association to the keys by the young preliterate users. With these enhancements of the keys on the keyboard, children would have a higher rate of success in making the intended keystroke.

1.3 Objectives and Scope of Study

This study investigates the preference of young children for color and size of font on the keys. Most relevant research indicates that the use of computer keyboard for young children is increasing. Therefore, consideration of user preferences could influent the children's learning curve and enhance their interest. The preferences of children are particularly important as they would be the users of the future.

The current study considers the case where children's perceptions are used to develop and reinforce literacy skills. In the applications of the computer keyboard, the visual aspects of the keyboard have a direct effect on the children's receptiveness to the learning process. Since adults and children have different visual preferences, the research on the keyboard interface design for adults does not suit children's requirements. The result of this study would be the prototype of the computer keyboard.

This project is an attempt to implement exclusive key designs on the conventional computer keyboard. Its aims are:

- To research on the best computer keyboard design for pre-school children to expedite the learning curve.
- To develop a prototype for the proposed design of the keyboard for pre-school children.
- To test on the usability of the prototype.

1.4 Relevancy of the Project

A recent study has state that children learn to recognize, name and write alphabet letters as they engage in meaningful reading and writing activities with their parents, teachers, and other children. Learning to name and recognize alphabet letters seems to be a function of the meanings that children find in the world of print (McGee, 1989).

To provide a more legible word processing for young children, typing is introduced. This is in addition to the reason that handwriting would pose a problem for certain children due to the lack of hand motor skills control. Combined with the ubiquity of personal computers, a computer keyboard would aid young children in recognizing alphabets.

1.5 Feasibility of the Project within the Scope and Time frame

The effects of color and size of the key on the visual preferences of pre-school children is examined in a series of experiments conducted in kindergarten and elementary school students in Malaysia. Based on the results and findings of the study which is expected to consume the duration of two months, a design prototype would be available to be tested for various text-entry research including Fitts Law.

The study also focuses on a larger font size of the characters on the keys of the computer keyboard. It is expected that children are able to identify and recognize the characters on the keyboard better if it were larger in size. Another issue that may arise is children does not fully utilize all of the functions and keys on the keyboard, therefore, it is more reasonable to remove certain keys that have little or no function to children.

1.6 Definition of Terms

1.6.1 Home Position

The letters ASDF for the left hand, the letters JKL; for the right hand, and the space bar for the thumbs make up the home position where the typist's hands should be kept while using a keyboard

1.6.2 Touch-keyboarding/Correct Keyboarding/Touch-typing

For the purpose of this study, the correct keyboarding method or touch-keyboarding method is defined as keeping both hands in home position at the keyboard and then reaching with the correct finger to press a key

1.6.3 Increased Keyboarding Skill

In this study, an increased in keyboarding skill means that the speed in which the children type the letters, after an adjustment for errors, went up

1.6.4 Adjustment for errors

For each error made the children's typing speed was reduced by 0.5 words per minute (Reagen, 2000). For example, a typing test score of 20 w.p.m. (word per minute) with 3 errors would be recorded as 18.5 w.p.m.

1.6.5 Fitts Law

A model for human hand movement, developed by Paul Fitts. Fitts noticed that the time for hand movements was dependent on the distance, D, users had to move (from the starting point to the centre of the target) and the target size, W (actually the width of the target measured along the axis of motion). Doubling the distance, from 10cm to 20cm took longer, but not twice as long. Increasing the target size, from 1cm o 2cm, enabled users to point at it more rapidly.

Since the time to start and stop moving is constant, an effective equation for the movement time, MT, for a given device, such as a keyboard, turns out to be:

$$MT = a + b \log_2 (D/W + 1)$$

where a approximates the start/stop time in seconds, for a given device, and b measures the inherent speed of the device. Both a and b need to be determined experimentally for each device. For example, if a were 300 ms, b were 200 ms/bit, D were 14 cm and W were 2 cm, then the movement time MT would be $300 + 200 \log_2 (14/2 + 1)$, which equals 900 ms.

1.6.6 Error-Free Zone

The distance between the two closer edges of the top surfaces of two opposite sided neighboring keys to that key. Specifically, it is the horizontal distance between two neighboring keys, that is the right top surface edge of the key to the left of that key and the left top surface edge of the key to the right of that key, and the vertical distance between two neighboring keys, that is the lower top surface edge of the key above that key and the key below that key.

1.6.7 Usability Test

Usability testing is a technique ensuring that the intended users of a system can carry out the intended task efficiently, effectively and satisfactorily. Generally, the best method to conduct a usability test is where representative participants interact with representative scenarios. The tester collects data on the participant's success, speed of performance and satisfaction. The findings, include both quantitative data and qualitative observation information, are provided to designers in a test report.

1.6.8 Hunt-and-Peck Method

The method at which users of the computer keyboard adapt the natural bird technique of hunting a pray and pecking on the prey. In computer keyboard, the hunt-and-peck method is defined as the finger hunting for the characters on the keyboard and pecking as it discovers its prey.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Continued practice with handwriting is essential for developing further written communication skills for children; however word processing would provide the support in handwriting being more legible. Handwriting would always pose as a problem for some children at an early age due to the lack of hand motor skills control. It would be more apparent for the children to master their motor control over a period of time however; the children would never attain adequate speed and/or legibility of their handwriting. The Figure 2.1 below shows the contributing factors to the need to introduce typing to children.

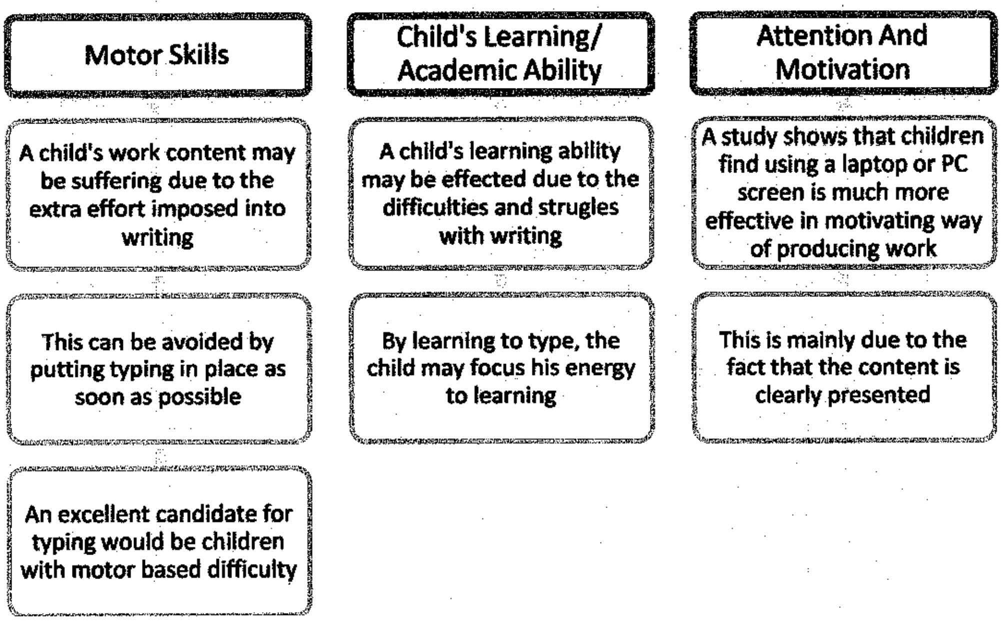

Figure 2.1: Lists the Contributing Factors (Sassoon R, 1993)

Increasing use of computers in especially in the education industry has made the efficient use of computers a basic skill (Russin, 1995). As the keyboard is the most common means to access the computer, children must be given the opportunity to use this tool of the technology era effectively by developing basic fundamental keyboarding skills (Warwood, 1985). Chang (1995) adds that due to the continuing increase in use of computers in personal, educational and professional lives, good keyboarding skills are more important than ever. Despite other technological advances such as voice recognition, the keyboard is, and will continue to be the mode widely used device input in communicating with computer. Hence, keyboarding can no longer be considered a secretarial skill, but a basic communication skill needed by all individuals.

Early research concluded that the use of computer by young children have a positive learning benefits. It is also said that children's writing abilities are enhanced with technology (Cochran-Smith, Kahn and Paris, 1988). Children have special computer keyboards as children have different needs as opposed adults. By putting less effort in using the keyboard and in addition to providing a uniform interface of the keyboard interface, it may possibly create a higher level of concentration on the material being studied (i.e. word processing) and so it has important implication (Edwards & Holland, 1992). Lucas (1991) furthermore adds that the interface design should provide a clear, consistent and attractive communication due to the fact that the quality of the interface contributes towards the ability of user to perform well.

2.2 Keyboard Layout Comparison

The three most popular keyboards known to man today are the QWERTY, Colemak and Dvorak. The Colemak and Dvorak keyboards were design especially to overcome the shortcomings of the QWERTY keyboard.

2.2.1 QWERTY Keyboard

The QWERTY keyboard first made its appearance on a type-writer in 1872 (Noyes, 1998). The main driver for the design of the QWERTY keyboard was to paradoxically slow the typist down to avoid from the keys being jammed frequently on the type-writer (David, 2001). The keys on the keyboard were arranged in the now familiar QWERTY sequence which forces typists to move their fingers further than was really necessary to type common letter sequences but it gives the keys time to fall back into place after typing. The Figure 2.2 below depicts the 1878 Typewriter Patent Drawing, featuring the QWERTY Keyboard. Years after its debut, it was considered important enough to include in a patent.

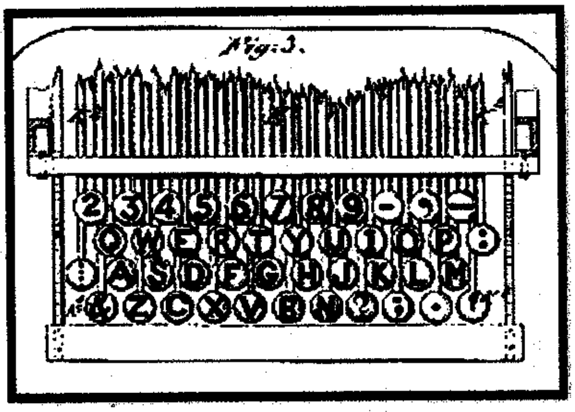

Figure 2.2: Typewriter Patent Drawing, Featuring the QWERTY Keyboard

The QWERTY keyboard has been criticized throughout the 20th century with reference to its poor design which includes in the list below (Noyes, 1998):

- When typing English text, QWERTY overloads the left hand- this is the non-preferred hand for the majority of the population.
- It also overloads certain fingers, especially the little fingers.
- Too little typing is carried out on the home (middle) row of keys- the distribution of typing loads across the three rows is uneven with 52% being carried out on the top row, 32% on the middle and 16% on the bottom row.

- Excessive row hopping is required, often from the top to the bottom row and back again – this occurs in such high-frequency letter sequences as 'br, un, in' etc.
- Many common words are typed by the left hand alone, e.g. taking a sample of 3000 words it was found that for every 10 words typed by the right hand alone, 90 words are typed by the left hand.
- Of all movements to reposition the fingers laterally between consecutive strokes are one-handed rather than easier two-handed motions.
- QWERTY requires reaches from the home row for 68% of all typing – on a well-designed keyboard these reaches can be reduced to 29%.
- The easiest keying movements are two-handed without reaches from the home row – only 4% of words fall into this category on the QWERTY keyboard, whereas it has been suggested that, on a well-designed keyboard, this could increase to 34%.
- The QWERTY layout slopes diagonally from the top left to the bottom right – this results in the little fingers having to stretch up to the top row.
- The division of keys into diagonal 'strips' for the different fingers is made by oblique parallel lines resulting in the strips for the fingers of the left and right hands being identical, regardless of the fact that the hands are not congruent, but inverse images of each other.

Despite the shortcomings of the QWERTY keyboard, it currently dominates the computer keyboard market. Over the last century there have been a large number of keyboards developed in order to challenge this supremacy, and much empirical work and investment of time have been carried out on other layouts and designs. The early arrival of the QWERTY keyboard in the marketplace and subsequent ubiquity has ensured that it has been accepted as the de facto keyboard. There are many reasons for this as described in Figure 2.3.

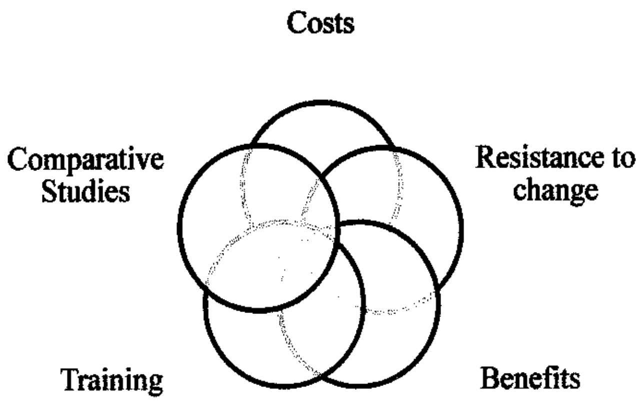

Figure 2.3: Reasons for the Supremacy of the QWERTY Keyboard (Noyes, 1998)

2.2.2 DVORAK Keyboard

In 1932, 60 years after the reign of the QWERTY keyboard, Dvorak was funded by the Washington State University to develop the ultimate type-writer keyboard (David, 2001). Dvorak arranged the keyboard according to the frequency. The keyboard layout's home row uses all five vowels on one side and the five most common consonants on the other side: AOEUIDHTNS. Having this feature, a rough typing rhythm would be established as each hand would tend to alternate. The Figure 2.4 below is the Dvorak keyboard layout.

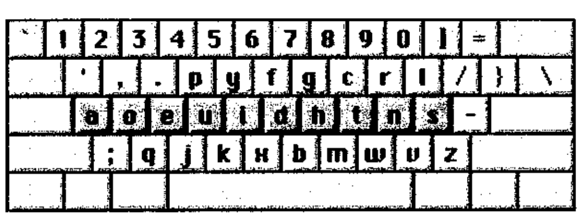

Figure 2.4: Dvorak Simplified Keyboard (DSK)

Dvorak hypothesized that the DSK would have the following advantages over

QWERTY (Noyes, 1998):

- It would be mastered in about 50% of the time required to learn to touch-type on QWERTY.
- It would allow faster typing speeds (by an average of 35%)
- It would allow more accurate output.
- It would be less fatiguing – finger travel for a fast typist would be cut from 20 miles a day to about one mile.

Economist Paul David (1985) had once suggested that the Dvorak keyboard introduced in 1930s never stood a change in the marketplace against the less efficient however universally accepted QWERTY.

2.2.3 Colemak Keyboard

The Colemak keyboard is the third most popular keyboard after QWERTY and Dvorak and was released in 1st January 2006 (Soukenik, 2010). The Colemak keyboard maintains all of the punctuation keys in their QWERTY position to ease the transition from QWERTY. 17 keys in identical positions to QWERTY were maintained to ease the learning and preserve the location of frequent keyboard shortcuts. When comparing the Dvorak Simplified Keyboard and Colemak, it is often concluded that the latter is better and usually revolve around several statistical metrics. The Colemak keyboard has several advantages over the Dvorak Simplified Keyboard (Soukenik, 2010):

- The distance that the finger needs to travel favors Colemak with a 7.5% reduction
- Colemak prioritizes having all the top-frequency letters on the home row (which is the easiest to reach)
- Colemak also achieves an 8% reduction in the "same-finger" typing

Figure 2.5 shows the Colemak keyboard layout which maintains 17 keys from the QWERTY keyboard.

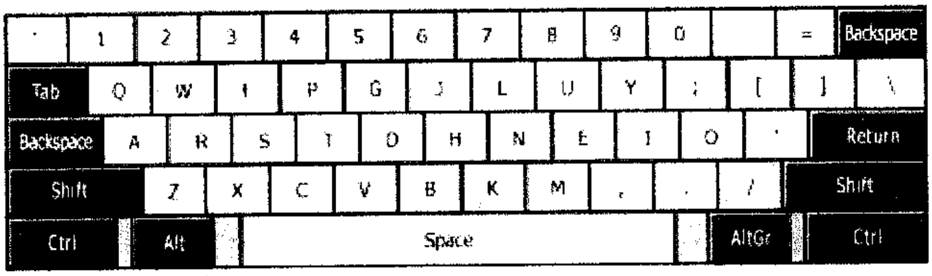

Figure 2.5: Colemak Keyboard Layout

A Keyboard Compare Applet shows the three different keyboards each specifying the distance that the finger must travel, the percentage of use of the same hand and the percentage of use of the same finger. Table 2.1 shows different results obtained by typing the sentence "The quick brown fox jumps over the lazy dog".

Table 2.1: Keyboard Layout Comparison

Keyboard/Feature	**QWERTY**	**Colemak**	**Dvorak**
Distance (m)	1.153	0.874	0.815
Number Row (%)	0.0	0.0	0.0
Same Hand (%)	22.22	22.22	22.22
Top Row (%)	50.0	27.77	25.0
Same Finger (%)	11.11	2.777	2.777
Home Row (%)	27.77	50.0	50.0
Bottom Row (%)	22.22	22.22	25.0

Based on these factors, the results have shown that QWERTY keyboard requires user's finger to travel more than the other two keyboards. QWERTY, throughout the years has stayed course as the strongest keyboard layout. This is the ultimate example of path dependency (Shalizi, Cosma (2001), David (1985,1997,2000)). Path dependency is the view that technological change in a society depends on its own past. The QWERTY layout, may not have been in use today apart from it happened to be the selected keyboard layout a hundred years ago and was adopted at appropriate times through history. This has been proven to be one of the most prominent path-dependent features of the economy (Puffert (1999), David (1985, 1999)). Even with all the problems, once the QWERTY keyboard started getting widely used, it became difficult to change the layout cause of simple economics, as no one was able to justify expense of time and money to convert existing typists to new layout may it be Dvorak or Colemak.

2.3 Existing Design Comparison

Paloyan et al (1995) suggested an ornamental design for a children's keyboard. This design may possibly provide a challenge for children when switching to the conventional computer keyboard design used by adults. The transition period may be challenging to children as they will be used to the shapes and ornaments of the design suggested by Polayan et al Under this influences, the keyboard design suggests that the shape of the conventional keyboard design to be maintained.

Another proposed design by Kuhlenschmidt (1997) was that the keys of the keyboard enlarged together with color-coded keys according to the functional input. The proposed design for the keyboard is to change the size of the font on the keys with the slight improvement to color-code the keys according to the correct finger use to aid in learning finger-association which is crucial for touch typing. Figure 2.6 depicts the ornamental keyboard design by Polayan et al (1995).

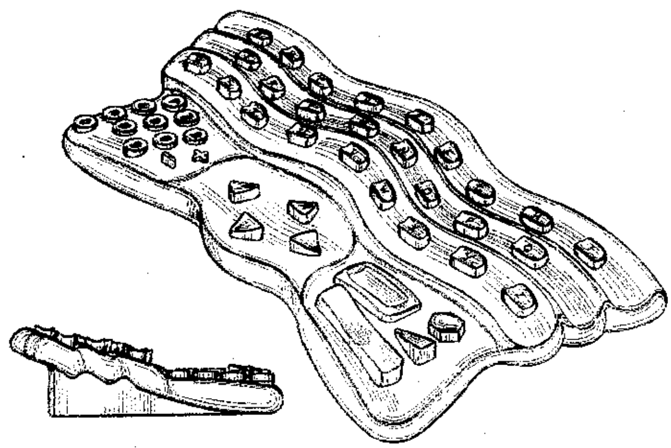

Figure 2.6: Ornamental Children Keyboard Design by Paloyan et al (1995)

A more recent study separates the number and letter keys into a physical gap. This is done to ensure that the children do not have difficulty in making the intended keystroke apart from the reason of the small error-free zone. The Figure 2.7 below depicts the description in the recent study.

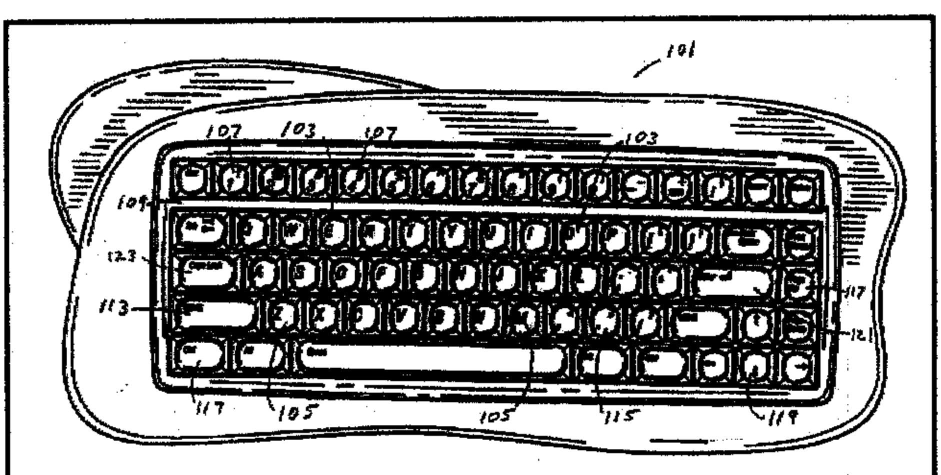

Figure 2.7: Computer Keyboard Design by Giles (2007)

Apart from the patents describe above, computer keyboards for children have already been in the market for quite some time. These designs mainly focus on color-coding the keys based on the input. These color-coding inputs focuses on children to be creative while learning their volews, consonants, numbers and also function keys. The Figure 2.8 below is an example of the color-coding inputs on the computer keyboard. One of the attractive features of keyboards is that they support novice as well as expert users (Goldberg and Richardson, 1993). Novice users can enter text using "hunt-and-peck", experts use touch typing. Although it takes time to learn touch typing, there is a large payoff in faster operation. The proposed keyboard design would also focus on aiding children to learn to touch-type at an early age.

Touch typing is when a user types on the keyboard without having to refer to the keyboard to make the intended keystroke. While touch typing is focused on expert computer keyboard users, early steps to develop this skill would later provide the child with expert keyboarding skills at such a tender age.

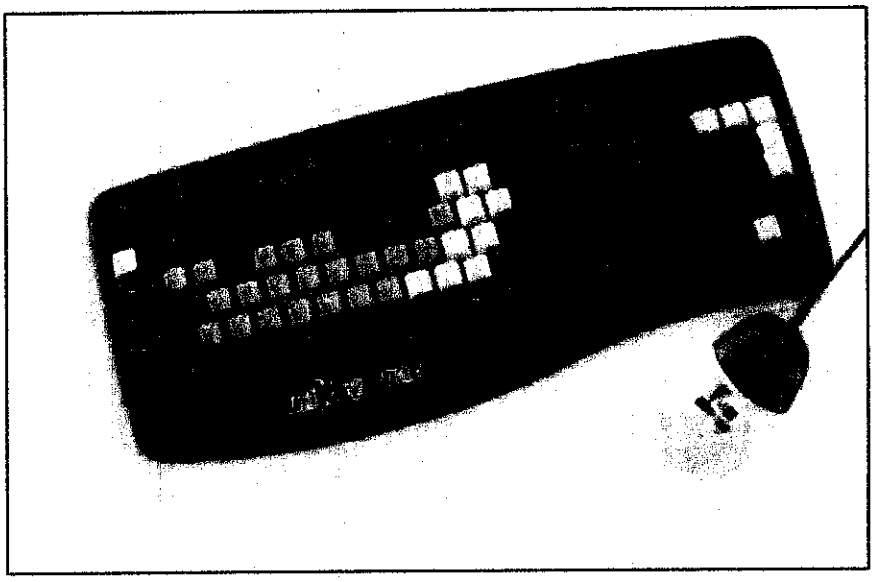

Figure 2.8: FunKeyBoard Design by TinyEinsteins

2.4 Color

The theoretical basis of this color coding application is consistent with psychological principles and research findings. A research supported that grouping smaller units encourages a chunking effect (Miller, 1956). Chunking allows information, like letters, syllables and words to be grouped into familiar and manageable units which assist encoding, storage and recall (Lefton, 1994). It was further added that discrimination will be impaired if objects and their backgrounds have the same color (Javadnia & Ruddock, 1988). This statement is consistent with the current keyboard design which is usually available in a single color.

The basic purpose of human color vision is to distinguish different objects at a more elaborate level, vision is used to attribute salience and meaning to chromatic stimuli. The effects of color may very well create easier learning experience for pre-school children. In a broad-spectrum, children have more intense feelings towards colors (Birren F, 1969) as opposed to adults. The intensity of the feeling can be generally depicted in the ratio of 1.03 (children to adults).

Children are attracted to colors based on the theory of optimal simulation. The theory assumes that there is a biological need for an optimal simulation (Hebb, 1955). When the optimal level is not present, a shift in attention and activity can serve as instrumental responses functioning to optimize simulation. The theory can be applied in designing a keyboard where colors are used as stimulation to improve the overall performance to ensure the attention of adolescents.

The use of color is an important consideration for effective perception. The physiological benefits of color application are well appreciated. Color is an extremely effective way of organizing stimuli (Wickens & Andre, 1990) and an ideal means of segregating, defininf and connecting units of stimuli (Davidoff, 1991). Segmentation through color coding quickens visual search responses (Green & Anderson, 1956; Carter, 1982; Bundesen & Pedersen, 1983). Color aids the processing and recall of information as well as stimulus organization. Color coding also enhances memory performance (Siple & Springer, 1983).

Color-coding the fingers to the keys would result in the preliterate young user to easily locate, conceptualize and discriminate between the different finger association to the keys. In a separate study, there were attempts to help young user discriminate between individual keys on the computer keyboard (Liljenquist, 1990). The study was to incorporate colors together with shapes to help young users to discriminate the keys.

2.5 Font Size

In the era of technology, one issue that has remained to be a concern is the ability to change font size for the reading material viewed on the devices (DeLamater, 2010). A recent post reported that it is easier to read books on iPhone due to the reason that the spacing 'seems' generous and readers do not lose pages. Similarly, when the study was conducted among middle school students in the United States, it was reported that increasing the font size on the device helped the students to read more easily and quickly (DeLamater, 2010).

Studies have also showed that readers develop the ability to decode smaller and smaller text as they become older and more facile with the process of reading. It has also proven that children, especially pre-literate require larger text which is reflected in books for early readers. One study observes "Our data showed that critical print size decreases with age", this suggest that younger children need larger print to optimize reading performance (O'Brien, Mansfield, and Legge, 2005). This tells us that struggling children will achieve their optimal reading rates (as well as distinguishing characters on the keyboard) when the text is larger.

The conventional size of the computer keyboard is designed so that each alphanumeric key has a rectangular upper surface of 17mm to 20mm in width and 20mm to 25mm in length. In addition to the design, the distance between the upper surfaces of each key is also set as 6 to 10mm. The issue that arises with the keys on the keyboard is that the font size on alphanumeric key is fairly small for children to be able to distinguish the characters on the keyboard and ultimately make the intended keystroke. To design a more legible keyboard for children, the font of the characters on the keyboard should be larger.

Children using the conventional computer keyboard are less likely to make the intended keystrokes. This would lower the typing speed of the user due to having to spend a substantial amount of time to correct this error. Children are also less likely to make the intended keystroke due to the reason that the conventional computer keyboard fonts on the keys are made for adult users. The relatively small font size on keys of the conventional computer keyboard does not take into account the random exploration and risk-taking which is involved in the learning process of the preliterate child (Liljenquist, 1990). This reason may be the main driver of the smaller keys and less tolerant for errors of the computer keyboard.

The conventional computer keyboard in addition to the issues stated above also has a small error-free zone. The error-free zone is defined as the distance between the two closer edges of the top surface of two opposite sided neighboring to those keys.

2.6 Touch Keyboarding

Touch typing is defined as typing on a computer keyboard without looking at the actual keyboard. The idea of touch typing can be easily summarized below (Winitzki, 2009):

- Typing the letter keys with eight fingers (thumbs are only used for space bar)
- Each of the eight fingers is responsible for typing letters belonging to the same vertical row

The correct position for touch typing is described in the paragraph. The position of the index fingers is at the keys F and J. These are made to help the user to put the index fingers at the correct position by touching the keyboard that is without looking at the keyboard. The middle fingers are then placed next to the index fingers in the horizontal row, and all other fingers are placed onto the neighboring keys in the middle horizontal row. This position should be maintained while typing. The wrists must be high above the keyboard, and the eight working fingers must lightly touch the eight keys A, S, D, F, H, J, K, L (Winitzki, 2009).

Binderup (1988) states that frustration peaks when students (i.e. children) lose their creative ideas while searching for the correct keys. Chang (1995) also adds that hunt and peck typist are not able to concentrate on what they are inputting because all their attention must be focused on the fingers. This is further supported by Wetzel (1985) whom stares that students who have adequate keyboarding skills use their time at the computer efficiently- that is, they can concentrate on problem solving or composing rather than on the mechanics of typing.

A further study by Goins (1996) concluded that without adequate keyboarding skills, writing using computers is difficult and time consuming. Artwohl (1989) reported that familiarity with the keyboarding skill stimulates interest and enables concentration to be focused on the task to be accomplished, thus awareness and understanding about computers is increased and anxiety is decreased. Wetzel (1985) also included this in his report..

> I watched students after frustrated student scan handwritten notes for the last word typed, and then lock down for the key that represented the first letter of the next work, look up at the screen to verify the letter and correct letter position – and then lose the place. Fingers would point and eyes would search from paper to keyboard screen and back to paper. The cycle continued and the frustration grew (Wetzel, 1985, p. 131)

A study by Dalton (1988) was conducted to illustrate the benefits students (fourth-grade) gain from keyboarding instructions. He stated that the students who received no direct instruction appeared fairly competent on the keyboard during the first few months of the project when writing assignments were relatively short. However, their weak typing skills became evident during the latter part of the year when they began to write more extended pieces on the computer. Dalton (1988) further extended his research on students whom were given touch-keyboarding instructions. Much to his expectation, the students were able to easily complete the assignments. McEntee (1994) states that his research confirms that students who have become proficient in touch-keyboarding complete work faster and more efficient in their use of keyboard. Boyce (1992) specifically stated that teaching students to touch-keyboard lays the foundation for a vital lifelong skill. The benefits of touch typing can be summarized in Figure 2.9 below.

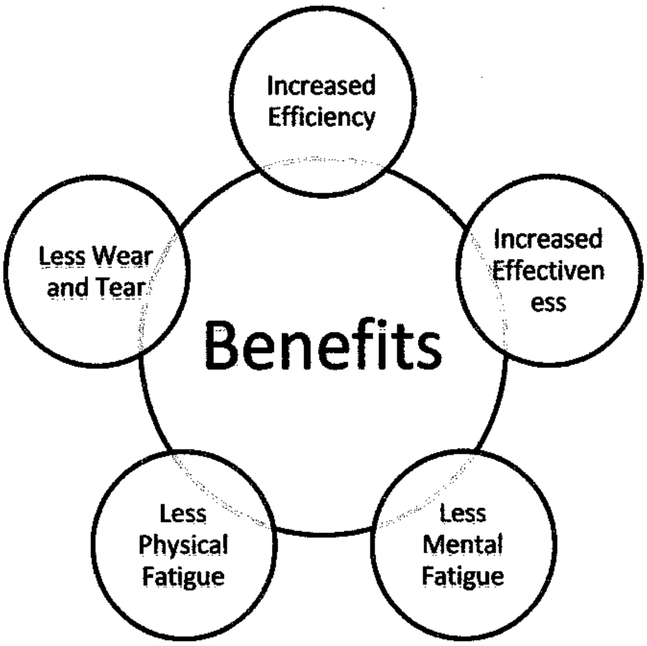

Figure 2.9: Benefits of Touch Typing (Tactus Keyboard Corporation, 2002)

Many articles reported ideas that would be in agreement with most of the following suggestion by McEntee (1994) in regards to when is it best to teach touch-keyboarding. The suggestion mentions that students should become aware of the keyboarding process as soon as they are asked to input information into the computer. It further adds that students should learn the correct position of their fingers on the keys and the correct posture as they learn the computer. However, if this learning process takes place in elementary school, a keyboarding awareness should be thought. The research of this paper focuses on creating awareness to children about the keyboarding course and prepping the children for keyboarding course until the children have matured in their finger dexterity and eye-head coordination.

By using the keyboard for pre-school children, it will emphasize proper technique and accuracy rather than speed as a guideline for determining successful touch keyboarding skills (Warwood, 1985).

Learning to touch type also reduces wear and tear on the few fingers that are constantly being used. This load is spread over many more fingers and thus the risk of Cumulative Trauma Disorder is reduced.

2.7 Usability Test

When conducting usability testing, the first and foremost important issue is to ensure that the best possible method for testing is used. In general, the best method is to conduct a test where representative participants interact with representative scenarios. Usability test is in its details. Usability testing demands both creative and innovation and meticulous attention to details. Only after that is settled does the critical-path nature of some details become obvious (Kantner, 1994). The tester collects data on the participant's success, speed of performance and satisfaction. The findings, including both qualitative data and qualitative observations information, are provided to designers in a test report. Using 'inspection evaluations,' in place of well-controlled usability tests, must be done with caution.

The second major consideration is to ensure that an iterative approach is used. After the first test results are provided to designers, they should make changes and then have the design tested again. Generally, the more iterations, the better the final product would be.

Kanter (1994) suggested the following in carrying out usability testing:

- Recruit participants who truly match the target audience for the product
- Design tasks that match expected – and natural – use of the product (realistic tasks)
- Minimize variables and activities that do not generate meaningful results
- Make sessions as consistent as possible for each participant

- Test the test. Before conducting the actual sessions, a dry-run should be conducted to verify the flow of the task.

Kanter (1994) also added further information regarding planning the test. The end product of planning the test is a document describing the test goals and methodology, participant-selection requirements, working procedure and schedule, and resource requirements. The planning process should elicit agreement on the following information:

- Major questions the test should answer, with assigned priorities
- Number of participants desired and characteristics
- Completeness, maturity, or fidelity of the product (and documentation) for the test
- Resources available to plan and conduct the test, and the desired schedule
- Participant compensation available (optional)

Kanter (1994) suggested the working time requirements for usability test phases in Table 2.2 below.

Table 2.2: Working Time Requirements for Usability Test Phases (Kanter, 1994)

Project Phase	**Working Time**
Design	20 to 40 hours
Participant recruiting	2 to 4 hours per final participant
Materials preparation	30 to 80 hours
Session administration	Number of participants times the session length, plus time for dry-runs, pilot-testing, breakdowns between sessions, and modification to materials
Results reporting	50 to 150 hours (depending on study complexity, number of participants, session length, and level of detail in final report)

According to usability researchers Neale and Nicholas (2001), data collection involves several steps:

- Data is grouped according to the question or hypothesis it addresses
- Data is recorded on a simple matrix, with rows to shows data from individuals and columns for summarizing data
- The matrix is retained throughout the iterative process of defining themes, allowing researchers to view and analyze the data individually and then collectively
- Usability researchers read throughout the data a number of times until the response of the participant becomes familiar

The following is an example of data collection: Researchers review focus group data and thinking-aloud protocol responses gathered during a test in which participants type several different types of words using the keyboard for pre-school children. Researchers categorize the results based n such distinction as participant age, previous experience with similar keyboard and intuitive understanding of characters on the keyboard.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology and Tools Required

3.1.1 Development Life Cycle

The Figure 3.1 below depicts the life cycle that would be used in the study and the development of the prototype. The detailed description of activities in each phase would be explained in the paragraphs below.

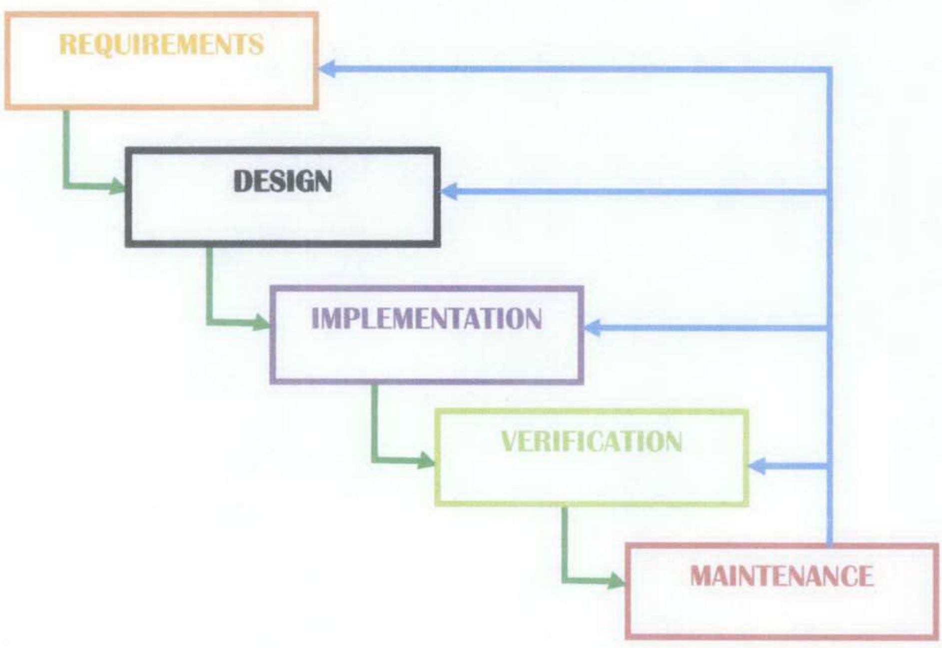

Figure 3.1: Iterated Waterfall Model

3.1.1.1 Requirements

The development of the project uses the waterfall model as a reference. Using the waterfall model, the preliminary phase is to gather the user requirements. This research is focused to develop an alternative computer keyboard design for young children by improving the following aspects: heighten the success rate of making the intended keystroke, making it effortless for children to locate and recognize keys and having an error-free zone on the computer keyboard.

The advantages and disadvantages as well as the reliability of this instrument were also part of the objectives. In order to answer these research goals, the researcher opted to study the preferences of young children in line with this topic. Specifically, a total of 60 respondents from three kindergarten and elementary school within Malaysia were selected to make up the sample.

3.1.1.1.1 Color Preference

Color overlays are identified as sheets of colored plastic designed to be placed over a text. The intention was that the color would interfere unduly with the clarity of text. The design of color overlays were based on two simple assumptions:

- There are certain colors that improve reading speeds (character recognition)
- These differ from one individual to the next

Tyrell et al. (1995) examined the speed of each child to read a passage photocopied from a book chosen by the child from the school library. The testing was conducted with a control mechanism where one passage was not given a color overlay. The reading was carried out for 15 minutes, and initially there was no different in speed between the two conditions.

Differences emerged only after the children has been reading for 10 minutes and had begun to tire. The children who had chosen a clear overlay reported slowed down when they were reading without it, and reported symptoms of eye-strain; the children who had chosen a color overlay reported fewer symptoms, did not slow down which shows some benefit from use of the overlay.

As stated previously, this study assigned three different attributes to the computer keyboard. One study found that children prefer primary colors (Halse, 1978), while another found that by the age of pre-school, children have already developed a sophisticated taste of color (Ferhrman, 2000). The preferred color for both boys and girls which is red (Bornstein, 1975; Adams, 1987) will be the anticipated preference of the young children.

Table 3.1 : Color Recommendation on Keyboard

Color	Recommendation
Red	Olsen (1970); Troudet (1994)
Blue	Olsen (1970); Ladner & William (1990)
Orange	Olsen (1970); Ladner & William (1990); Troudet (1994)
Green	Olsen (1970); Ladner & William (1990); Troudet (1994)
Yellow	Olsen (1970); Ladner & William (1990); Troudet (1994)
Pink	Olsen (1970); Troudet (1994)
Black	Olsen (1970)
Purple	Olsen (1970); Ladner & William (1990)
Dark Pink	Ladner & William (1990)
Grey	Ladner & William (1990)
Light Pink	Ladner & William (1990)

To ensure that the results are unbiased, all the tests will be done at different times of a day, under florescent or natural light. This is mainly to ensure there is no variance in perception of the same color due to lighting. The Table 3.1 above lists down the color recommendations. Based upon the number of recommendations, the colors are suggested to be coded on the keyboard interface.

Eight main colors will be tested; three prime colors and monochromatic colors. The eight graphics would be 20x20 cm and will be colored Blue, Red, and Yellow which are the prime colors and Green, Purple and Orange and Pink which are the monochromatic colors. The graphic will be held up for five seconds and the interviewees will be asked about their color recommendations to verify the recommendations above. Figure 3.2 lists the sample of recommended colors according to Table 3.1.

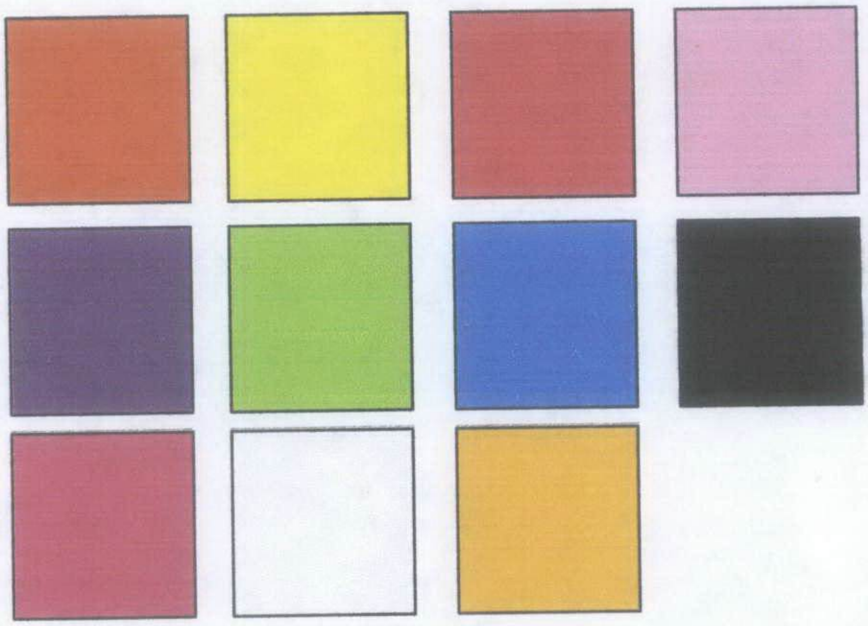

Figure 3.2: Recommended Colors

3.1.1.1.2 Size of Font

To conduct the study on the preferred font size on the keys of the keyboard for young users, a cardboard with different font sizes are laid out according to the conventional computer keyboard layout. Children are then required to identify the alphabets according on the cardboard.

By identifying the characters on the keyboard, we can safely deduce if the larger font size contributes to the letters keyboard being more legible to young users. The time taken for the child to identifying the letters of the word would determine the effects of the font size on the keys on the conventional keyboard.

As shown in Figure 3.3, the keyboard will be tested in seven font sizes. The largest font, in which each first row character on the cardboard is formed, has a font size of 82 pt. At the other extreme, the dimension of each character on the last row has a font size of 26pt.

To ensure that there will be no impartial judgment, the cardboard made keyboard will be laid out on a white surface. Figure 3.4 depicts the conventional font size on the keyboard having ample of empty space for the font to be larger while Figure 3.5 depicts the proposed font size on the keyboard.

82pt UMBRELLA

74pt UMBRELLA

66pt UMBRELLA

58pt UMBRELLA

50pt UMBRELLA

42pt UMRELLA

34pt UMBRELLA

26pt UMBRELLA

Figure 3.3: The Seven Different Font Sizes to be Tested

The conventional font size on the keyboard is roughly 4mm which is approximated to be 26 pt. The proposed font size on the keyboard brings the intention to ensure legibility and has a rough size of 12mm which is approximated to be 82 pt.

Q	U	E	R	T

Figure 3.4: Conventional Font Size on Keyboard (26 pt)

Q	U	E	R	T

Figure 3.5: Proposed Font Size on Keyboard (82pt)

3.1.1.2 Design

The design phase focuses mainly on translating the specifications or user requirements into a design. In this phase the designer emphasizes on the interface design. The design of the keyboard is sub-divided into two stages:

- Preliminary design
- Final design

During the preliminary design stage, major emphasis is on the aesthetic and architectural design. All the required investigations, including the analysis of color, font size are made before completing this step. Based upon investigations, the criteria are developed for the right keyboard for pre-school children. A sufficient number of drawings are then completed to communicate the design concepts. The preliminary design would undergo testing before it can proceed to the final design stage.

During the final design state the detailed architectural drawings of all the physical components of the project are produced. Sufficient detail must be provided by the drawings to ensure that the prototype can be made and also that the product meets the user requirements and specifications which have been refined since the preliminary design stage.

3.1.1.2.1 Color

Color pattern discrimination relies on the detection ability of color that make up the units of a visual pattern (Fitts, 1966). Each unit's color within the subject color patern corresponds to each color category's characteristic range of radiation (Marczenko, 1986). Those ranges may be represented as parameters of frequency in Hertz (Wright, 1964), wavelength specifications in nanometers (Giancoli, 1980) or color-hue specifications. Hence, the segregation of part of the keyboard by color-coding facilitates awareness of the keyboard as a whole for children.

The application of color-coding to the computer keyboard encourages young users to use the keyboard correctly and efficiently apart from learning finger-key associations, which are a necessity for learning to touch-type. In addition to that, young user would also be able to discriminate the keys using the color-code input. Table 3.3 describe the suggested color-code for the keyboard design for the prototype.

discriminating and efficient responses may be made. The color-coded keyboard reveals the organization of color units and the pattern formed through the color transition which is segregated into zones by a spectrum-ordered pattern of colors. This spectrum-ordered pattern corresponds to the range of so-called "visible light" within electromagnetic radiation spectrum (EMS) which increases stimuli.

Stimulus perception can occur at various levels of scale (Duncan and Humphreys, 1989). In line with those findings, the spectrum-colored pattern enhances organization of the units at both the within-stimulus level and the whole-stimulus level, where responses are based on the perceived properties of the entire stimulus.

The spectrum-ordered pattern of colors, as a whole, is perceived as an ordered pattern because its colored sub-units, at the columnar focal regions provide information at intervals of a spatial gradient (function between units of a sequence). The strength of that relationship is a measure of a sequence's organization and hence a factor determining how readily a pattern may be perceived. Example of this is the sequence of "1, 3, 4, 5, 6" which is more readily perceived than "1, 3, 2, 4, 5".

Preferably, the eighth color, pink is a "constant hue" (Bums, Elsner, Pokorny & Smith, 1984) being the same hue as the "red" used for the left-hand pinky but increased in lightness (unsaturated). That color scheme produces a relation between the pinky fingers whereby the terminal hues of the pattern are the same; they lie on the same radial hue-angle of a color when but have unequal lightness. The color pink also has a mnemonic advantage as it is naturally related to the "pinky" finger of the right hand.

3.1.1.2.2 Font Size

The expected results of the study are that young children prefer the font of size on the keys to be larger than the conventional size. As mentioned, this computer keyboard unlike the existing computer keyboard design for pre-school children primarily focuses discriminating and efficient responses may be made. The color-coded keyboard reveals the organization of color units and the pattern formed through the color transition which is segregated into zones by a spectrum-ordered pattern of colors. This spectrum-ordered pattern corresponds to the range of so-called "visible light" within electromagnetic radiation spectrum (EMS) which increases stimuli.

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3.1.1.4 Verification

In this phase all designs are integrated into a single product design and tested (usability testing) to ensure that the complete design meet the user requirements. The testing is concerned with verification and validation.

Scientific control refers to a concept that allows for comparisons as part of the scientific method. There are many forms of controlled or designed experiments. For the research, the researcher separates research subjects into two groups: an experimental group (using the newly designed keyboard) and a control group (using the conventional keyboard).

The control group is practically identical to the experimental group, although the experimental group is changed according to some key variable of interest (color and font size), while the control group remains constant during the experiment.

Controls are needed to eliminate alternate explanations of experimental results. The underlying cause of increase in efficiency could be the due to the new keyboard itself or something unrelated. Other variables, many of which may not be readily obvious, may interfere with the experimental design.

Another aspect of the verification phase will use usability testing. The guidelines for usability testing are specified below by (Neilsen and Molich, 1990; Neilsen. 1994):

- Each individual evaluator inspect the interface alone
- After all the evaluations have been completed, evaluators are allowed to communicate and have their findings aggregated
- Result of the evaluation is recorded in a written report or verbal comments
- An observer is added to reduce the workload on each evaluator

3.1.1.4.1 Testing Plan

Dickleman (1997) specifies twelve steps in the usability testing:

- Determine Test Site

  The test site that have been selected to perform the usability test would be where the children feel at home and is comfortable with the environment

- Select Evaluators

  The evaluators would consists of the parents of the children as well as the researcher

- Document Usability Goals

  The goals of the usability test is to ensure that the keyboard produce is meets the satisfaction and expectations of the children as well as heighten the ability for children to distinguish and recognize the characters on the keyboard

- Develop Scenarios

  The children will be required to type several words and the duration of typing the word is recorded. The performance of the child is recorded and later drafted into a graph to conclude findings. The performance is calculated using the Fitts's Law

- Develop Briefing

  The children would be brief on the test. Specific questions will be asked to ensure that the results of the findings matches the objective of the project.

- Develop Debriefing

  Following the debriefing session would be the questionnaire, where the children will be asked personally regarding their experience in using the keyboard. The questionnaire is attached below.

- Schedule Evaluators

  The children will be scheduled accordingly to their preference of time and place to ensure that the children are at the optimal environment (without the stress factors)

- Set Up Lab

  The selected location would then be prepared to ensure that the usability test can be conducted successfully
- Select Observation Team

  The observation teams comprises of the parents of the children where the performance of the children is recorded. Parents also record if they see a significant change in the mood of the children when the test is conducted
- Conduct Dry Run

  A dry run of the usability test is done to ensure that all the materials needed to conduct the test is ready
- Conduct Evaluation

  The usability test commences in the evaluation stage where the observations are recorded for further findings
- Document Usability Test Findings

  A conclusion of the findings is placed in a document

Based on the observations during the usability test, a table of participant's behavior is recorded. The sample can be seen in Table 3.4.

Table 3.4: Sample table of participant behavior

Participant Behavior	**Type of Behavior (Raw Data Theme)**	**Behavior group (Higher order theme)**
P1 Looked at the clock P5 Looked at the ground and sighed P8 Looked at other participants	Looked away (3)	Change in visual behavior (5)
P4 Squinted eyes for more than five seconds P7 Squinted once or twice	Squinted (2)	

The data noted for individual participants represents a behavior record (Participant Behavior column). The Type of Behavior (Raw Data Theme) column lists the frequency count for each type of behavior. The numbers in the parentheses represents the total count for each type of behavior. The numbers in the parentheses represents the total number of participants who had responses that fit into that theme.

The Higher Order Theme column is a summary of all like behavior. Raw data themes are summarized under one label and all responses are totaled so that more general themes can be assigned to responses. A higher order theme, according to Neale and Nicholas, requires a higher level of inference than a raw data theme. There may be several levels of higher order themes.

The use of frequency counts to analyze qualitative data, as described above, is one example of how qualitative and quantitative methods of collection and analysis can complement each other.

3.1.1.4.2 Post-Study-Satisfaction-User Questionnaire (PSSUQ)

After having screen a list of potential standardize measurement instruments devised to capture some aspects of usability criteria the Post-Study-Satisfaction-User-Questionnaire (PSSUQ) (Lewis, 1995) was chosen, slightly adapted to a non-technical wording and extended by typical aspects relevant for recommendation of the keyboard.

The children will be interviewed regarding each of the items combined with a thinking-aloud method to ensure that the children understand the tasks required to be completed together with the level of satisfaction.

The PSSUQ rates the results in a Likert scale where the weights are listed as below:

- Strongly Disagree = 1
- Disagree = 2
- Neutral = 3
- Agree = 4
- Strongly Agree = 5

Table 3.5: Usability and User Satisfaction Questionnaire (adapted from PSSUQ)

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Percentage Agree
Design/Layout/Function						
I liked using the interface of the keyboard						
The interface of the keyboard was pleasant to use						
The keyboard has all the functions and capabilities that I expect it to have						
Ease of Use						
It was simple to use this keyboard						
It was easy to find the information I need						
Overall, the keyboard was easy to use						
Learn ability						
It was easy to learn to use the keyboard						
There was too much information available on the keyboard						
Satisfaction						
I felt comfortable using this keyboard						
I enjoyed constructing my words through this keyboard						
Overall, I am satisfied with this keyboard						
Outcome/Future Use						
I was able to complete the task quickly using this keyboard						
I could not complete the task in the present time frame						
I believe I could become productive quickly using this system						
From my current experience, I think I would use it regularly						
Error/System Reliability						
Whenever I make a mistake using the system, I could recover easily and quickly						

3.1.1.5 Maintenance

There are four types of maintenance according to Lientz and Swanson (1980): corrective, adaptive, perfective and preventive. The approach for the keyboard would be the perfective maintenance.

Perfective maintenance mainly deals with accommodating to new or changed user requirements. Perfective maintenance concerns functional enhancements to the keyboard and activities to increase the performance of the user or to enhance its user interface (Van Vliet, 2000).

The output of the maintenance phase is typically user manuals and documentations. In this phase, the product design is updated to:

- Fulfill the changing needs of the user (if any)
- Adapt to accommodate change
- Correct errors undetected in testing
- Enhance efficiency of the design

3.2 Project Activities

3.2.1 Work Plan

Table 3.4 describes the project work plan.

Table 3.4: Project Work Plan

Stage	Task

Facto-perceptible (Requirements Phase)	- Selection of the research topic
	- Selection of the references
	- Accuracy of historical antecedents (literature review)
	    o Literature search about research field and object
	    o Wording and style revision of the historical antecedents
	- Presentation of the historical antecedents to the scientific committee

Elaboration	- Study on the visual perception of children (experiment)
Application (Design, Implementation, Verification and Maintenance Phase)	- Assessment and corroboration of the results - Construction of the conclusion - Design of the prototype - Presentation of the design prototype to the scientific committee - Re-evaluation of the results - Completion of the research

3.3 Key Milestones and Key Performance Indicator (KPI)

The following Table 3.5 is the key milestones and key performance indicator to measure milestone completion for the project:

Table 3.5: Project Milestone and Key Performance Indicators

Milestone	Key Performance Indicators
1. Identify the possible stakeholders and topic selection (Requirements Phase)	Stakeholders identified & initial proposal sent to the scientific committee
2. Consultation of full draft research proposal (Requirements Phase)	Finalize the key research elements
3. Relevant qualitative and quantitative data collated (Requirements Phase)	Document outlining results from the analysis completed and consulted on
4. Implementation of the research field (Design, Implementation and Verification Phase)	Design prototype and test usability of the prototype
5. Completion (Maintenance Phase)	Completion of the research

3.4 Gantt chart

Figure 3.8 depicts the Project Gantt Chart.

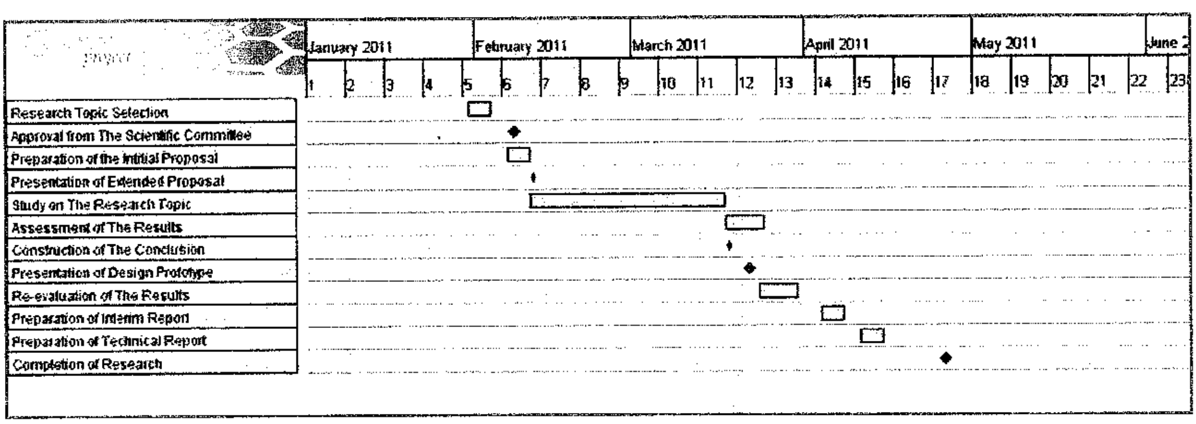


Figure 3.9: Project Gantt Chart

Figure 3.7 depicts the Project Gantt Chart for FYP 2.

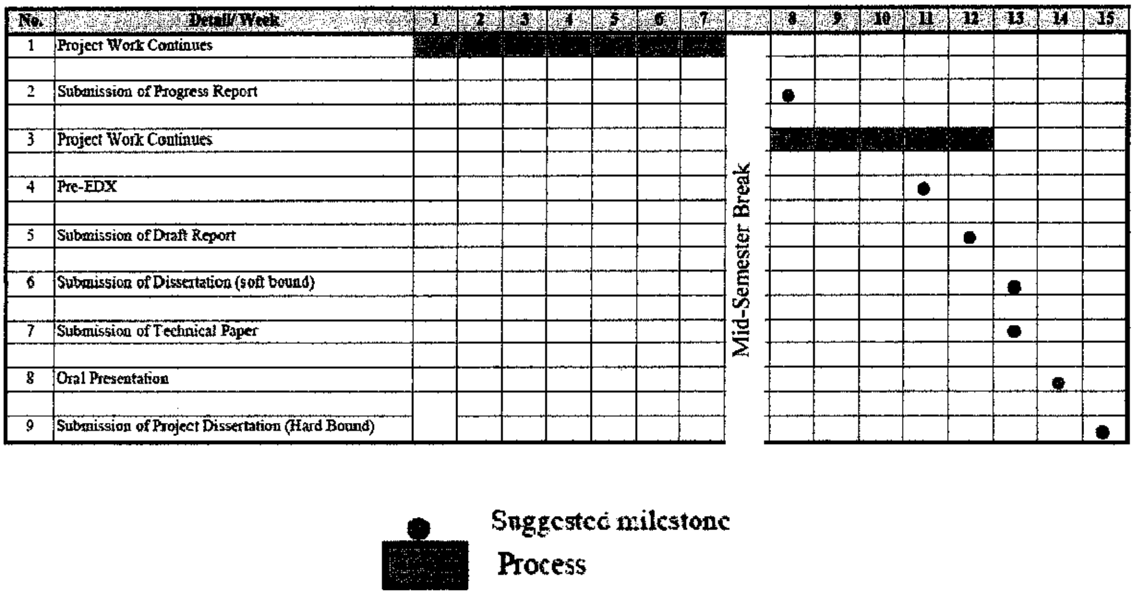


Figure 3.7: Project Gantt Chart for FYP2

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Color

The results obtained based on the study were consistent with the suggested color-coding design where eight colors were preferred amongst the 60 children. The 60 children were allowed to vote twice on their favorite and preferred colors. The results can be found in Figure 4.1 below.

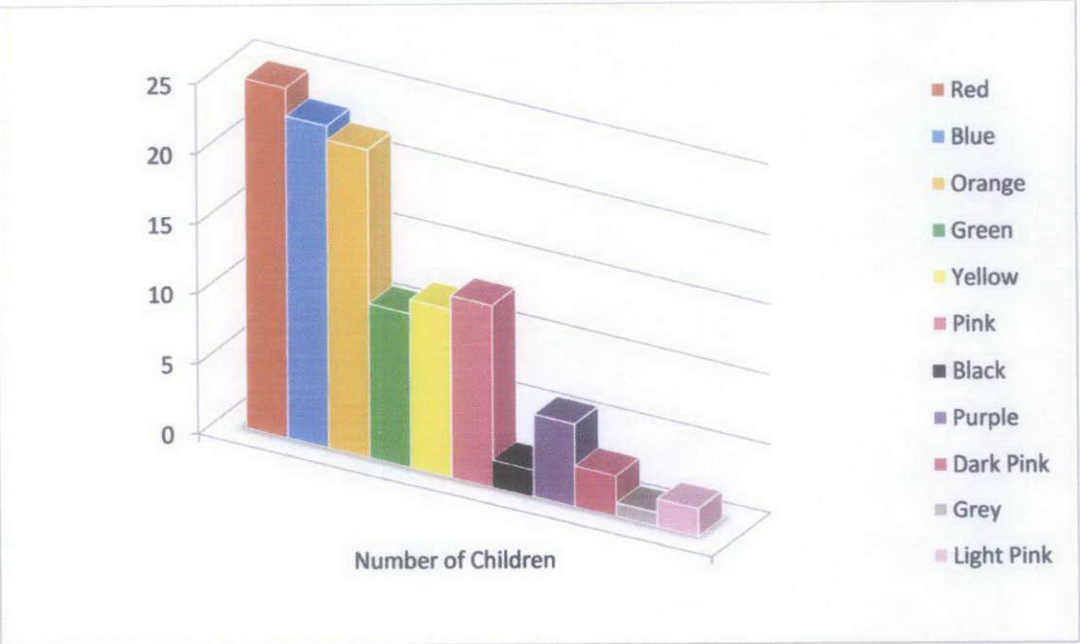


Figure 4.1: Children's Color Preference Chart

The results were consistent with the expected results where children preferred bright colors such as red, blue, orange, green, yellow, pink and purple. Based on these results the new keyboard would be color-coded according to the right finger association as discussed in Table 3.3. Table 4.1 shows the number of votes according to the color.

Table 4.1: Children's Color of Preference

Color	Number of Children
Red	**25**
Blue	**23**
Orange	**22**
Green	**11**
Yellow	**12**
Pink	**13**
Black	2
Purple	6
Dark Pink	3
Grey	1
Light Pink	2
Total Votes	**120**

4.2 Font Size

The study found that children are able to identify, recognize and differentiate the characters of the keyboard primarily when it is 82pt in font size. The children were asked to read five words, ranging from the font size of 26pt to 82pt at random to obtain the legibility of the word according to its size. The time was taken using a stopwatch and was recorded in a table. The results of the average time taken by the children can be deduced in the Table 4.2 below.

Table 4.2: Means (SDs) for font size

	Easy to read	Reading faster	Attractiveness
82-point size	4.7 (0.9)	4.8 (1.1)	5.1 (1.0)
74-point size	4.5 (0.7)	4.5 (1.4)	4.9 (0.9)
66-point size	4.5 (1.1)	3.8 (1.7)	4.4 (1.2)
58-point size	3.8 (1.3)	3.8 (1.5)	3.8 (1.7)
50-point size	3.8 (1.5)	3.8 (1.2)	3.6 (1.7)
42-point size	3.8 (1.7)	3.8 (1.5)	3.8 (1.7)
34-point size	3.6 (1.1)	3.8 (1.2)	3.6 (1.7)
26-point size	3.6 (1.3)	3.6 (1.5)	3.6 (1.5)

Analyzing participant's mean preference for each font size revealed a significant difference in ranking. The analysis found that 82-point was significantly preferred over the 26-point font size. Examining participant's 1st and 2nd preference choice further shows the popularity of the 82-point font in Figure 4.2.

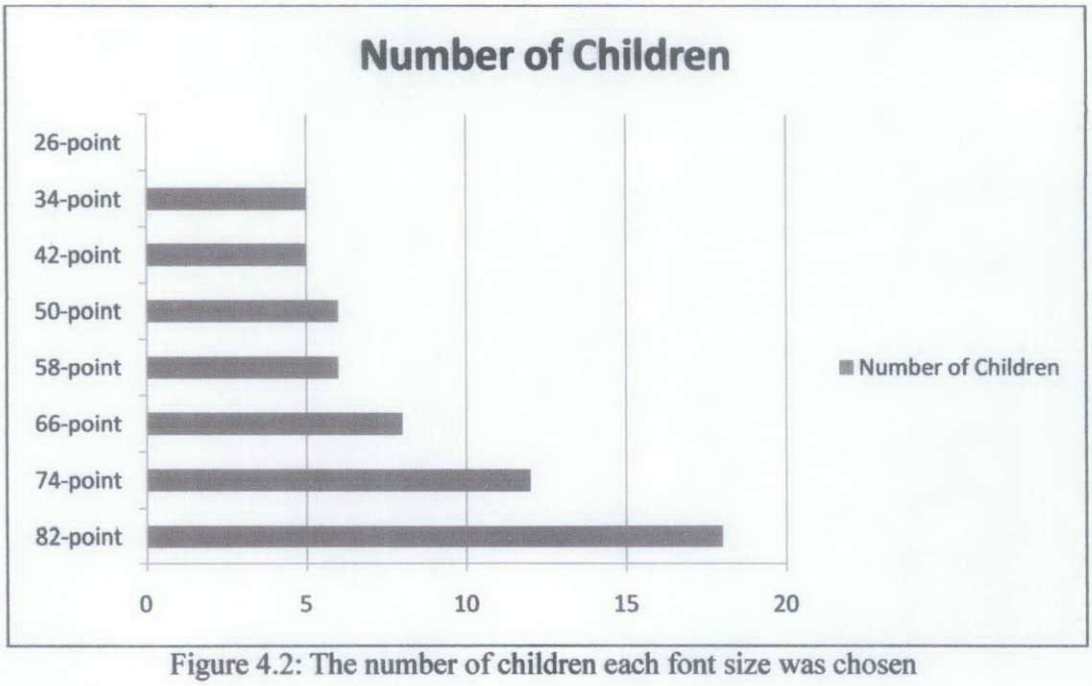


Figure 4.2: The number of children each font size was chosen

4.3 Discussion

The combination of results above have resulted in the ideal keyboard design for pre-school children having color-coded keys according to the finger association for touch typing instead of the conventional "hunt-and-peck" method used by young children this age.

Touch typing is the ability to type without using the sense of sight to find the keys. In other words, a touch typist require on the muscle memory to find the location of the keys on the keyboard. Touch typing typically involves placing the eight fingers in a horizontal row along the home row and having them reach for the keys.

Color-coding the keys of the keyboard for touch typing is expected to efficiently bring an average speed typist to 40 words per minute (a rough comparison) in comparison to 60 words per minute for a coherent QWERTY keyboard user. It is also expected to increase accuracy by great amounts. To learn how to touch type, it is natural for children to position their fingers at the home row initially. Figure 4.3 depicts the keyboard design for young children with the color-coded according to the finger association as suggested in Table 3.3.

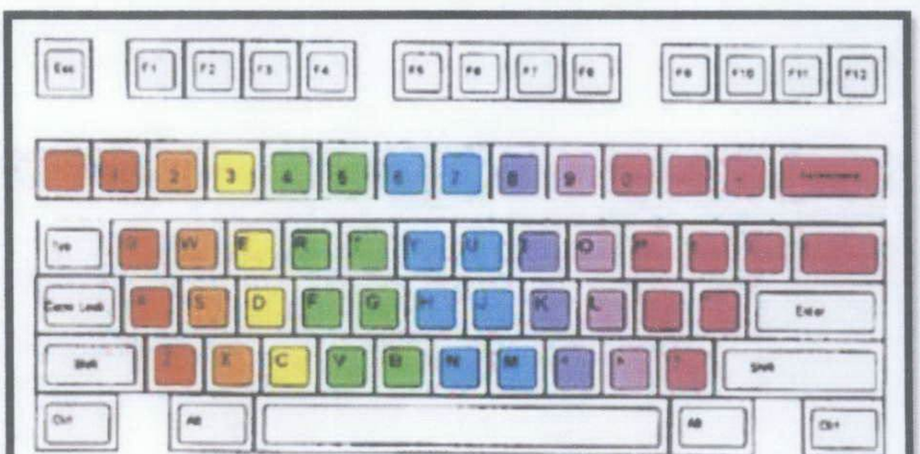


Figure 4.3: Color-Coded Keys for Touch Typing

Figure 4.4 below indicates that in order to train for touch type, young children must learn to use the keyboard from the home row (middle row).

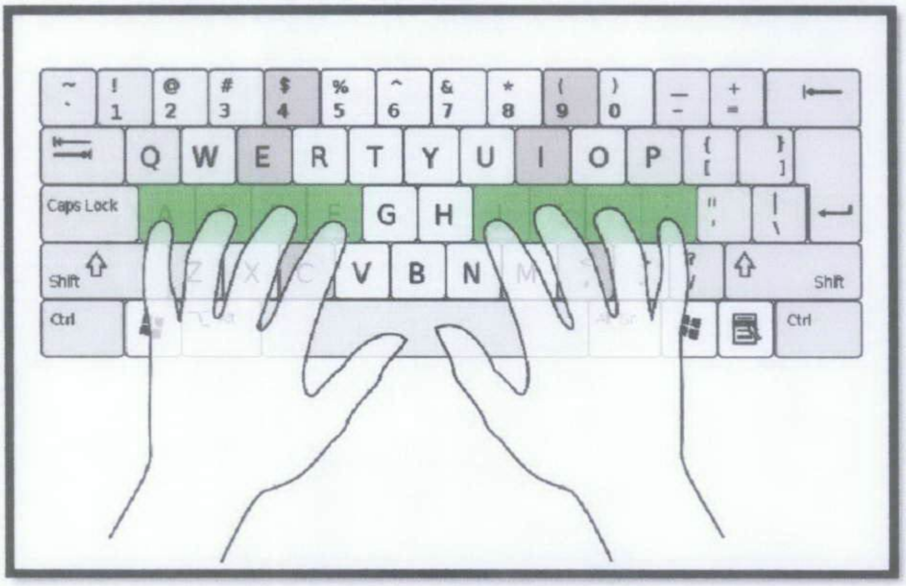


Figure 4.4: Finger Positioning on the Home Row

The results have yielded the following output for the keyboard design. Figure 4.5 shows the prototype design of the keyboard for pre-school children. The keys in darker grey (e.g. beside the key '1') are made into a dummy key where there will be no output produced when the keys are pressed. The symbols on the keyboard which are generally underused by children are also removed to ensure that children can concentrate on the alphabets and numbers on the keyboard without the distractions of the symbols.

The design will be made into a prototype where further tests and investigations can be carried out. The tests that will be carried out are the usability test and in addition the user acceptance test to ensure that the keyboard is accepted and will be used by the children.

Figure 4.5: Prototype design of the keyboard for pre-school children

Figure 4.6 below shows the user view of the keyboard.

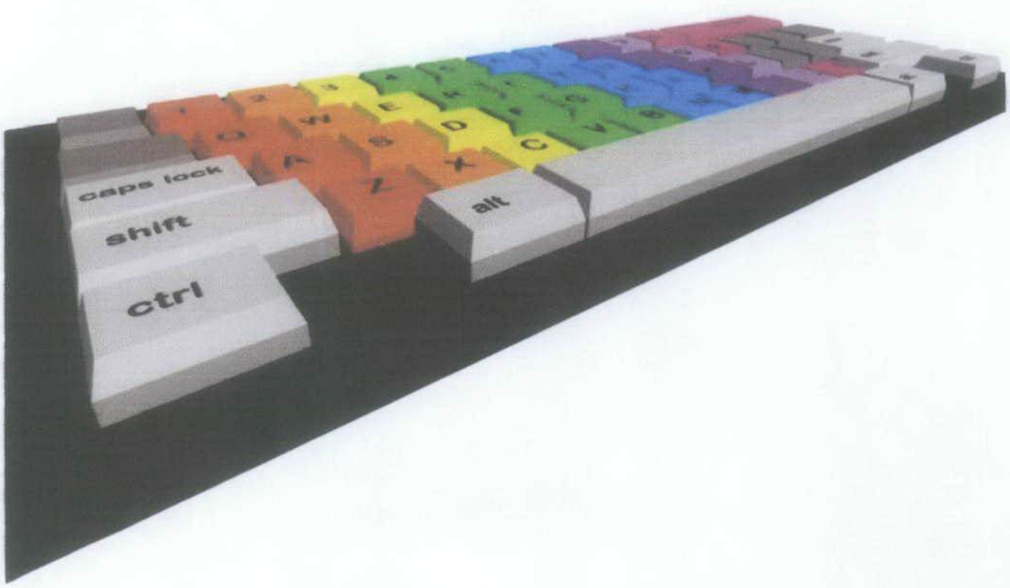


Figure 4.6: User view of the keyboard

4.4 Usability Test

The usability test was intended to determine the extent of the keyboard interface facilitates the children's ability to complete the task given. Typically the test is conducted with a group of potential users (pre-school children) on-site with portable equipment. Users were asked to complete a series of routine tasks. Sessions are recorded and analyzed to identify potential areas for improvement to the keyboard.

4.4.1 Introduction

The researcher conducted an onsite usability test at the homes of the children from the 5^{th} of August to the 7^{th} of August, 2011. The purpose of the test was to assess the usability of the keyboard interface design, information flow (in terms of characters of the keyboard) and information architecture (layout of the keyboard).

Eight children participated in the test. Typically a total of eight to ten participants are involved in usability test to ensure stable results. Each individual session lasted approximately 30 minutes. Test scenarios differed over the two test days.

In general all participants found the computer keyboard to be clear, straightforward and 92% thought the keyboard was easy to use. 5 of the 8 participants used the computer keyboard on a regular basis.

The test identified only a few minor problems including:

- Difficulty in association to the alphabet and the color
- Association of the color and characters are of no relevance

4.4.2 Session

The test administrator contacted and recruited participants via kindergarten school located in Bandar Kinrara. The test administrator sent e-mails to the parents of the children informing them of the test logistics and requesting their availability and participation. Participant's parents responded with an appropriate date and time. Each individual session lasted approximately half an hour. During the session, the test administrator explained the test session and asked the participant to answer the questionnaire (PSSUQ).

After each task, the administrator asked the participant to rate the interface on a 5-point Likert Scale with measures ranging from Strongly Disagree to Strongly Agree. Post-task scenario subjective measures included:

- How easy it was to identify the characters on the keyboard
- Ability to locate the characters on the website
- Color and font size in helping to identify the characters on the keyboard

After the last task was completed, the test administrator asked the participant to rate the keyboard using a 5-point Likert Scale (Strongly Disagree to Strongly Agree) for six subjective measures including:

- Design/Layout/Function
- Ease of Use
- Learn ability
- Satisfaction
- Outcome/Future Use
- Error/System Reliability

In addition, the test administrator asked the participants the following overall keyboard questions:

- What the participant liked most
- What the participant liked least
- Recommendations for improvement

4.4.3 Results

All participants successfully completed Task 1 (type the word "dog"). Two of the eight

(25%) completed Task 2 (find the letters A to Z). approximately half (50%) of participants were able to complete Task 3 (type the word "umbrella") and 37.5% (three participants) were able to complete Task 4 (type within the given time limit). Table 4.3 shows the task completion rates.

Table 4.3: Task Completion Rates

Participant	Task 1	Task 2	Task 3	Task 4
1	√	√	-	-
2	√	-	√	-
3	√	√	-	√
4	√	-	-	-
5	√	-	√	√
6	√	-	√	-
7	√	-	√	-
8	√	-	-	√
Success	**8**	**2**	**4**	**3**
Completion Rate	**100%**	**25%**	**50%**	**37.5%**

Table 4.4 describes the participant's behavior during the test.

Table 4.4: Results of Participants Behavior

Participant Behavior	Type of Behavior (Raw Data Theme)	Behavior group (Higher order theme)
P1 Squinted eyes for more than five seconds P4 Squinted once or twice P8 Squinted once	Squinted (3)	Change in visual behavior (5)
P3 Lost interest after looking at keyboard P5 Looked at other participants	Looked Away (2)	
P2 Identified characters more than five seconds P7 Identified characters less than two seconds P6 Concentrated on the task given	Attentive (3)	No clear change in visual behavior (2)

After the completion of each task, participants rated the ease or difficulty of completing the task for three factors:

- It was easy to distinguish the characters on the keyboard compared to the conventional keyboard
- As I was searching for the characters on the keyboard, I was able to associate each finger according to the color
- I was able to accurately predict which color is associated to which finger

The 5-point rating scale ranged from 1 (Strongly disagree) to 5 (Strongly agree). Agree ratings are the agree are the agree and strongly agree ratings combined with a mean agreement ratings of less than 4.0 considered as the user agrees that the characters on the keyboard were easier to distinguished compared to the conventional keyboard, they are able to associate each finger according to the color and they are able to accurately predict which color is associated to which finger.

The testing software recorded the time on task for each participant. Some tasks were inherently more difficult to complete than others and is reflected by the average time on task.

Task 2 required the participant to locate the alphabets A to Z and took the longest time to complete (mean = 210 seconds). However, completion times ranged from 110 (approximately 2 minute) to 390 seconds (less than 7 minutes) with most times less than 80 seconds (less than 1.5 minutes). Table 4.5 describes the time on task.

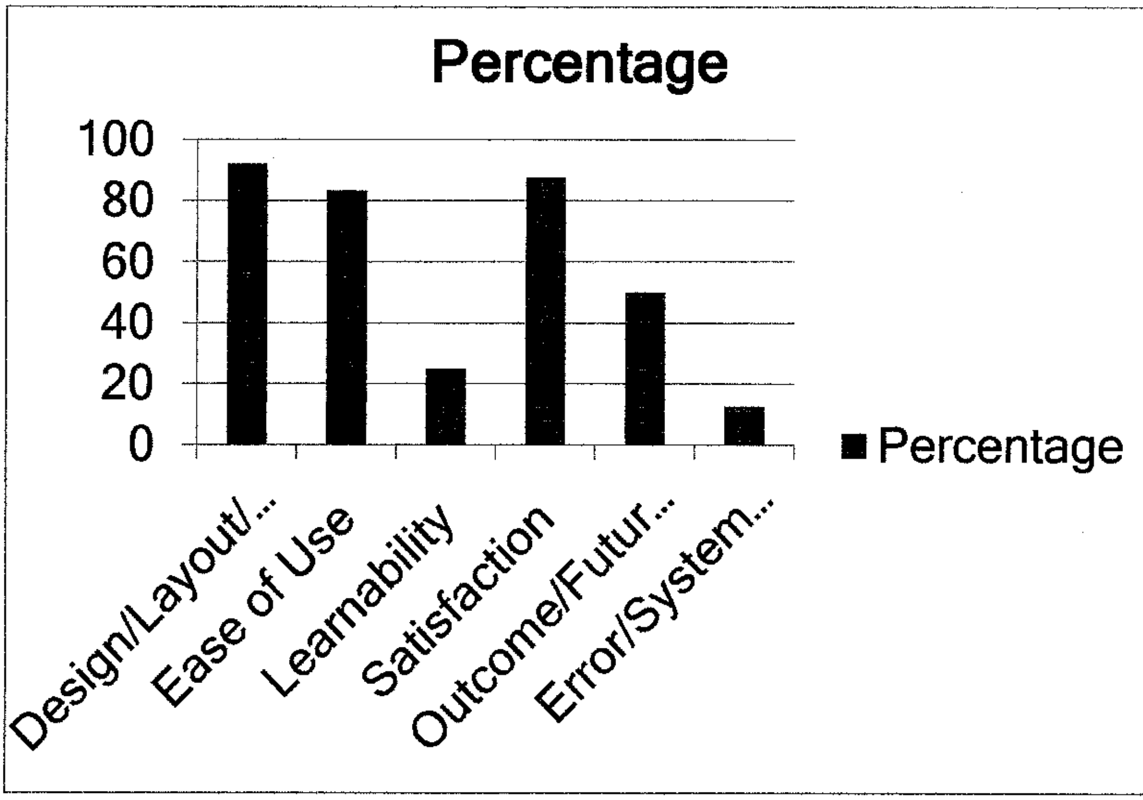
Table 4.5: Time on Task

	P1	P2	P3	P4	P5	P6	P7	P8	Avg. TOT*
Task 1	30	40	20	35	38	28	33	**42**	33.25
Task 2	130	370	150	200	110	155	390	250	**219.38**
Task 3	80	90	83	75	100	**110**	105	95	92.2

After task session complete, participants rated the keyboard for six overall measures. These measures include:

- Design/Layout/Function
- Ease of Use
- Learn ability
- Satisfaction
- Outcome/Future Use
- Error/System Reliability

Most of the participants (87.5%) agreed that the keyboard was easy to use. The majority participants (87.5%) agreed that they would use the keyboard frequently and that the colors and font of the keyboard would keep them coming back. Even though participants' average agreement rating was 3.9, only 50% (due to 5 neutral and 5 strongly agree responses) agreed that the aesthetics of the keyboard would make them want to use computers more. Table 4.6 shows the post-task overall questionnaire results.



.Figure 4.7 : Post-Task Overall Questionnaire Results Chart

Figure 4.7 shows the results of the post-task overall questionnaire in a graphical form. The usability test was also conducted using the think-aloud method. The results of the think-aloud method can be found in Table 4.6.

Table 4.6 : Think-Aloud Method Results

Participant	**Comments**					
	Design/Layout /Function	**Ease of Use**	**Learnability**	**Satisfaction**	**Outcome/Future Use**	**Error/System Reliability**
P1	Colorful	Need more training before use	Task can be difficult to complete	Unable to complete certain tasks	Hope to use it again	-

P2	Too many colors	Confusing at first	Easy to understand after sometime	Unable to complete certain tasks	Interested in the colors	Fine
P3	Like the colors	Unable to understand the interpretation	Difficult tasks	Unable to complete certain tasks	Want to try again	-
P4	Interesting compared to normal keyboard	Fun to use	Understand the spectrum colors	Unable to complete certain tasks	-	-
P5	Like the association of fingers	Need more training	Like the spectrum colors for learning	Unable to complete certain tasks	Hope to have one at home	-
P6	Colorful	Need more training	Difficult tasks	Unable to complete certain tasks	-	-
P7	Like the different use of fingers	Confusing at first	-	Unable to complete certain tasks	Hope to use it again	-
P8	Too many colors	-	-	Unable to complete certain tasks	-	-

Table 4.6: Post-Task Overall Questionnaire Results

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Percentage Agree
Design/Layout/Function						
I liked using the interface of the keyboard			1	7		87.5
The interface of the keyboard was pleasant to use			1	2	5	87.5
The keyboard has all the functions and capabilities that I expect it to have					8	100
Ease of Use						
It was simple to use this keyboard		2	1	3	2	62.5
It was easy to find the information I need			1	2	5	87.5
Overall, the keyboard was easy to use				8		100
Learn ability						
It was easy to learn to use the keyboard		3	3	2		25
There was too much information available on the keyboard			6	2		25
Satisfaction						
I felt comfortable using this keyboard			1	3	4	87.5
I enjoyed constructing my words through this keyboard			2	5	1	75
Overall, I am satisfied with this keyboard				8		100
Outcome/Future Use						
I was able to complete the task quickly using this keyboard			5	3		37.5
I could not complete the task in the present time frame			4	4		50
I believe I could become productive quickly using this system		2	4	2		25
From my current experience, I think I would use it regularly			1	7		87.5
Error/System Reliability						
Whenever I make a mistake using the system, I could recover easily and quickly			7	1		12.5

*Percentage Agree (%) = Agree & Strongly Agree Responses combined

CHAPTER 5

CONCLUSION

5.1 Conclusion

The conventional QWERTY keyboard design was found to be unsuitable for young children due to the reason being preliterate. The study was done to design a suitable computer keyboard for young children with the main intention to facilitate young children in learning how to touch type with the QWERTY keyboard. The research includes the study of children's color preference to color-code the keys on the keyboard. In addition to the study, the research also concentrates on the suitable font size on the keyboard for young children for exploration purposes and providing children with a clearer view of the keys on the keyboard for identification purposes.

The results of this study concurred with the initial expectations. The result of the study yielded the design prototype of the keyboard having color-coded keys according to the finger association together with a larger font size. There were two major explanations for this outcome. First, it seems reasonable that the larger font size contribute to the high legibility on the characters on the keyboard. The results of the test might be more apparent due to the reason that children have to go through an initial difficult period of adjustment before positive results became more apparent. Secondly, the color on the keyboard stimulated the children's mind and helps them distinguish characters better on the keyboard.

5.2 Recommendation

A tabled PC is defined as "a type of notebook computer that has an LCD screen on which users can write and type". Recent projects have focused on student's usage of tablet PCs. Kravcik et al (2004) describes the use of tablet PC for elementary children in the design of a system enabling "virtual field trips". The study for the suitable keyboard for young children can be further extended by implementing on touch screen devices such as tablet PCs.

Other recommendations include the study of picture association to the characters on the keyboard to further aid the children in associating the characters with something more familiar. For instance, the alphabet A could be associated to "apple" as commonly learned by children and the picture is appended to the keys on the keyboard. Another example may be the alphabet B associated to "ball" with a picture of a ball on the key of that alphabet.

Further recommendation of this study is to study how animals with high brain capabilities could interact with humans using devices such as the keyboard. The study may include how animals such as chimpanzees may learn how to use the keyboard using brain stimuli such as color to aid them in communicating with humans.

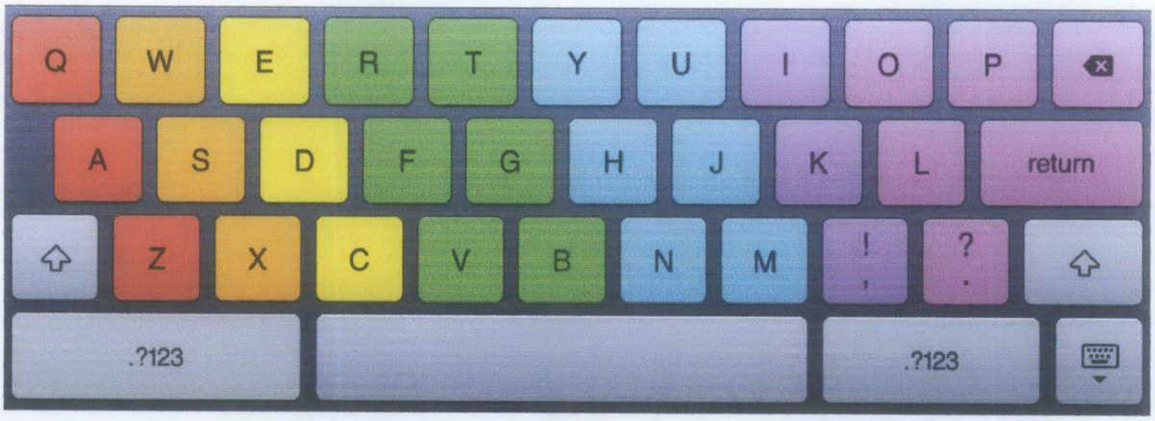


Figure 5.1 : Color-coded keyboard on iPad Keyboard

The researcher hopes that the research on the keyboard to be expended to the size of the keys. The size of the keys on the keyboard can be measured by using Fitts Law. Fitts' law was modeled to study the behavior of the human's psychomotor (Fitts', 1954). Fitts' Law is used to predict the time required to rapidly move to a target (in this case from one keystroke to another) area. The Fitts's Law is a means to measure the time taken for one child to complete his or her task. The Fitts's Law is formulated as below:

$$MT = a + b \log_2 (D/W + 1)$$

where a approximates the start/stop time in seconds, for a given device, and b measures the inherent speed of the device. Both a and b need to be determined experimentally for each device. For example, if a were 300 ms, b were 200 ms/bit, D were 14 cm and W were 2 cm, then the movement time MT would be 300 + 200 $\log_2$ (14/2 + 1), which equals 900 ms.

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