ASHESI UNIVERSITY COLLEGE

PRINCIPLES AND GUIDELINES FOR DEVELOPING WEB APPLICATIONS FOR CHILDREN; A GHANAIAN PERSPECTIVE

By

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I hereby declare that this dissertation is the result of my own original work and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature: ……

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I hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by Ashesi University College.

Supervisor's Signature: ……..

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Date: ……..

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Abstract

Children, in Ghana, between the ages of 5 and 10 have a good amount of knowledge on the use of web applications and browsing for information on web sites. However, knowledge on how to develop web applications for these children is very limited. The process for establishing principles and guidelines for the development of web application for these children has been started, though, in countries like the United States of America. The aim of this dissertation is to start the process for establishing such principles and guidelines for Ghanaian children as well.

By combining the study approaches used by a number of researchers discussed in this paper and analyzing the results, findings proved that the use of color and images should be minimal and the display of instructions should be visible and straight to the point. The facts mentioned above in addition to many others have been discovered. It is therefore essential that web developers, who seek to develop for Ghanaian children within the given age range, consider these during development.

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CHAPTER 1: INTRODUCTION

Introduction

The use of computers and the Internet for communication, access to information, etc. has become widespread in Ghana due to the phenomenon of globalization. Today, it has become important that people acquire knowledge in the use of computers and subsequently the Internet due to the increasing demand of businesses and individuals for IT expertise. Consequently, Computer Science has become one of the important majors offered in tertiary institutions and has almost taken the place of the Engineering majors. Many job positions advertised by companies in Ghana require some level of computer proficiency without which getting the job is close to impossible. In response to this demand is the proliferation of what has come to be known as "computer schools".

This trend has influenced many primary and junior high schools to include computer studies in their curricula. Some elite institutions like Lincoln Community School and Ghana International School have computing as an integral part of their educational process. Consequently, children in Ghana are increasingly gaining knowledge in the use of computers and mobile phones. Children need to be able to take advantage of all the educational opportunities that computers and the Internet have to offer. This is the essence of this dissertation.

How do all these developments link to this dissertation? More young people in Ghana are gaining access to computers and the Internet daily. This

is confirmed by the number of Ghanaian people who are using social networks like Facebook and Twitter. On Facebook alone, there are about 300,000 (0.1%) out of the about 300 million users. [21] Unfortunately, many of these websites and software are not targeted towards children. Therefore, many children use the computer and Internet solely for the purposes of gaming and watching movies.

Developing software and websites for adults is more standardized and researched due to the role organizations like the World Wide Web Consortium (W3C), International Organization for Standardization (ISO) and Institute of Electronic and Electrical Engineers (IEEE), etc. have played in the process so far. There are a number of recommendations and standards to guide and synchronize efforts. Usability organizations like the Nielsen/Norman (N/N) group, in the United States, have done similar research for American and Israeli children. This dissertation seeks to examine and propose a set of principles, recommendations and guidelines for developing web applications from the Ghanaian perspective.

Background

Research and real-life occurrences, especially, show that the world is becoming increasingly dependent on technology, and Ghana is no exception. According to research on children's use of the Internet organized in 2007 by the NPD Group, a leading global provider of consumer and retail market research to a wide variety of industries, [20] more and more children between the ages of 6 and 7 years have been introduced to and are using

technology. This contrasts their research in 2005 which found that children who used the Internet were between the ages of 8 and above [8]. It can thus be extrapolated that in 2010, three years later, the age range may have reduced further to 4 – 6 years. The US Department of Education also undertook some research in 2005 that revealed that the US population has 32% of kindergarten age children and 50% of those in 1st through 5th grade using the Internet. In addition, the Pew Internet and American Life Project also estimates that 87% of children aged between 12 and 17 years old go online. [7] From all the statistics above it can be seen that the use of computers and the Internet in the developed countries by children is really high and growing.

Furthermore, Elementary-age children form a majority of computer and Internet users in the US. [3] Research has confirmed that 83% of homes in the U.S. with children own computers and 78% use the Internet. [3] This was in 2002 and in 2003, 42% of children between 5-9 years and 67% between 10-13 years used the Internet. [13] A number of reasons require children to use the Internet, including schoolwork, which they mostly use search engines and digital libraries for, playing games and communicating. [13]All these often require their use of the Internet. [13] Finally, the University of California, Los Angeles (UCLA) Centre for Communication Policy (2003) reported that there had been a 12% increase in the number of children who went online in 2002 since their research in 2000. And about

75% of children who used the Internet in 2002 went online at their school. [14]

With the increasing dependence on technology and specifically the Internet in everyday activities, it is not surprising that the World Wide Web Consortium (w3c), in collaboration with leading software companies, published recommendations for web design. These recommendations have become very successful and hence have been standardized for the development of web applications. The recommendations have also contributed to the success in building web application for children.

There are also legal aspects to this discussion. In 1998 the legislative body in the United States of America and the District of Columbia had a discussion on how to protect children's privacy online [9]. The Children's Online Privacy Protection Act of 1998 was the result of their deliberations. In this legal document there are a number of definitions, for instance, a child is defined as any "individual under the age of 13" [9] and the operator is any individual who controls some form of operation on the Internet. The important point in this document is the measures put in place to ensure that operators do not take undue advantage of the children while they use the Internet for any purpose.

Objectives

To understand better the importance of this research paper, the above statistics, policies and laws have been discussed. The growth in the

developed economies has become contagious for the other economies due to the phenomenon of globalization, which has technology and communication as its main catalysts. To function efficiently in this "global village" it is necessary that users understand technology and the means of communication which works best for them.

Thus it is for this aim, first; presenting the cultural bias of the use of web applications by Ghanaian children, that this dissertation's importance is presented. It seeks to present a cultural bias to the existing principles and guidelines for developing web applications for children. Secondly, this dissertation seeks to offer an extension to the already existing principles and guidelines to include Sub Saharan Africa with specific emphasis on the Ghanaian setting.

Research Questions

There are a number of questions that this dissertation seeks to answer but, the author has two main ones:

- Will Ghanaian children learn better with the existing web applications with guidance from the older generation as proposed by Lev Vygotsky's theory?
- Do the principles and guidelines of the researches organized by researchers all over the world, for example Shiva Naidu, Allison Druin and Alexandre Mano and José C. Campos apply to Ghanaian children?

These are the questions this dissertation seeks to answer.

Literature Review

This section focuses on researches that have been done in this area of study; developing usable web applications for children. Like most areas of study, a lot of research has already been done, however, one important fact the researchers never fail to mention is that the area is in its infancy stages. Jakob Nielsen, called the guru of Web page usability by New York Times and the king of usability by Internet Magazine [17], confirms, in one of his many usability tests for web users, that although the number of children who use the Internet increases continually, researchers have very little knowledge about how children actually use websites or how to design sites that children can use easily. [17]

Most research that has been undertaken for the development of web applications for children has had the American populace as their main focus. Other countries of focus are China, Israel, Portugal and a few more. One unfortunate thing noticeable throughout research is the lack or unavailability of such research for African countries. This is the reason, among many, which makes this research very important. Three distinct and unofficial groups are identifiable throughout the researches: the theorists, the usability group and the researchers. The discussions that follow will be centered on these three groups and further on what each of these groups has to offer to the development of principles and guidelines for the creation of web applications, for children.

The Theorists

The theorists list and explain the reasons why children have difficulty using most of the already existing web applications. They do this by finding ways of explaining the process by which children develop cognitively. Cognition is generally described as the brain processes that take place when people undertake daily activities like thinking, remembering, learning, daydreaming, decision-making, seeing, reading, writing and talking.[12] There are two general modes of the cognition: experiential and reflective. Experiential cognition is the effective and effortless state of mind in which people and children perceive, act and react to the incidences that take place around them. It needs some level of expertise and engagement. [12] Experiential cognition develops especially when an individual gains formal education or engages in some activity for a period of time. Reflective cognition, on the other hand, involves thinking, comparison and decision making. It more often than not leads to the generation of new ideas and creativity. [12]

Generally a child is able to perform activities depending on how well developed these individual parts of that child's cognition are. A child also develops cognitively when his or her way of understanding this world changes due to changes in either age or experience or both. [1] By studying cognition in children, the theorists help teachers and educative web application designers to understand the children in order to use the best,

necessary and available methods to communicate efficiently to them at any given age range. [4]

The theories propounded by these theorists have become accepted generally in the psychology as the ways in which children develop cognitively. Consequently, these theories can help find a suitable solution to the discussion on developing usable web applications for Ghanaian children. In line with the goal of emphasizing the importance of culture in the development of web application for children, two theorists have been chosen: Jean Piaget and Lev Vygotsky. Vygotsky is one of many theorists who stress the importance of cultural tools; language and social interaction in the cognitive development of a child. [2] Between Lev Vygotsky and Jerome Bruner, two well accomplished psychologists who share the same ideas, Vygotsky is preferred over Bruner for this research because the former has a better explanation of how the cultural tools influence the development of the cognitive abilities of a child. The theories of the chosen theorists will now be discussed briefly.

Jean Piaget

Jean Piaget proposes that children develop their cognitive abilities in four stages: the sensorimotor stage, pre-operational stage, concrete operational stage and lastly the formal operational stage. Two main processes; assimilation and accommodation, form the basis of Piaget's theory on the cognitive development of children. According to Piaget, assimilation is the process by which a person receives information into his or her mind from

the environment. This may sometimes mean adjusting the evidence of their senses to make the received information fit. [3] Accommodation, on the other hand, is the difference made to one's mind, concepts or ideas by the process of assimilation. [3] The two operate together.

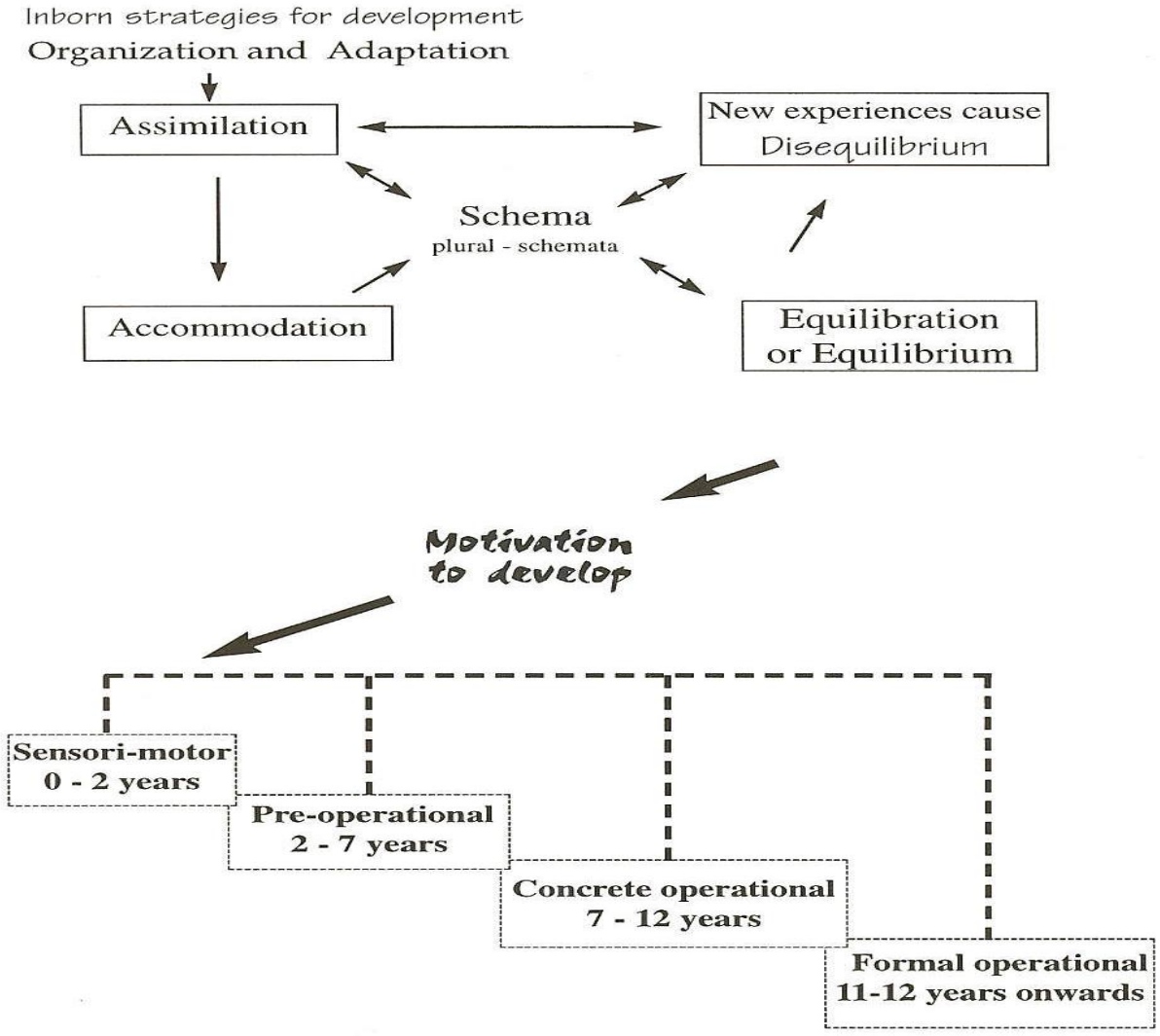
In other words, assimilation is the information one already knows while accommodation involves adapting the knowledge that one already has to what he or she perceives. [4] Thus any child who has not reached a particular stage will be completely unable to perform activities in the new stage since there is disequilibrium which occurs when one's accumulated knowledge does not match new knowledge. [4] Throughout a child's life schemes are developed. Schemes are the mental representations of people, objects, or principles that are created in a child's mind. [4] Piaget further explains that assimilation and accommodation are the activities performed on the schemes developed by the child. Equilibrium is reached between these two processes when a child has reached the next stage.

The Sensori-motor stage is a period between the ages of 0 and 2 years. [4] During this stage the child experiences his or her own world through his or her senses and the movement of people and things around the child. [4] The child also comes to a realization that objects seen exist even when they are out of sight and the child gets to appreciate that every action taken has a reaction. [4] The Pre-operational stage is the next stage. This stage spans from the child's 2^{nd} to 7^{th} years. Piaget states that the child has not yet mastered the ability of mental operations and still does not have the

ability to think through actions. [4] Again the child assumes that the whole world revolves around them which results in egocentricism.

The Concrete operational stage ushers the child into a period of working with tangible objects and learning through hands-on discovery and exploration. Reasoning processes also begin to form at this stage. [4] According to Piaget there are three basic reasoning skills that the child acquires during this stage: identity, compensation, and reversibility. [4] The child at this stage is between the ages of 7 and 11. The ages, 5-10, chosen for this dissertation is between the pre-operational and mostly the concrete operational stages. The last stage, formal operation, is from 11 years to adulthood. This stage, though not everyone reaches, endows an individual with the ability to think abstractly. [4] People in this stage are able to use diverse strategies to solve problems. They achieve skills such as inductive and deductive reasoning abilities and are thus able to identify the factors of a problem, and deduce solutions.[4] There are a number of flaws with this theory, but the main one is the fact that in real life the stages described by Piaget do not flow into each other as smoothly.

Figure 1.1[2]: Piaget's Theory of Cognitive Development showing the relationship between the Invariant Functions and Stages



Lev Vygotsky

Vygotsky's theory proposes fundamentally that children do actually grow in stages; however, unlike the theory proposed by Piaget, they are able to perform activities that are above their stage with guidance from older people, like parents, siblings and teachers, through a process called scaffolding. He adds that a child's cognitive development is largely influenced

by the cultural environment in which the child finds him or herself. This idea is of greater importance to this dissertation due to the emphasis on the Ghanaian perspective which implies a cultural relevance. Vygotsky further discusses that the development of a child consists of passage through a series of periods of stable development namely, infancy; childbirth to a year, early childhood; 1 to 3 years, pre-school age; 3 to 7 years, school age; 7 to 13 years and finally puberty that lasts from 13 to 17 and even afterwards. [5] These periods of stable development are punctuated by periods of crisis: at birth and at the ages of 1, 3, 7, 13 and 17. [5] Figure 1.3 discusses the crisis at the different stages and how the child relates to himself or herself is summarized.

Figure 1.3

Crisis period	**Self-Relation**
Birth	The child physically separates herself from the mother and creates the conditions for the 'front brain' to begin work, through which alone social interaction is possible.
Crisis at 12 months	Still unaware of herself as a person distinct from those around her. The child manifests her own will and her own personality for the first time through interaction with adults.
Crisis at age 3	Having gradually developed a consciousness of themself as a distinct person, the child separates themself from the mother psychologically, and by differentiation of behavior from affect, brings their behavior under control of their own will.

Crisis at age 7	Having gradually expanded their radius of activity beyond the family, the child gains control over their relations with other people by the differentiation of internal and external life, manifested in an ability to act strategically.
Crisis at age 13	Having acquired knowledge appropriate to their social position, the child distances herself from her birthright by taking a critical stance toward it.
Crisis at age 17	Note that the child begins totally undifferentiated, physically, biologically development.

Thus, Vygotsky's theory has two main views. The first specifies the 'line of natural development of behavior which is closely bound up with the processes of general organic growth and the maturation of the child.'[6] The second, on the hand, defines the 'line of cultural improvement of the psychological functions, the working out of new methods of reasoning, and the mastering of the cultural methods of behavior.'[6] With this foundation, Vygotsky explains further that the growth process and transformation that goes on in children is the same for all children, however, under different social conditions these transformations happen differently, and sometimes at different ages as well[6]. His assertion that the development of children takes place very differently in different historical circumstances is not just a matter of empirical fact, but also points to the need for concepts which makes it possible to understand the route by which cultural factors aid in the development of children. [6] This also makes it easy to understand the

mechanism by which the culture and institutions of a society are reproduced from generation to generation. [6]

Like Piaget, Vygotsky also has a number of principles that he explains and uses in propounding his theories but the most relevant ones to this dissertation will be discussed. Scaffolding, as mentioned before, is the process by which children learn how to perform activities by being directed by older people. This is done by giving the learner, in this case the child, hints or clues for solving problems in order to offer the student a better way of approaching the problem in the future [4]. The children learn through social interactions and their culture, unlike Piaget's theory which states that children act on their environment to learn. [4] The development of language is considered to be a major principle of Vygotsky's socio-cultural theory. The language of a certain group of people indicates their cultural beliefs and value system. [4]

Another “Vygotskian” principle for teaching involves the zone of proximal development. Like Piaget, Vygotsky believes that there are some problems out of a child's range of understanding. However, Vygotsky believes that given proper help and assistance, children can perform a problem that Piaget would consider to be out of the child's mental capabilities. The zone is the area in which a child can perform a challenging task, given appropriate help. [4]

Lastly and very importantly in this discussion is an emphasis on the importance of cultural tools in the cognitive development of a child. Cultural

tools are any tools: technological or symbolic, etc. which aid in communication. [4] Language, the media, television, computers, and books are only a handful of all the cultural tools available for problem solving or learning. After receiving co-constructed help, children are able to internalize the use of these cultural tools, and are better able to utilize the tools in the future on their own. [4]

In summary these two researchers were discussed due to their contribution to the understanding needed to develop web applications for children. Vygostsky's discussion on the importance of the use of cultural tools in the cognitive development of children contributes immensely to understanding how to use the computer and Internet as cultural tools for the Ghanaian child's cognitive development.

The Researchers

The researchers aim to analyze how children use the Internet and web applications and then, based on their analyses, give guidelines or best practices for making web applications for children more children-friendly. They do this mainly by organizing surveys, handing out questionnaires and lastly and mostly used, giving the children a number of web applications to perform tasks on. Most of these tasks are either a set of activities that the children perform on the given applications or they are just left to browse. With a specified set of criteria the researchers observe how the children use the web applications. Based on their findings they propose guidelines and best practices for developing web applications for children or make the

information available to the people who propose the guidelines. Due to the focus of this dissertation the principles and guidelines proposed by these people will be given more consideration.

For this dissertation three researches by other researchers will be discussed. Each of the researches will be discussed with the outlined format below. There will be a little introduction on the purpose of the research and what the researchers hoped to achieve with the research. Then the findings and conclusion; principles and guidelines will be given.

Evaluating the Usability of Educational Websites for Children by Shiva Naidu is a study that examined the usability of educational websites for children [14]. This study was organized in 2005 and the evaluation of the sites was particularly done between April and May 2005. In this study as stated above the researcher hoped to ascertain how well the educational websites that had been developed for the children (7-11 years) were serving their purposes to their audience. The research achieved its aim by observing how the children used the website to find educational information while they worked. One particular fact about this study, like some of the others, is its consideration of the important role the developers play in making or creating websites that are useful to children.

Some guidelines from two previous researches Naidu referred to in her research can be concluded into two main points: children prefer and work better with interactive web applications, however, a lot of frames cause confusion and elaborately listed tables and poorly organized links burden the

children cognitively. Secondly, children find it easier browsing than keyword searching because the former required less cognitive skills.

Naidu's study evaluated three components: children's' success, navigational efficiency, and satisfaction. With these components Naidu sought to further understand what aspects of educational websites influence performance and satisfaction. [14] The chosen websites Enchantedlearning.com®, Factmonster.com™, and Infoplease.com's Homework Center offered similar content but different interfaces to their users. In Figure 1.4 the web pages, EnchantedLearning.com, FactMonster.com and InfoPlease.com Homework Center have been represented respectively. One important fact to note is that these sites changed after this research.

Figure 1.4

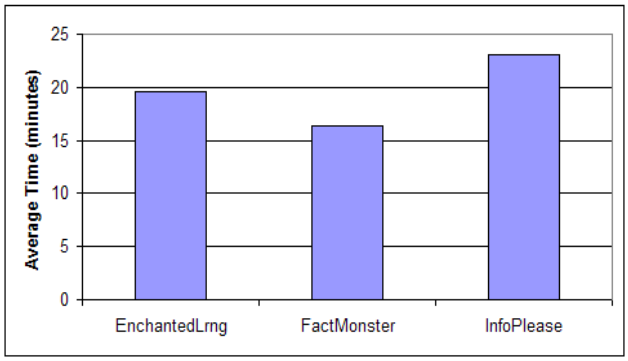
After analyzing the information from the study Naidu came up with some very important findings which are summarized in Figure 1.5 in Table 1, Graph and Graph 2. Their titles explain the variables measured.

Figure 1.5

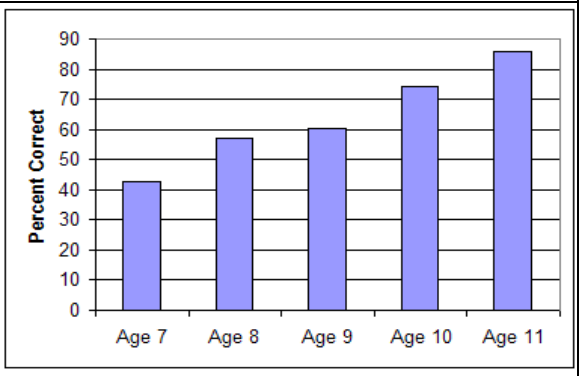
Table 1: Success rate for each task by website (bold indicates least successful tasks)

Task	**EnchantedLearning**	**FactMonster**	**Infoplease**
Find the state capital of Wyoming	100	81.8	66.7
Use the search field to find location of Great Wall	80	100	100
Find site contact Information	10	63.4	33.3
Find origin of Mars	70	63.6	33.3
Find a multiplication table	70	72.7	77.8
Find info on Sir Edmund Hillary	70	36.4	22.2
Find how to say "Thank You" in Italian	40	54.5	0
Average	**62.8**	**67.5**	**47.6**

Graph 1: Average time to complete all 7 tasks for each site.



Graph 2: Success rate for each task by age



From her findings, Naidu came to the conclusion that age was the only discriminating factor identified as the possible reason for the disparity in their success. She made three discoveries; experience, better knowledge of

answers and lastly better vocabulary base, [14]to explain the reason why the younger children(less than 10 years) had less success than the older ones. The principles she discussed included: first; removing advertisement from these pages because they confuse the children, second; presenting the right content in a concise manner and third; reducing the length of the page (how much information there is on page), the number of choices (number of links) on page, the depth of the site (how deep the participant had to travel to find the information), and lastly using the right font size and pictures (how big or small they were). For the younger children, less information on a page, at most a link to direct to the needed information, larger font sizes and pictures, simpler, more descriptive words rather than confusing terminologies, and lastly a shorter depth were preferable.

A study on usability criteria regarding interfaces for Children by Alexandre Mano and José C. Campos is research that had the sole aim of designing a set of guidelines for developing software interfaces for children between the ages of 5 and 7 years old. The children were gathered from 1st and 2nd grade classes. [15] Tests conducted in May 2005 on two primary schools in the city of Braga, Portugal had a two-fold purpose. The first was to discover the possibilities of developing guidelines for the construction of software interfaces based on the features of the children's cognitive development level. The second was to develop a method capable of identifying these guidelines. [15] Although the results of this research were

not available, it was chosen because of the systematic way of gathering the information for study which this dissertation emulates. [15]

Like this dissertation, Mano and Campos first explained how children develop cognitively. They chose Jean Piaget's theory and, because of the age period, the pre-operational stage was discussed. In their discussion, they outlined the abilities of children in this age frame. After identifying the features of the child's cognitive make up during this period, they accommodated the features identified into questions with which they designed six experiments or interfaces to ascertain their findings from the theory proposed by Piaget. [15]. Each experiment or interface had its description, purpose and results recorded. The description of the interface described what the children had to do for that particular experiment. The purpose explained what Mano and Compos hoped to ascertain from the experiment and the results was what the children were able to do.

For the data collection there were two independent scenarios created. The first was in a computer lab with the children in groups of four, in order to mimic the classroom setting. The second setting was the home where the children took the tests individually. [15] The researchers made it possible for the children in the classroom setting to interact with other children and ask for guidance when necessary. However, the ones in the home setting did not have this option. They found out that for children in the school setting, peer influence was a negative factor. Thus the need for Vygotsky theory, proposed

in this dissertation, which allows the children to be educated mainly by older people in the society.

With these interfaces and the information collected Alexandre Mano and José C. Campos hoped to achieve their purpose of linking a child's cognitive stage to the kind of tasks he or she could do. Based on this research rather than empirical evidence, the researchers hoped to be able to design a set of guidelines for developing interfaces for the children. Although the results and conclusions from the analysis of this study are not yet available, the researchers are confident that their research is a better way to achieve their aim compared to the researchers who perform empirical research. They believe this because their research identifies the reasons why children are unable or able to use the already existing web interfaces.

The Usability Group

This group focuses on giving principles, guidelines and best practices for making web applications for children. Most of the people in this group analyze what the researchers have done further to come up with facts about the things that work or do not work when developing web application for children. It is important to note that there are a number of people who lie in the intersection. This means, they do the research themselves to find the facts and then go further to analyze it to come up with the principles and guidelines.

Jakob Nielsen is one of such people in the intersection. The results of his usability study on children's' use of websites has resulted in the creation of a 132 page report titled, Usability of Websites for Children; 70 design guidelines based on usability studies with kids. The purpose of this document is to outline 70 guidelines that are necessary when developing web applications, especially websites, for children. In this study "*Web Usability for Children"* organized in 2002, Nielsen seeks to find out how children use the Web.[18] To achieve this aim the study involves 55 children between the ages of 6 and 12 from the United States of America(39) and Israel(16) who were observed while they browsed 24 sites.[18] There were three main categories from which these sites were selected: mainstream sites designed for adults which has sites like Amazon, Yahoo! and Weather.com, sites specifically devoted to children which also included Alfy, MaMaMedia and Sesame Street and finally kid-oriented subsites produced by mainstream companies, such as ABC News for Kids and Belmont Bank's Kids' Corner. The sites listed above are a few examples of the chosen sites for the study.

The detailed analysis of this research is in the report which is not available for free. However, some conclusions can be drawn from an article on the results of the study published by Nielsen himself. He found out that like adults children get perplexed by confusing websites though unlike adults they consider advertisement as contents which makes it more confusing for them when they browse. However, they tend to like colorful designs and require simple text and navigation.

Another surprising but important thing the research revealed was that the sites that had been developed for the adults that complied with the Web design conventions and were simple were most preferred by the children. Some problems Nielsen identified were children's use of out-dated computers that are usually handed down to them by a parent or sibling who has got a newer model. The main problem with this is that the developers have up-to-date computers which have the capacity for better software which most children do not have. Also he identified classic Web usability problems which included unclear navigational confirmation, inconsistent navigation, non-standard interaction techniques, lack of perceived clickability and finally fancy wording. Most of the developers' aim of making the sites interesting for the children is defeated by the problems created.

The World Wide Consortium (W3C) is an accredited organization whose main aim is to create principles and guidelines for the development of web application in general. As the research discussed before this states, it has been noted that all the websites that operate by the recommendations given by the W3C have had great success with children as well. They came up with a new set in 2008 known as the Web Content Accessibility Guidelines (WCAG) 2.0 which is an improvement on the first version WCAG 1.0. [16]

One concept that ran through all the researches available was the word *usability*. A number of people have defined usability in different ways. In general, usability is the property software; a web application in this case, has that makes it easy and simple for its audience to use in a given context.

In their research, *Consolidating the ISO Usability Models*, Alain Abran, Adel Khelfi, Witold Suryn, Ahmed Seffah, the authors' aimed to fix the limitations of two software models created by the ISO, by proposing a consolidated one. The ISO 9126-1, 2000 and the ISO 9241, 1998[11] were analyzed with highlights focused on the point of views from which they were made and their limitations. In addition to their analysis they added the findings from other usability researchers and analysts to propose the Consolidated ISO usability model.

The International Organization for Standardization (ISO) made up of 159 countries is the world's largest network of national standards institutes. It develops and publishes international standards. [10] The ISO 9126-1, 2000 model, one of the models proposed by the ISO is a product-oriented model that describes the characteristics that software with good quality possesses. It mentions usability as one of the characteristics of such software in addition to functionality, reliability, effectiveness, maintainability and portability. Its objective was to provide a framework for the evaluation of software quality [11]. It defined the quality of software as good or bad based on the number of the characteristics mentioned above that the software possessed or otherwise. This model was made from the Software Engineering point of view and it defines usability as 'the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions' [11].

The second model discussed in the research, *Consolidating the Usability Models* is the ISO 9241, 1998. It was made from the Human Computer Interaction point of view. It represents a process-oriented approach to usability [11]. Usability is defined here as 'the extent to which a product can be used by the specified users to achieve specified goal with the effectiveness, efficiency and satisfaction in a specified context.'[11] This model gives a more precise measurement for usability which consists of three attributes; effectiveness, efficiency and satisfaction.

The attributes of usability proposed by the ISO 9241 served as the baseline for the consolidated model. Learnability and security, the other two attributes were added from the ISO 9126 and other researchers like Jakob Nielsen, mentioned above, Dix et all and other standards like the Information Technology Security Evaluation Criteria (ITSEC).[19] Security is not discussed in this paper at all. Finally with the structure for representing the model chosen from the ISO 9126, the authors of this research developed the consolidated usability model. Considering the importance of usability to this research paper, the Consolidated Usability Model which captures the foundation for usability is the model that has been proposed for the development the principles and guidelines for the creation of web applications for Ghanaian children. Any additions and subtractions that are necessary will be added to or subtracted from this model to be presented as the set of principles and guidelines for developing web applications for Ghanaian children.

Appendix A.1 summarizes all the discussion on principles and guidelines discussed by the researchers and usability group.

Outline of Dissertation

This chapter has given a brief introduction, background and literature review to this dissertation. The next chapters have been designed to discuss the other areas of this dissertation**.**

Chapter 2 reviews the methodology proposed by the author and its limitations. Chapter 3 records the research; data collection done and further discusses the analysis done. Chapter 4 then summarizes the analysis made in Chapter 3 in relation to its importance to the criteria and hypothesis proposed for the dissertation; summary analysis and broader discussion.

Finally Chapter 5 summarizes the findings from the study done for this dissertation, proposes some guidelines for developing for Ghanaian children and then finally proposing some future work.

CHAPTER 2: REVIEW OF METHODS AND LIMITATIONS

Approach

This section reviews the proposed methodology. This includes all that goes into organizing a successful study; what needs to be measured, how it will be measured and finally who the participants for the study will be. The section before discussed some researches and theories that have formed the foundation of most research work for children. A set of criteria for the measurement of the variables that will be identified for the study will be outlined. The Consolidated ISO Usability model, the proposed fundamental model for this study, will be specialized for the Ghanaian setting based on the result of the study.

What needs to be measured?

What needs to be measured is the crux of this study. There are two categories of things to be measured. One main idea proposed by this dissertation is the important role that older generations in the Ghanaian society need to play in the Ghanaian child's use of computers and the Internet. Thus the first measurement is to prove whether the theory proposed by Lev Vygotsky, discussed in the Literature Review, is real in the Ghanaian setting as well. The second measurement will have its results from the measurement of a set of criteria that have been gleaned from the researches read and/or discussed and observations by the author of this dissertation. These criteria will be measured for the Ghanaian setting.

- The interest areas of the children: What did the children find most interesting throughout the whole study (between three and five things both for the experiment and the website). In simple terms, what the children did and did not like and why.
- The ease of finding information: How efficient are the children at finding information? How fast were they able to finish all the work on each the site and experiments? (Navigation and time used to complete an experiment or find information on a site)
- The characteristics or the features on the pages that make the two points above possible for either the experiment or the web site.
- How satisfied are the children with the sites and experiments (Did they like a particular site or not and why)?
- How successful are the children at the tasks given?

In addition to the criteria given above a number of hypotheses will be tested specifically with the experiments.

H1. The Aided Browsers will perform better in reference to efficiency and success than the Unaided Browser: This is to prove Lev Vygotsky's theory.

H2. The participants who used large buttons will perform better in reference to success and efficiency compared to the ones who used smaller buttons.

H3. The participants who had their instructions pop-up in an alert will perform less compared to the ones who had their instructions displayed on the page.

H4. The use of no color affects the performance of 5 year olds. It is believed color attracts them but does its absence affect performance?

H5. The difference in ages and classes influences performance because of the development of motor skills and knowledge level.

Who is needed for the measurement?

Participants

With a minimum of one and a maximum of three primary schools in the Labone and Cantonment vicinity, a sample of between 15 to 20 students will be taken. Participants will be from Kindergarten 2 through to Class 4. The class range fits the age range (5-10) chosen for this study. This particular age range has been chosen because it is the period within which children get to explore the world around them apart from their immediate families, [4] e.g. school. Often the knowledge acquired during this period is very influential in their entire development process. It is thus important that knowledge of computers and the Internet is imparted into them at this foundation level. If possible, there will be an equal number of girls and boys for the study to cover the bias that might result from a gender imbalance. The proposed schools are Glorious Kids Nursery School, Rangoon Basic School and Holy Star Academy. The participants will be chosen from a wide range of the perceived social classes; upper class, lower class and middle class etc. They must each have some basic, suitable level of exposure to computers and the Internet. The absence of this though will not in any way impact their selection.

For the study, research assistants were required to help the children settle down in the computer labs and ready for the study. Their duties included among others putting on the computers, taking the children through basic lessons; clicking, typing, painting, etc. Their main duty was to offer the adult guidance; scaffolding, needed to do the experiments when the participants faced any difficulties. The assistants were used during the studies and the performance especially for the kindergarten children can be explained by this. However, they were more (5 and 3 for the first and second respectively) for the first two studies but 1 for the first set of the third study. This change was made to ascertain that the level of scaffolding being done was not too much for the children; too many clues were not being given.

How it will be measured?

Procedure

To prove Vygotsky's theory of cultural importance in the cognitive development of a child, the chosen children will be divided into two groups. One of these groups will be called the Aided Web Users/Browsers and the other, the Unaided Web Users/Browsers. It must be noted however, that each group will be a cluster of all the participants from the different classes or grades. The former group will have guidance and assistance throughout the process of the study. By guidance and assistance this group will, in addition to the required explanation for the study, have research assistants to help them solve problems using the techniques or principles; scaffolding,

proposed by Vygotsky in his theory. The Unaided Browsers will not have any further assistance.

Two main methods are going to be used in this dissertation to accomplish the objectives of the dissertation. The first will be the use of experiments that were developed by the author of this dissertation. These experiments will consider the cognitive development level of children proposed by Lev Vygotsky and will cover three areas: counting and simple mathematical operations, object recognition, shape identification and spelling. To authenticate his theory for the Ghanaian setting, the success levels will be checked for the two groups.

The second method will include the use of already-existing educational web applications for children within the age domain given. A similar study to the one discussed above by Shiva Naidu, of Software Usability Research Laboratory (SURL), will be organized for this dissertation. The purpose is to evaluate the children's use of the already existing applications developed for them. Based on this also more information will be gleaned with more emphasis on the differences for the development of the principles and guidelines.

The criteria given above will be measured by observation and questions. The children will be observed while they perform the allocated experiments and browse, after which they will be asked questions on their opinion of the session. All sessions will be recorded and saved for further analyses. A session, made up of two parts, will last a maximum of one hour.

The first part will have participants performing the designed experiments and their ability to understand and complete the given tasks will be measured. During the second part of the session, the Factmonster web site, one of the sites chosen by Shiva Naidu, will be opened for the participants to browse. For this site, a number of tasks, mainly focused on finding information on the site, will be given to the children to perform. Each group will contain children from classes 1 to 4. Based on the findings from the sessions the Guidelines and Principles will be designed for the development of web applications for Ghanaian children between the ages of 5 to 10 years.

For the measurement of the criteria above, both experiments and web applications will be used. To measure their satisfaction, the children will be asked questions to which their answers will be analyzed to ascertain their satisfaction level. To measure success, the total number of children who are able to complete a task is mapped to the experiment or application. A percentage of the total number of successes for a given application or experiment is calculated and mapped to the application or experiment. Measurement of efficiency will have the overall time taken for finishing tasks and the performance in the given time on both applications and experiments. To check for the time used for either an experiment or application, the average time used will be mapped to the experiment or site.

For the experiments developed a number of questions are listed below which will be answered with the results of the experiments from which more

Principles and Guidelines will be gleaned. It must be noted that some of the questions asked here are also used in *A study on usability criteria regarding interfaces for children* by Alexandre Mano and José C. Campos.

1. Are children able to use the keyboard?
2. Are children able to identify or images or operators?
3. Are children able to identify the purposes of objects?
4. Can children understand an interface divided in categories?
5. Can children correctly associate images with the actions that will occur?
6. Are children capable of recognizing when an action must be undone?
7. Are children capable of recognizing an image link or is a link with text and image more efficient?
8. Must the number of interactive controls be minimized?
9. Are children capable of spelling?
10. Are children able to us the mouse?

Data Collection and Analysis Tools

Like the studies discussed already some statistical analysis tools like Analysis Of Variance (ANOVA), post-hoc tests, measures of central tendency will be used for the analysis of the data that is collected. For the collection of data on the experiments, the author has included a tracking feature and a means of storing the information entered by the participants during the study into the experiments. In addition, all the possible means of gathering information for analysis will be used to collect as much information as

possible from the studies to be organized. For the websites chosen browsers that will allow tracking like Mozilla Firefox or Internet Explorer can be used.

What makes this dissertation's approach better?

This dissertation combines different approaches to research, analysis and recommendation of renowned individuals in the field. The research approach is a blend of the approaches of Shiva Naidu and Alexandre Mano and José C. Campos. The analysis approach is chosen from the research by Browne Hutchinson, Benjamin B. Bederson and Allison Druin. Finally the recommendation approach was chosen from the authors of the "Consolidating the ISO Usability Models". Unlike Shiva Naidu's study this approach has all the participants using just one web site. Some of these researches have been discussed in this dissertation and the others were read. However, combined with the experiments the results are expected to offer a much broader base for the definition of the Principles and Guidelines for Ghanaian children.

Limitations of this Dissertation

This dissertation has time as the main limitation. The work that is needed to complete the development of a good, conclusive and inclusive set of principles and guidelines requires more time. However, the aim is to develop a foundation upon which more research can be done to create a more inclusive set of principles and guidelines that can be used to develop for children. This impacted the choice of schools; location only in the Labone-Cantonment vicinity, the choice of the tools and technology used for

development, etc. Appendix B has the Activity Schedule and Timeline proposed for this paper.

CHAPTER 3: ANALYSIS OF PROJECT RESEARCH AND RESULTS

User Studies

In total there were two purposes for the studies that were organized and both experiments and web browsing helped to achieve them. One purpose was to test Lev Vygostky's theory of the importance of the cultural aspect a child's development. This dissertation was set out to prove that Ghanaian children will learn faster and catch up with their counterparts in the other developed countries through the use of the Scaffolding principle proposed by Lev Vygotsky. This principle proposes that the older people in society should be involved in the development and the learning process of children.

Scaffolding's purpose is to present children with mind-provoking clues that aids them in solving problems and thus impacts their development and learning. This is done to equip children with information on how to solve similar problems in the future. This cuts out the trial and error part of the child's development process proposed by Jean Piaget. The second purpose was aimed at observing the way Ghanaian children use computers, the Internet and educative web applications by giving them these exercises to do. Based the results, principles and guidelines for the development of educational web applications for them will be developed.

In total, three different studies were organized for 31 students from three different schools situated in the Labone vicinity in Accra, Ghana: Rangoon Basic School, Glorious Kids Nursery School and Holy Star Academy.

The first was organized for the students from Rangoon Basic School, on 4th February, 2010, the second was organized for the children from Glorious Kids Nursery School on 2nd March 2010 and finally, the last school, Holy Star Academy had its experiment organized on 9th March, 2010. The first two experiments were organized in the Ashesi University Computer Science Laboratory also in Labone on the 3rd Norla Street. The last one was organized on the premises of the school, in their Computer Science Laboratory.

Study Designs

Participants

For the first study, there were ten children from the Rangoon Basic School between the ages of 6 and 10 years, from classes 1 to 4. Two from classes 1 to 3 and four from class 4, four boys and six girls; uniformly split for classes 1, 3 and 4. Children had very basic knowledge about computers: all of them had seen computers before and knew what the different parts were used for, however, about 60% had actually used one before and it was solely for the purpose of playing games. For the next study with the children from Glorious Kids Nursery, there were four children from Kindergarten 2 (age 5); three girls and one boy. The last group from Holy Star Academy had sixteen children in all, split equally among classes, gender and experimental groups. They were from classes 1 to 4 and between the ages of 6 and 10.

For the materials used, all the computers used during the study were tested to ensure that they had the necessary software and technologies for organizing the studies; experiments and web browsing.

Interfaces

The first session (experiments) of the study had interfaces that allowed the students to perform all the tasks they were required to perform: object recognition, mathematical expressions and counting, spelling and shape recognition. To manage the content on these experiments the textbooks recommended by the Ghana Education Service (GES) was used in the design of the tasks. Interfaces had large buttons, text, images and colorful pages. For each of the individual group of experiments, e.g. object recognition, the background image and color were the same which gave a mental switch whenever the experiment changed. For the experimental studies, there were three categories; Alert control, Button control and Color control; limited only to the kindergarten children. The control groups are referred to as the "Normal" group. The second session of the study; the web browsing had a very colorful and interactive interface. For this there were the aided and unaided browsers.

Procedure

For the study (research), participants who had been given consent primarily by their schools were allowed to take part. The participants from Rangoon Basic School had a single session; the experiments, with all ten of them guided by five research assistants. These students had very little knowledge and thus had to be guided throughout the whole session. Because they were the first group there were a number of setbacks: inexperience of

research assistants, bugs in the software, problems with setting up the system, etc. All these prolonged the period for the research to over an hour.

Contrarily, the second and third groups from Glorious Kids Nursery and Holy Star Academy had better study processes. The children from Glorious Kids Nursery came in for the color-control study. Based on the first study, this second research was improved to measure one particular thing. Out of the four students selected; two, the Color Control group, equally split between genders, had no background image and color and the other two, Normal served as their control. The five-year olds had the administration of their school permission in addition to their parents' consent before the children could take part in the research.

The final school did both sessions of studies; web browsing and experiments. For the experiments they were subdivided to include the experimental groups. The first two groups of fours (first set); which did the Button and Alert controls, were aided through scaffolding by the research assistant in charge, however, the second set was not aided although there was a research assistant available. After doing the different categories of experiments that had been completed, they were further divided into two groups equally divided among the classes and gender for the second session; web browsing with the factmonster website; www.factmonster.com.

Tasks

For the Web browsing, the questions were similar in content and approach to the one used by Shiva Naidu in her research.

Q1. Find the capital state for Ghana

Q2. Use the search field to find the location of Mount Everest

Q3. Find a multiplication table

Q4. Find information on Barrack Obama

Q5. Find how to say "Thank you" in Spanish

Q6. Use the dictionary to find the meaning of the word "Appreciation".

The tasks for the experiments included:

1. Spelling: Typing
2. Object Recognition
3. Shape Identification
4. Mathematical equations (Class2-4) and Counting (Kindergarten2 and Class1).

Analysis

After three different data collection sessions the following is the result of the last two studies for the different schools. Considering the standard of software and the quality of the research process used in the second and the final studies this analysis was based on their studies. This notwithstanding,

there was analysis of the study done for the first school and its results was used to refine the study to improve it for the last two.

Educational Experiments

For the experiments, each child completed four sets of tasks: shape identification; Experiment 1, object recognition; Experiment 2, spelling; Experiment 3 and finally counting and simple mathematical equations; Experiment 4. All the children were picked from the age and class range specified for this dissertation. They were further grouped into three different experimental groups: alert control, button control and color control with control groups for them. The participants in the alert control had their instructions displayed in alert pop-up and the control had instructions displayed on the screen. The button control had smaller buttons compared to their control. Finally, the color control had no background images and minimal color compared to their control. It must be noted here that these experimental groups were identified after the analysis of data collected from the initial study. Thus further research can be done to cover more areas. With these groups the listed variables were checked whether their presence or otherwise affected the performance of a group in an experiment.

These tasks were averaged by the time, success, efficiency and finally satisfaction on the experiments by the classes and groups. All the different measurements were done with the different measures of Analysis of Variance (ANOVA) and also graphed with 95% confidence. Post-hoc analysis was done with Tukey tests. These tests were used to further explore significant results

in factors with more than two levels. All analysis was performed overall, by class and by group. Some of the results are not significant for the classes because of the small size for the research. Due to the difference in sample size for the children in KG; four divided into two groups instead of four divided into four groups, their analysis was done separately. Also one of the groups who did the normal; had all the right conditions for the experiments, experiments from classes 1 to 4 was randomly chosen and not both groups. This was done to make the analysis of the groups comparable.

Results: Success on Experiments by Groups

The success of the groups was measured by calculating a percentage of the grades of the individuals in the group and summing that up. This was submitted to a 4 (experiment) x 3(group) ANOVA for experimental and control groups: Alert, Button and Normal. Results of this analysis showed a significant difference in success by experiments $F(2, 2) = 19$, $p<.05$ (Figure 3.1) but no significant difference by groups. Among the groups performance on each experiment was around the same average, however, performance of the groups on the experiments was very different. Tukey post-hoc tests, on the experiments further indicated that the participants performed best on Experiments 1 and 2 and better on Experiment 4 but good on Experiment 3.

For the kindergarten groups: Color and Normal the same process was used for measurement and was submitted to a 2(group) x 4 (experiment) ANOVA. Results indicated that there existed no significant difference in the success of the kindergarten groups and also on the experiments (Figure 3.2).

The performance on the experiment among the groups had the same mean and performance on the experiments also had the same mean.

Figure 3.1

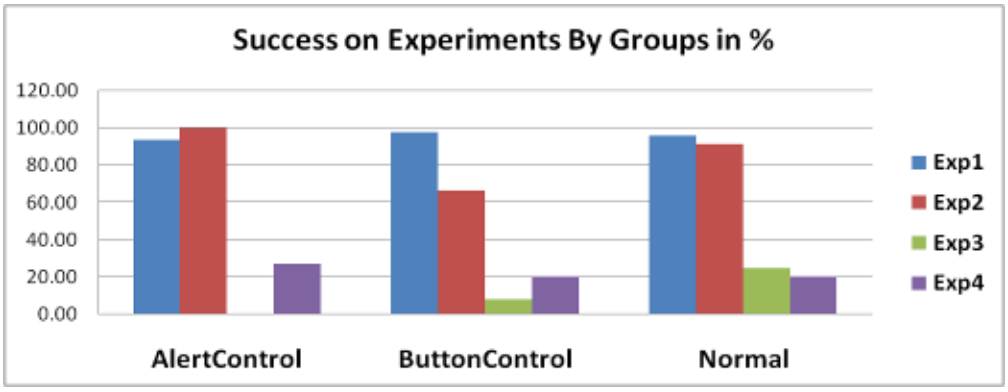
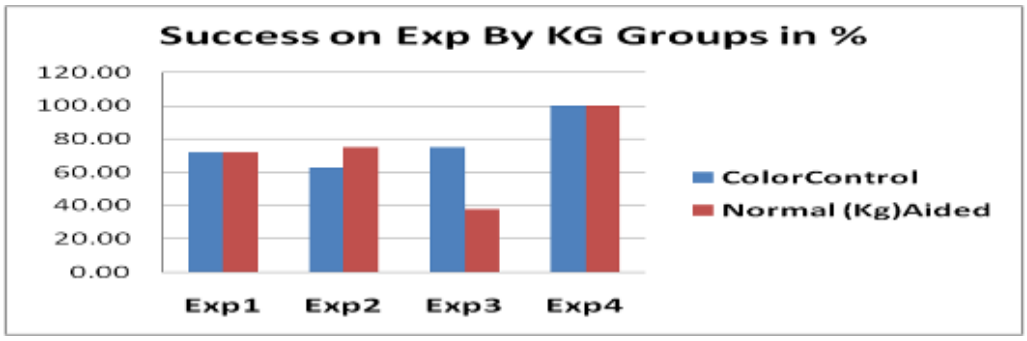


Figure 3.2

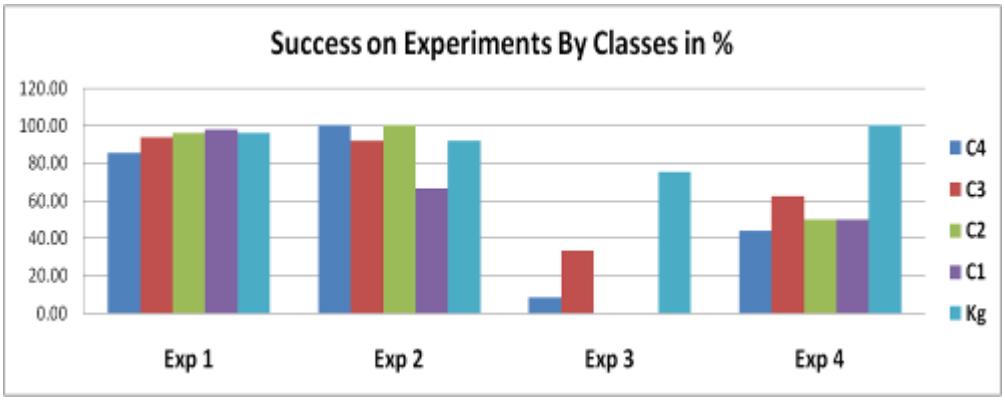


Results: Success on Experiments by Classes

Overall for all 21 participants grouped into their classes; Classes 1 to 4 and Kg 2, their success, as calculated in the analysis before this one, was submitted to a 4 (experiment) x 5 (class) ANOVA. Here also the results indicated significant difference by experiments $F(2, 6) = 5.143$, $p<.01$ and none by classes (Figure 3.3). Each class performed around the same grade

for each of the experiments. However, the classes' performance by experiments was significantly different. Tukey post-hoc test showed that for all the classes represented, Experiments 1 and 2 had the most success. Experiments 3 and 4 had worse and bad success respectively across all the classes.

Figure 3.3



Results: Average time on Experiments by Groups.

The average time spent by the groups on the experiments was calculated by finding the average time each member spent on each experiment and then averaging that by the members in the group. This was submitted to 4(experiment) by 3(group) ANOVA. The results indicated no significant difference in the time spent by the groups on the experiments and among the groups (Figure 3.4). The groups spent around the same time on average to complete each experiment. Among the experiments the overall time spent by each group was not significantly different. The same procedure was followed for the participants from the Kindergarten class (KG/Kg/Kg2).

The results after it was submitted to a 2(group) by 4(experiment) ANOVA, was similar to the one above. It also showed no significant difference in the time spent by the groups on the experiments and no significant different in the overall average time spent on the experiments. (Figure 3.5)

Figure 3.4

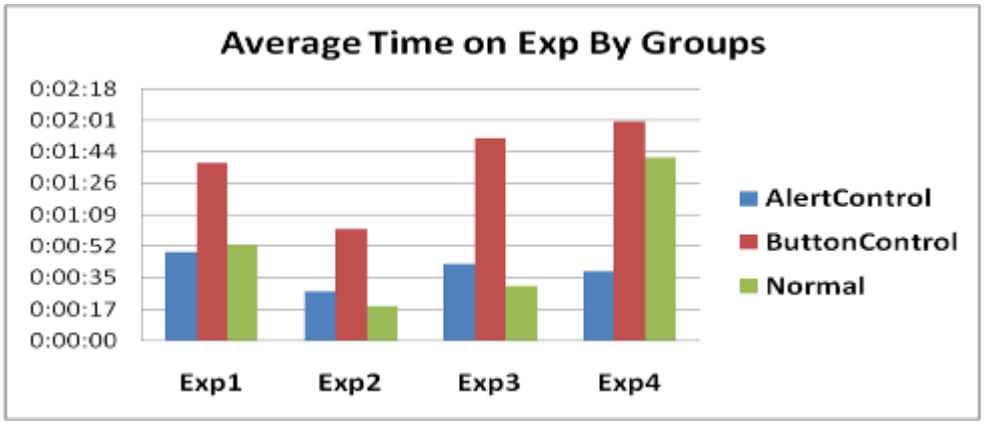
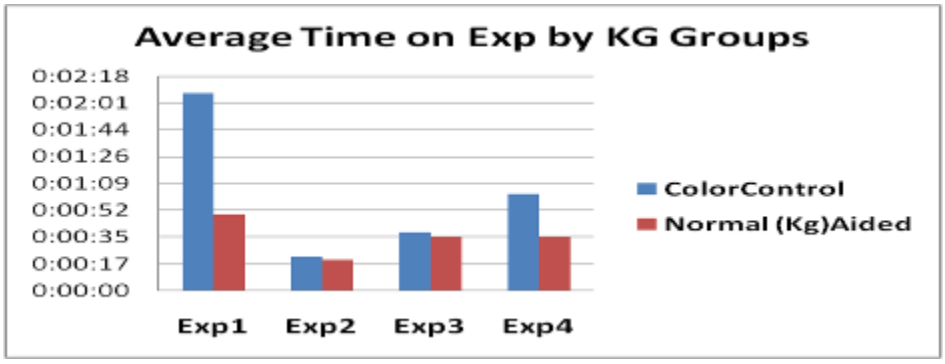


Figure 3.5

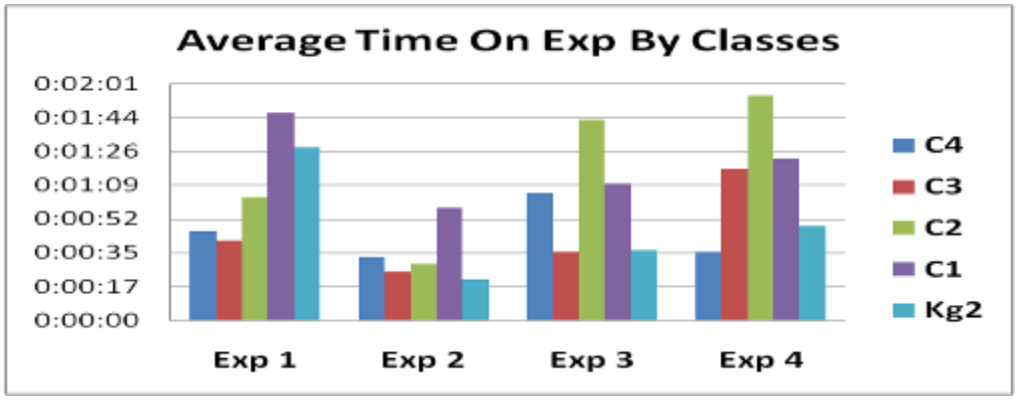


Results: Average time on Experiments by Classes.

The time spent by each of the classes on the experiments was also calculated as in the analysis before and was submitted to a 4(experiment) by 5(classes) ANOVA. The results showed significant difference by experiments

F (2, 6) = 5.143, p<.05 and none by classes (Figure 3.6). Overall, among the experiments, there was a difference in the mean time spent. However, the classes spent around the same time on each experiment. Tukey post-hoc test once again showed that for all the classes represented, participants in these classes spent the least time on Experiments 2, then on Experiment 1. Participants from the various classes spent the Experiments 3 and 4 had worse and bad success respectively.

Figure 3.6

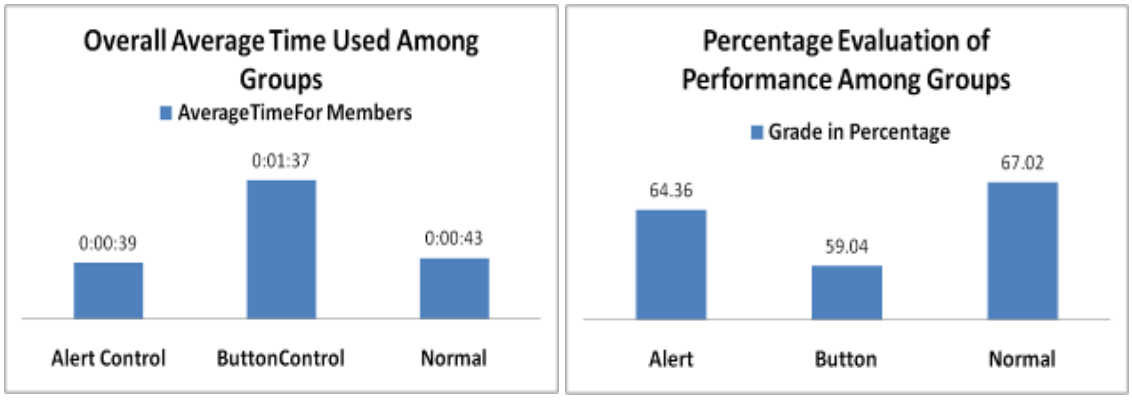


Results : Efficiency

Efficiency was measured by mapping the group or class that performed best to the amount of time that group spent overall on the experiments. The mapping was done with graphs. Generally on average, the Alert Control group spent less time on the experiments than the Normal and the Button Control groups and the Normal group spent less time than the Button Control group. However, it was observed that when the performance (success) of these groups were graphed against each other the Normal group performed

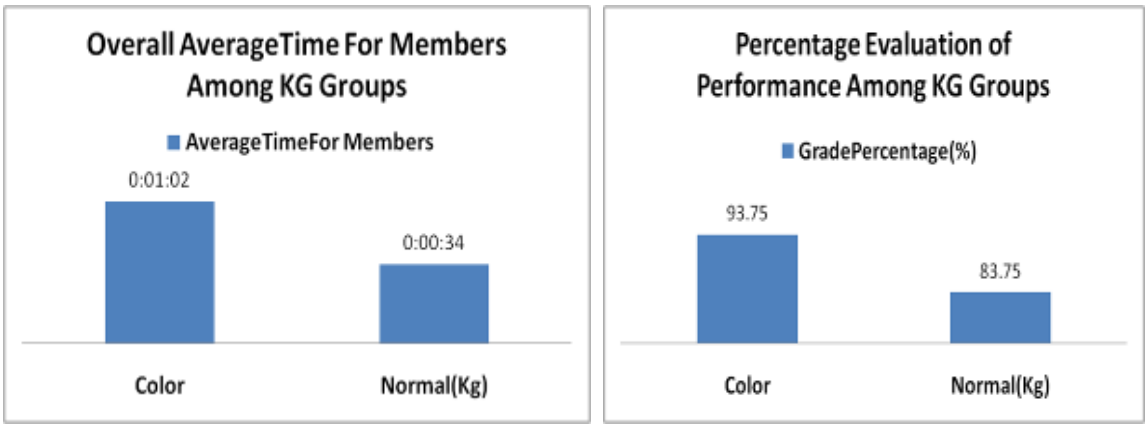
best compared to the Alert and the Button Control groups which performed better and good respectively (Figure3.7). Thus the Normal group was most efficient because it performed best in the amount of time it used. This was followed by the Alert group and finally the Button group which was the least efficient.

Figure 3.7



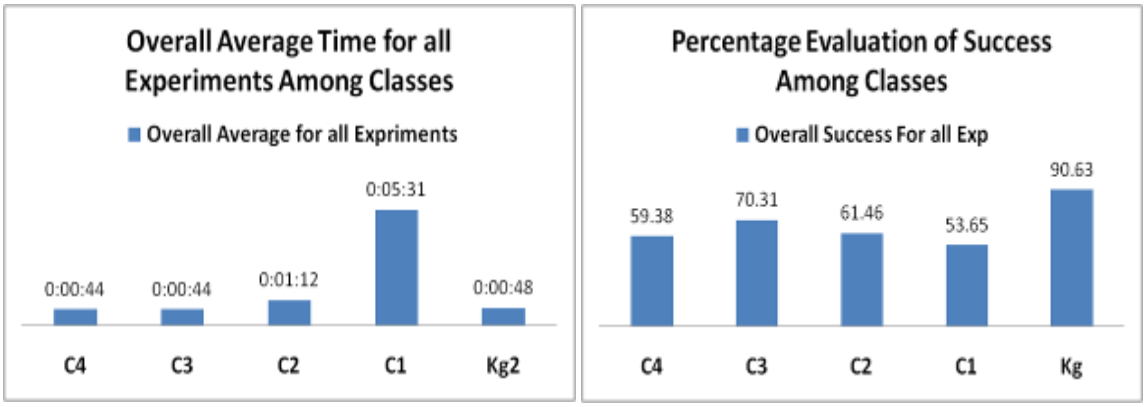
The overall average time used by the two Kg groups; color and normal was graphed against the performance of the groups (Figure 3.8). And against prediction the participants in the Color Control group performed better and used the lesser amount of time on average Figure (3.8). Thus for efficiency, the Color group was more efficient than the Normal group.

Figure3.8



For the measurement of efficiency among the classes, the same procedure was followed and it was observed that among the main stream classes (1-4); classes 1 spent the most time and performed worst. This was followed by class 2 which also spent the most time among the three classes left and performed worst among them. Classes 3 and 4 spent the same amount of time although class 3 performed better than class 4. Thus for the measurement of efficiency among these classes, class 3 was the most efficient followed by class 4 and 2 and class 1 was the least efficient and for the Kg class the efficiency was very high (Figure 3.9)

Figure 3.9



Satisfaction

The measurement and analysis of satisfaction was pure informal and non-statistical. Participants from the different groups were observed and based on their body languages and their answers to the questions they were asked results were drawn. Among the groups, it was observed that the Button Control group and the Color Control groups were the least satisfied. This was because the members in these groups had the chance to the see the experiments of the other groups due to the lack of facilities and time. Also the Button groups especially had a lot of difficulty trying to click on the answers due to the size of the buttons. Thus, for some reason each of members independently devised a means of clicking on the buttons. They slowly moved the mouse pointer until it was on the button before they held the mouse and then clicked on the button. Most of these participants got very frustrated and resigned to just moving the mouse about on the screen, or looking on other people's work or just consistently calling for help.

For the color control group, one of the participants had to be begged to finish the work because she thought her experiments were not nice. Because these experiments were done with a lot of emphasis on the syllabus of the different classes it was observed that mostly the participants asked on how to use the technology; keyboard, mouse and not how to answer the questions.

Web Browsing

For the Internet browsing tasks, each group of children performed six tasks that required them to browse the Factmonster website for the answers to the tasks. These tasks were averaged by groups; Aided and Unaided browsers, time spent, success and satisfaction. All time and success analysis was made with measures of Analysis of Variance ANOVA and was graphed with 95% confidence intervals.

Success

The grades each group scored on the tasks was submitted to 2(group) by 6(tasks) ANOVA. The results showed no significant difference in the success of the two groups on the tasks and among the groups (Figure 3.10). Table 1 shows which of the groups was successful at each of the tasks on factmonster.com in percentage. The Aided Browsers had the highest rate of overall averaged success (100%) between the two groups.

There were a number of tasks, though, that were difficult for both groups. The only reason for the success of the Aided Browsers was the mind-

provocative questions (scaffolding process) that guided them to the correct answer. On finding how to say "Thank you" in Spanish, both groups found the route to the page but because the information was below the page they got very confused when they did not find it on the top of the page. After being given a cue to look at the first letters of the words to see if there was an order for the presentation of the information the Aided Browsers scrolled down to find the information.

The second group also got to the page but did not find the information because they did not scroll down. Another problem was using the dictionary to find the meaning of the word "Appreciation". The Unaided browsers spelt the word wrongly although they found the dictionary field to type the information into. The dictionary gave them clues which helped them to get it right. The Aided Browsers rather started searching the dictionary first to find the word instead of typing it into the dictionary field. After trying for so long to no avail because they did not know how to get to the next page from the first page of the dictionary, they were asked how else they could find the information then one of them pointed to the dictionary field. Here they typed the word in wrongly but the clues given by the dictionary directed them to the correct answer.

Figure 3.10

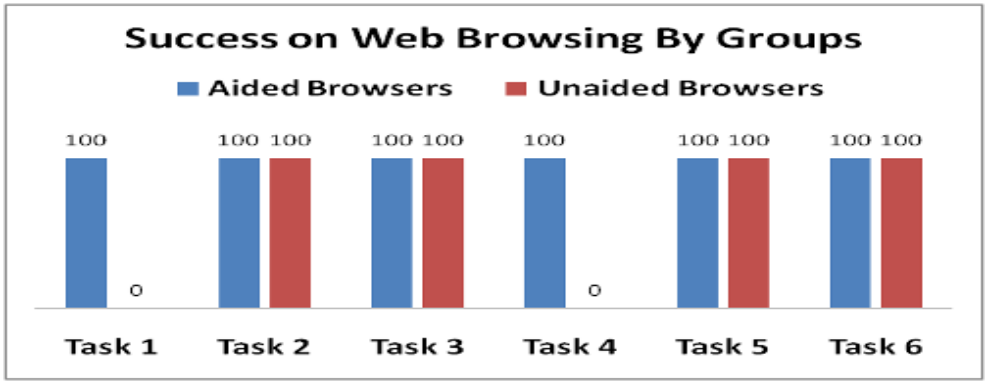


Table 1: Success grade for each task by groups in %

	Aided Browsers	**Unaided Browsers**
Find the capital state for Ghana	100	0
Use the search field to find the location of Mount Everest	100	100
Find a multiplication table	100	100
Find information on Barrack Obama	100	0
Find how to say "Thank you" in Spanish	100	100
Use the dictionary to find the meaning of appreciation.	100	100
Average	**100%**	**66.67%**

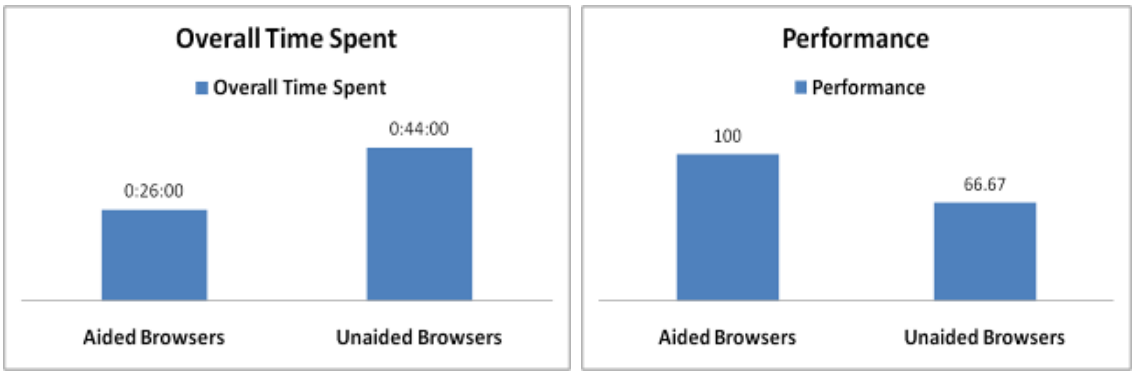
Time

The time spent on each task performed by the groups was not recorded; however, the overall time spent on finishing the tasks was recorded. The Aided browsers spent overall 26 minutes while the Unaided spent 44 minutes.

Efficiency

As measured before in the other experiments, the overall time spent on the tasks by the groups was graphed against their overall average performance and it was observed that the Aided browsers were the most efficient between the two groups. The spent the least time and performed best (Figure 3.11)

Figure 3.11



CHAPTER 4: SUMMARY ANALYSIS AND BROAD DISCUSSION OF RESULTS

In light of the data collected and the analysis completed above this chapter continues to discuss the results in relation to what the author of this dissertation set out to achieve with this dissertation. In this chapter a link is created that connects all that has been discussed and outlined so far. This is done by creating an association between the purpose of the study and the research questions of this dissertation. In relation to culture the success, efficiency and satisfaction of the Aided browsers will be matched against the Unaided browsers to confirm the theory. In relation to children's use of the Internet and computers the same factors mentioned will be measured for the control and experimental groups and classes. The findings will be later connected to the objectives of this dissertation in the next chapter.

The experiments were designed with the aim to prescribe a means by which developers can choose the content for their web applications and also to propose some guidelines on how to use the technology available in the right way to design for Ghanaian children. To choose the content, it is very important that the syllabus used in school and the education system is considered and given very high priority. If the children are unable to relate to and understand what is given or they find it difficult, it will deter them from using the application that has been developed for them. The second aim was to propose a usability guideline and this was achieved by presenting the children with different variations of the technology available by the use of

control and experimental groups. This ensures that the children spend all their time solving the problems on the exercises and not on figuring out how to use the technology; increase their experience thus improve usability.

The web browsing bit of the study was aimed at observing how Ghanaian children used the already existing web applications that have been developed for the children in general with specific reference to American children. Based on the results, it will be easy to identify the areas: usability or content, they experienced difficulty and did not, and also whether they needed adult help and supervision to use these applications effectively or not. The aim is that web application developed for children can be effectively used by children even without help from adults. Thus this was to equip developers with information that will help them exclude the mistakes of other developers on the other applications. They can then come up with better ways of delivering the information with the right use of technology available for the effective use of the Ghanaian child.

The questions listed in chapter 2 as the purpose for the study will be answered with the results of the study. Table 4.1 links the study name and purpose to the questions they were meant to answer.

Table 4.1

	Name	**Purpose**	**Question**
Experiment 1	Shape Identification	- To check their knowledge level on shapes. - To check their thinking patterns,	-The answer to question 2 and 10

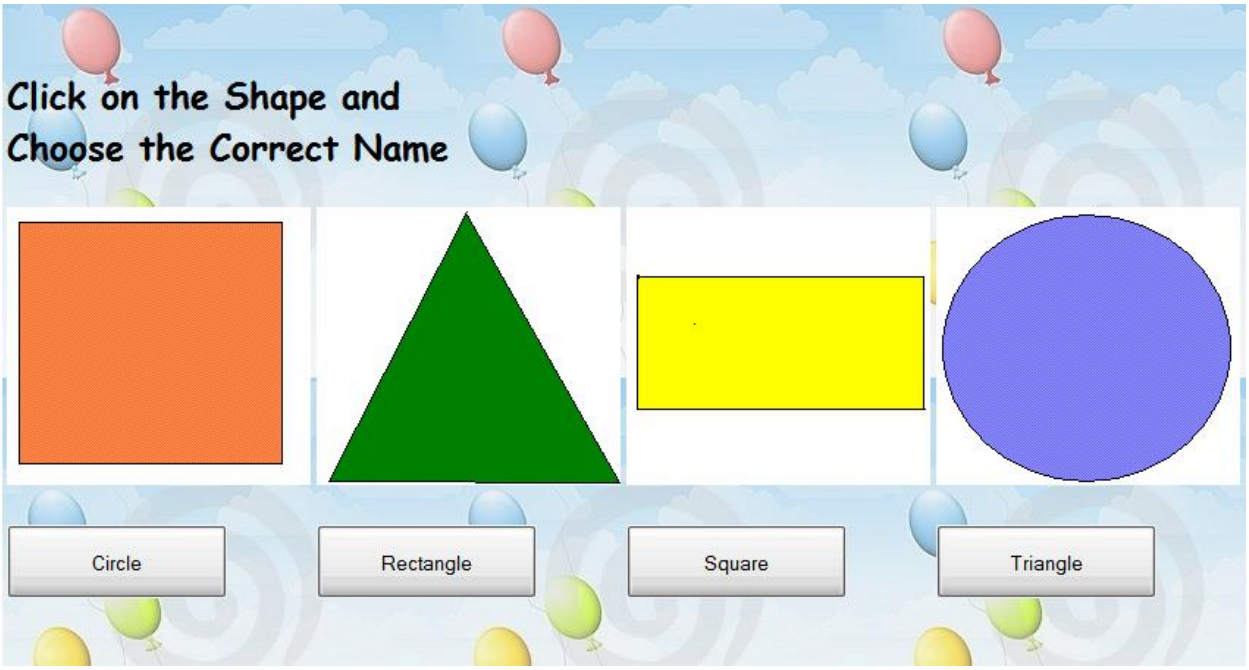
		i.e. Whether they are able to relate a shape to its name or the color of the shape to its name. This is to prove whether they have the ability to process information while they receive it or they create a format with which they solved similar problems.	
Experiment 2	Object Recognition	- To check if the children can link an image or object to a concept.	-The answers to question 2, 3 and 10
Experiment 3	Spelling	- To check if they know the alphabets and how to use the keyboard - Their level of knowledge of words and the words' spelling	-The answers to question 1 and 9
Experiment 4	Mathematical Equations and Counting	- To check the ability of the participant to perform simple arithmetic operations.	-The answers to question 1, 2, 3 and 10. The numerical keys of the keyboard
Web **browsing**	Factmonster Browsing	To observe how the children browse around the site for	-The answers to question 1, 4- 10. *Their general use of

		information.	web applications

Experiment 1: Shape Recognition

On this experiment the children were asked to pick a shape from a display of shapes and choose the correct name for the shapes. There were three different pages with alternating shape positions and colors. From the results of the experiments, it was seen that all the children performed excellently on this experiment. From the observations all the children had a good idea of what shapes: rectangle, triangle, square and circle, were. The purpose was to verify whether they processed problems as they encountered them or by a formula they had in. It was also to check their level of knowledge on shapes, the use of the mouse and whether they could identify the shapes. Among the groups and classes the success on experiment 1 was one of the best. They were able to identify problems and solve them. It can thus be concluded that the children relate to the problems as they encounter them; can identify shapes, have a good idea of the use of the mouse and shapes. Figure 4.1 has a snapshot of the page.

Figure 4.1



Experiment 2: Object Recognition

On this experiment also, the children were asked to answer three different pages of identifying objects, their purposes and the concepts that can relate to these objects. The purpose was to understand whether children were able to identify an object and its purpose, link the object to an idea, concept or action and finally whether they know how to use the mouse. On this experiment also the children performed very well. From the results on their success on the experiment by groups and classes it was observed that the children are able to achieve all the above purposes very well. Figure 4.2 illustrates a page from this experiment.

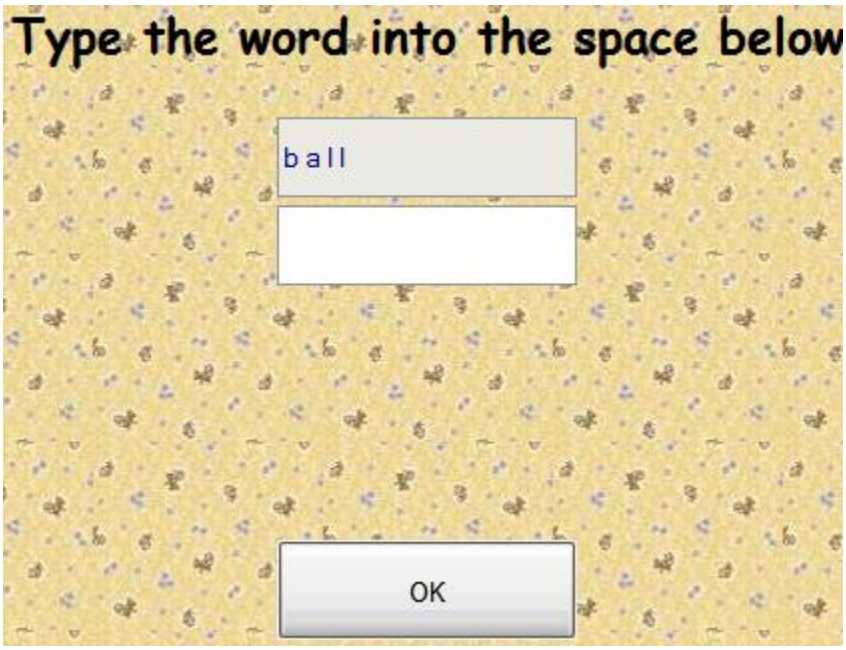
Figure 4.2

Experiment 3: Spelling

This experiment also had three pages as the other two discussed above. Each of the pages had a word that the children had to copy into a space provided below the word. The words were spelt in a mixture of capital and small letters. The aim of this experiment was to check their knowledge of words; the vocabulary base, their use of the keyboard; capital and small letters and whether they could spell. During this part of the study it was observed that most of the participants skipped the typing part and a number of them refused to do it until they were encouraged to just give them a try.

From the results two things were observed. First, children had a very small vocabulary base; they used words they had no idea of their spelling. They knew the words but had a lot of difficulty spelling them. Second, the children hated to type; some knew the words but got frustrated with typing them and just resorted to typing the wrong things and others just stuck with spelling the words in only capital letters or small letters while they were expected to do both. This observation was made across all the classes and groups. Thus it can be concluded that children are unable to use the keyboard efficiently; unable to type well and they use the words but are unable to spell them properly. Figure 4.3 illustrates the first page of this experiment.

Figure 4.3

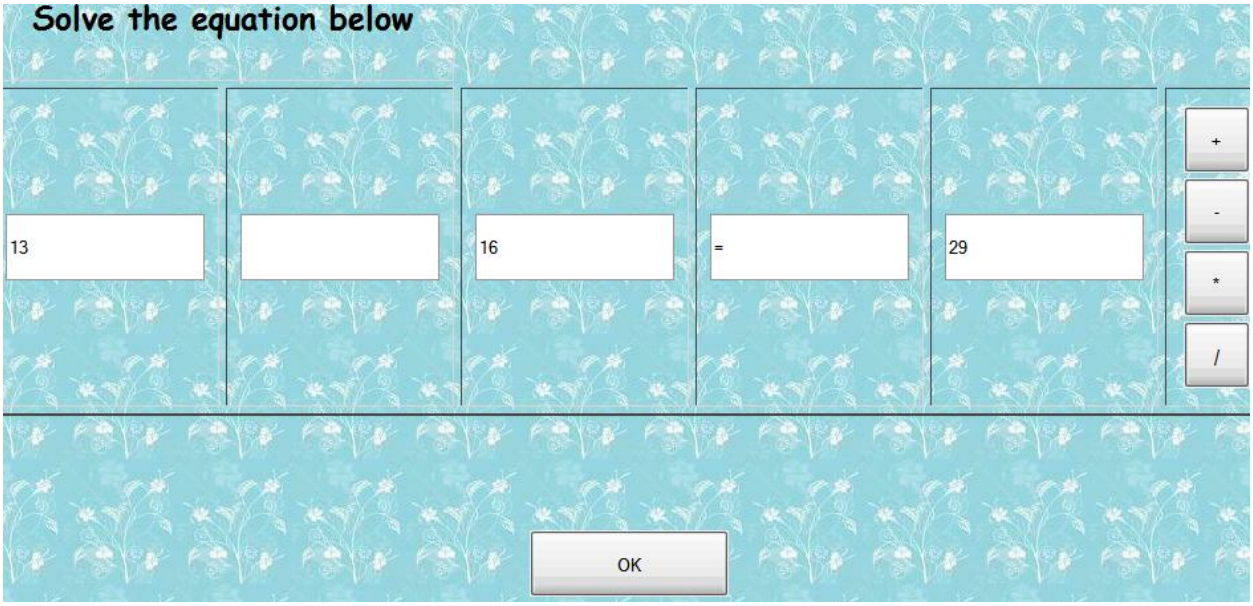


Experiment 4: Mathematical Equations and Counting

The children in classes 3 and 4 solved mathematical equations on the four operations; addition, subtraction, multiplication and division. Those in

class 2 solved equations in addition and subtraction. The children in class 1 and kindergarten 2 solved counting problems. The purpose of this group of experiments was to verify if the children could solve simple arithmetic problems and count, identify the operators and how they are used in operations, how to use the keyboard; the operators on the keyboard, and finally how to use the mouse. From the results a small number could do all the above. Most of them failed on this experiment, thus, the experiment's position as the lesser successful of all the experiments second to the experiment discussed before it. It must be stated however, that like the above conclusions drawn, children are able to use the mouse. The figure below shows a page for this experiment for the participants on class 4.

Figure 4.4



Web Browsing

This part of the study was aimed at observing and understanding the way Ghanaian children used the already existing web applications in general; their use of the mouse, keyboard, identify when to undo an action, identify a link, understand an interface divided into categories, etc. As established with the other experiments children have difficulties with spelling and their knowledge of the use of the keyboard is very limited, in general, they know what to do but are uncertain of how to do it. One important thing observed here was that their level of knowledge and their exposure to the use of computers and the Internet also played a very important role. It drew them as close to the answers as possible. Beyond that point, the assistance from the older generation was needed and as the results proved the Aided Browsers performed better on all fronts because of the additional input.

Figure 4.5 is the index page of the factmonster web site.

Figure 4.5

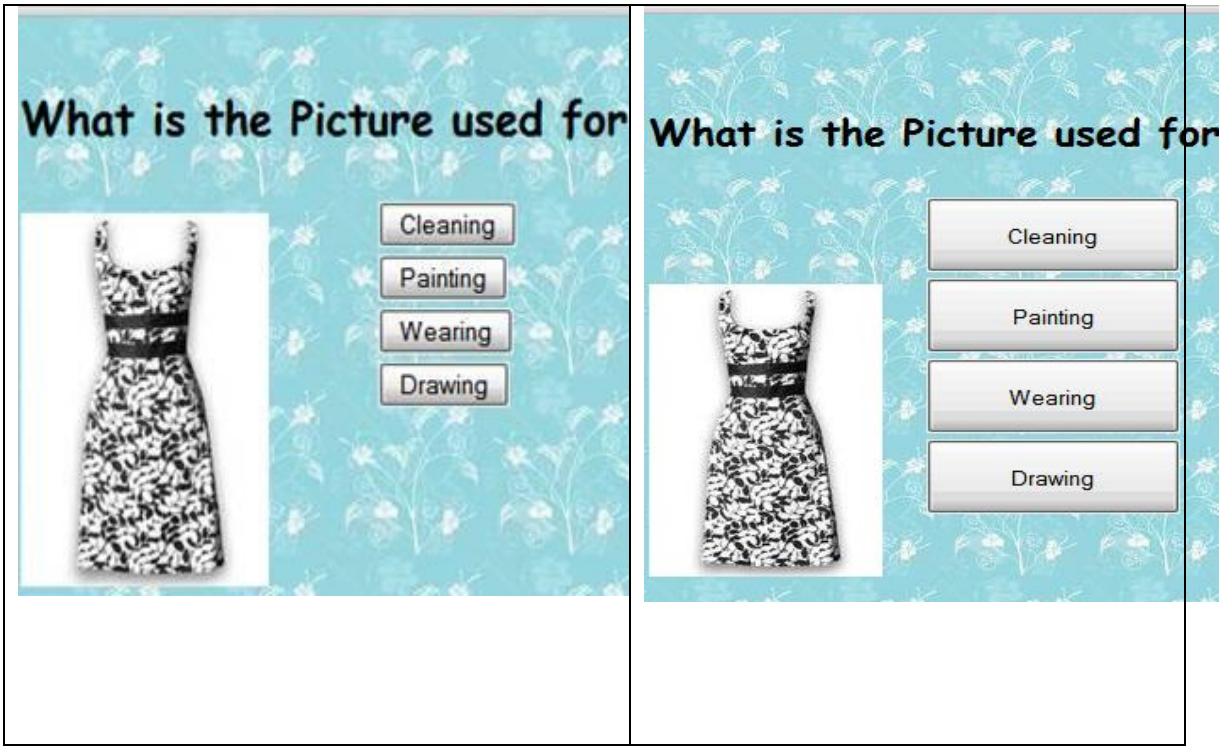
H1: Aided and Unaided Browsers

This hypothesis proved to be true. During the web browsing it was observed that lack of the appropriate knowledge on a particular question influenced greatly the performance. From the results it is clear that there is need for assistance from the adult generation when it comes to the use of already existing applications because the Aided Browsers performed better in their use of time and their success.

H2: Button Control

This hypothesis like the one above also proved to be true. The children in this group had small buttons for their experiments compared to their control group. From the results, their worst performance confirmed the hypothesis. Their poor performance can be accounted to the difficulty in doing the experiments due to size of their buttons. Among all the groups this group performed worst. This group had the most difficulty during the study because they were forced to share the time for doing the experiments between solving the problems and figuring out how to choose the answers available. This can also account for the time they spent on the experiments; they spent the most time on the experiments. Figure 4.6 is a snapshot of a page from the second experiment.

Figure 4.6



H3: Alert Control Group

The first part, time, of the hypothesis proved the hypothesis false however, the second part, success, proved to be true. The children in this group whose instructions were displayed in pop-up boxes finished their experiments in the shorter time compared to their control group (instructions displayed on screen), contrary to the hypothesis. However, in conformance with second part of the hypothesis the control group performed better. One observation made during the study was that most of the children in this group just closed the pop-ups immediately they saw them before even reading them to know their purposes. This could account for the short time they spent on the experiments, however, this reflected on their performance. They did not read most of the instructions thus their poorer performance on the experiments.

H4: Color Control

This hypothesis was completely proved false. It is believed that children, especially the younger ones, enjoy the use of a lot of color in their applications. Contrary to the hypothesis, the children with little color performed better both in their use of time and success compared to its control group. From the results it can be deduced that the use of color and background images does not impact the performance of the children. On a particular occasion during the study, it was observed that one of the children just sat down and enjoyed the view of the different colors and images on the page. Figure 4.7 illustrates a snapshot of the first page of this experiment.

Figure 4.7

H5: Difference by Age

According to the analysis on the classes, it can be safely concluded that there was significant difference in the performance on the experiments by ages; classes. For the main stream classes, class 1 performed worst followed by class 2, however, between class 3 and class 4 there was no significant difference and the children in Kg2 performed very well overall.

Limitations of the Study

This dissertation sought to measure one particular component; usability, for the development of these principles. This put a limitation on the variables that were measured during the study. Thus further research can be done in the future to include other components to this set of principles and guidelines.

Moreover, considering the fact that this was the first of such research work organized by the author, a number of things; inexperience, lack of correct estimations, bugs in software which were not identified until implementation, etc affected the study process. This was paid for with the first experiment which had bugs in the software, started late because of delays in set up, etc. But these could have been avoided because its results would have contributed immensely to this dissertation had they been included. However the analyzed results from the first were used to refine the subsequent researches.

CHAPTER 5: RECOMMENDATIONS AND CONCLUSIONS

Summary of Findings

The results from the studies have revealed a number of important things necessary to note for the design of web applications for children in Ghana.

1. The use of already-existing web applications by children requires the supervision and guidance of older people. Between the two groups; Aided and Unaided Browser, the former had 100% in performance and used 26 minutes to complete. While the later had 66.67% in performance and spent 44 minutes. To reduce and completely remove the need for adult assistance in the use of web applications, web application developers can avoid some of the mistakes which have already been discussed in the Literature review.
2. The use of pop-up boxes affects the performance of children, if the pop-up contain some of the instructions. During the studies the children who had some of the instructions displayed in pop-up boxes had a lower performance 64.36% compared to the children whose instructions were displayed on the page; 67.02%.
3. The use of small buttons; normal size of buttons for adults, on their application posed a big problem. The children found it very difficult to click on these buttons because they were too small. Their motor skills were not well developed to perform such tasks. This impacted their performance in a negative way; 59.04% compared to 67.02% for the children who had larger buttons.

4. The use of right content positively on the performance on an application. During the studies it was observed that over 90% of the participants scored above 80% on Experiment 1 and 2. This can be accounted to the fact that all of had classes and understood the lessons on shapes and object recognition. The analysis; charts and graphs and displayed in chapters 3 and 4 will confirm. However, for the mathematical and typing experiment performance was very low. A number of reasons account for this but the fact that the children do not take typing lessons and have not got a strong grip on arithmetic yet are among the main ones. Thus on Experiment 3 about 80% of the participants scored below 50% and on Experiment 4 about 50% of the participants scored below 50%. The graph on the success on experiment by classes depicts this.

5. The use of color and images does not impact on the performance of children. From the studies organized the children who had little color and no image performed better; 93.75 compared to the children who had color and background images; 83.75.

6. It was observed that overall, among the groups: Alert, Button, Aided, Unaided, Normal; separating the one who were supervised from the ones who were not, the participants in classes 3 and 4 were able to understand the questions and suggest or choose the correct answers faster and better than the ones in the lower classes.

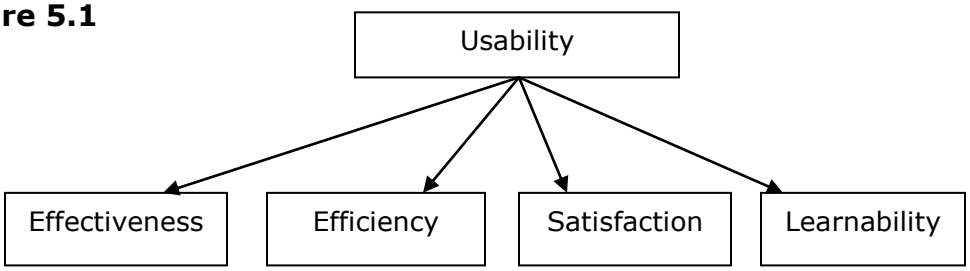
7. One other factor that was identified during and after the study, but was not measured was exposure. It was identified that for the children whose relatives had computers at home, their experience with the study was better

and they were more comfortable with participating in it. Those who did not have such exposure took a little more time to get comfortable and then to do the experiments.

Principles and Guidelines for Developing Web Applications

As already discussed in the Literature Review, a number of features have been identified as the pillars whose presence is necessary for the development of usable software. Most of the findings from this dissertation have confirmed what has already been discovered by other researchers thus they will be briefly discussed. The scope of this dissertation covers only four features or attributes of the consolidated usability model and Figure 5.1 illustrates this.

Figure 5.1



To achieve effectiveness, the right content must be used. In Ghana the syllabus of the children that has been given by the Ghana Education Service (GES) can be considered. The general information that children are expected to know at their ages can also be included. Again the cognitive development level of the children must considered and finally the right and consistent use of objects to prevent confusion.

The achievement of efficiency can be done by ensuring that the time the children have to work on the application does not exceed to make them

frustrated or bored. Satisfaction can be achieved by mainly ensuring that the children have a nice time with the application. For Ghanaian children use a good enough level and amount of color and images. They enjoy nice views and thus need to be attracted to the application by its appearance. Thus color and images must be used however, these must not be too much to distract them and not too little to discourage and make application not appealing for them. Interactivity is also a key tool in achieving satisfaction.

Finally the instructions needed for the child to learn on the application must be visible and straight to the point to achieve go Learnability. The use of pop-up boxes will defeat this purpose.

These specific ones for the Ghanaian setting in addition to all the already identified on by other organizations and individual can be combined to give the child an educative and yet enjoyable experience with the web applications developed for them.

Conclusion and Future Work

A cultural bias has been presented to the already existing principles and guidelines by proving them through the studies organized in this dissertation. The results confirmed most of what has already been discovered. Now these principles and guidelines have been extended to include the Ghanaian setting. By this the aims and objectives of this dissertation have been achieved.

In the future more studies can be done to cover more depth. The areas chosen for this dissertation were very few; use of color, images,

buttons, the right way of presenting information, the right content, etc. More research can be done to include the use of hyperlinks, the use of animation, measure the impact of exposure on performance, etc. Second organize more of these studies for more children in order to come to a more inclusive conclusion about Ghanaian children's use of web applications and how to make the applications more exciting for their use.

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APPENDIX A: Usability Features Discussed

Effectiveness

According to the ISO 9241, software is considered to be effective or not depending on "how well the users achieve their goals using that software."[11] In other words how successful are the users at the tasks on the application. Developers need to achieve high effectiveness with the web applications they develop for the children by

1. Choosing the right content: the information on the application must be relevant to the children.
2. Considering the level of development: this involves the cognitive development level of the children. Depending on the age range it must be considered that performing some activities; typing, using the mouse, etc. will be more difficult or easy.
3. Being consistent: the use of objects; hyperlinks, buttons, text boxes, checkboxes, and radio buttons etc. must be consistent. With the use of these objects, the children must be able to relate to them by the way they are consistently used throughout the application.

Efficiency

In the standard mentioned above another attribute, Efficiency is defined. The resources, e.g. time, that are consumed by the users in order to achieve their goals [11] define efficiency and the developer must achieve high efficiency with the web application. This is done by developer

1. Using familiar tools and objects in known or familiar ways: children learn a lot from their environment through observation and practice thus the tools and objects used must be consistent with what they have seen or observed.

2. Making information easily identifiable: children use the simplest ways to find the information needed. They do not scroll down pages and thus get frustrated and confused when they do not find information on a page they expect to find some information because they did not scroll down. Links to information should have one or at most two routes so that the children do not get to the same page through different routes, waste time and get frustrated. Developers must take note not to make children do the wrong things on so many occasions because they are not familiar with the "new wrong" route they are using

3. Putting only useful information on the page: if the children do not need the information to achieve a goal it is not important to put it on the page.

Satisfaction

Satisfaction is how the users feel about the use of the software [11] as defined by ISO 9241. Developers can achieve this when they

1. Create interactivity: the children must feel a sense of connection to the application. Feed back is very important to children. There must be no point at which they wonder what is going on or what to do with the application.

2. Use less complicated technology: technologies that require high RAM size and high speed to operate and are complex to use must be reduced.

Children have access to older version of computers, thus the need to use simple technologies that do not require too much complexity to operate them. The use of software or technologies that need to be consistently updated also creates a lot of problems which they have very little control over so should be avoided.

Learnability

This attribute is simply defined as the time to learn by a number of usability experts like Jakob Nielsen. To achieve high Learnability with their applications developers must

1. Give clear instructions and directions: children must know what and how to do what they have to do on a given application.

APPENDIX B: Activity Schedule and Timeline

Activity	Date/ Period Scheduled
Printing and Sending Out Letters to Head teachers for Children's Participation ✓ Writing and editing the letters ✓ Getting the letter of introduction from Supervisor ✓ Printing and sending the letters to the various schools	8th - 11th December, 2009
Reading for the development of the experiments ✓ Identifying the various technologies (e.g. Flash or Java Script) for the development of the experiments ✓ Reading on the technologies identified to facilitate the development of the experiments	21st - 28th December, 2009
Creating the experiments and Testing out the websites (Making sure that everything works) ✓ Developing the experiments and testing them to ensure that they work efficiently ✓ Using the websites chosen and recording the steps needed to finish the tasks ✓ Developing the scale for measuring the criteria with the experiments and websites	28th December, 2009 - 16th January, 2010

Organizing the Research (Data Collection) ✓ Acquiring a venue for the research project (Booking for Ashesi Labs or Visiting the school's labs if available) ✓ Contacting the necessary schools for the participants ✓ Choosing the suitable dates for the research period ✓ Getting volunteers to help with the research. ✓ Planning the means of observation and recording the tasks performed by participants ✓ Getting remuneration for participants. ✓ Getting the participants prepared and taking them to the chosen venue ✓ Undertaking the research.	18th - 29th January, 2010
Data Analysis ✓ Reading on the different tools (e.g. Statistical) for analysis. ✓ Analyzing the results of the findings with the tools chosen for the analysis	29th January - 8th February, 2010
Deductions of Principle and Guidelines ✓ Examine the parts of the analysis that form the principles and guidelines ✓ Using the Consolidated ISO model as the foundation for the principles and guidelines to be drawn out from the	15th February - 15th March, 2010

analysis	
Conclusions and Recommendations and Finalizing of the whole document. ✓ Conclude and give recommendations which will be in the form of the Principles and Guidelines ✓ Reading through the whole dissertation over and over to dot i's and cross t's ✓ Submitting the dissertation to other people for review as well. ✓ Add the other important parts of the dissertation to complete it ✓ Submit dissertation to my thesis supervisor for final review. ✓ Submit to the Dean of Academic Affairs	22nd March – 1st April, 2010