# DISCOVERABILITY A NEW LEARNABILITY PRINCIPLE FOR CHILDREN'S APPLICATION SOFTWARE

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***ABSTRACT***

*For more than two decades children's use of multimedia was restricted to watching television and listening to music. Although some parents complained about children being addicted to listening to music the idea that children could be addicted to television was a real concern to most parents. Nowadays parents not only need to be concerned about how much television their kids are watching, but also many other forms of media that are emerging with the fast development in information and technology such as the internet, video games, tablets and smart phones. From this the researcher came to realize that children are increasingly becoming the consumers of application software facilitated by these information systems. Children spend at least three hours according to research on these media which includes the use of computers, tablets, smartphones and music. The researcher was concerned that system vendors use the same learnability principles to make applications for all age groups based on learnability principles that were designed with adult users in mind. Many interface design principles used for adult products cannot be applied to products meant for children and further yet children at different ages learn differently. The research looked at the existing learnability principles by trying to evaluate them and come up with new principle(s) that can be used to further improve the current principles so that they can be used effectively by information system designers to improve on the learnability of their application software meant for children of different age groups.*

***KEYWORDS***

*Learnability, application software, principles, discoverability*

## 1. INTRODUCTION

Usability is a quality feature that evaluates the ease at which a user interface is to performing tasks [1]. The word "usability" also refers to methods for improving ease-of-use during the design process. Learnability is one of 5 attributes that compose usability. Other components are: understandability, attractiveness, operability and usability compliance.

The more learnable a system is, the shorter the period of time a user will take in order to comprehend how to do a specific task without having being previously trained and without using any documentation [2]. In this context, users of mobile-wireless information systems application software of different age groups learn how to use the devices easily, slowly or may never

completely learn how to use it efficiently. The purpose of the experiment was to find a way that applications can be built to suit the particular cohorts thus improve learning speed and by so doing it will take users a shorter time to understand functionalities and by doing so increasing efficient use of the system. The researcher had set out to extend the existing learnability principles for the different age groups of children. The results of the research were meant for the application software vendors to use during the development of the application software designed for children.

## 2. RELATED STUDIES

### 2.1 LEARNABILITY DESIGN PRINCIPLES

ISO Standard 9241-111 provided the following guidelines on the assessment learnability.

Table 1 Learnability measures.

| Measurement | Function of the measurement |
|---|---|
| Measure of how effective | Number of functions learned<br>Percentage of users who manage to learn |
| Measure of how efficient | Time it take learning<br>Time it takes to re-learn<br>Relative efficiency while learning |
| Measure of how satisfied the user is | Scale to rate the ease of learning |

Source: [3]

Other measures include: Number of errors; time taken to recover from an error; the period a new user requires to reach a given level of competence. As stated by [4] learnability can be measured by establishing different factors such as: User interface- visibility of operation, feedback, continuity of task sequences, design standards, user help, prevention of errors, information presentation; Compliance with user's expectations- concept clarity, contrast in function, differences in interaction styles and completeness of information. Training- Conceptual information, practices, direction on basic interaction, directions for solving problems, coverage of system functionality, material types and motivational content.

A learnability survey was done by Chimbo [5] compared what learnability meant for child and adult users. There was insufficient information in the literature dealing exactly with the learnability principle thus suggesting a missing part in the body of knowledge.

The comparing of what learnability means to children and adults by use an unconventional software yielded impacting results for application designers and HCI professionals in general. Thus they came up with a new learnability principle known as engageability. The word engageability was derived from the word engagement which is in the HCI context, engagement is a goal of interface design; it is also the main focus in the well-established frameworks of flow theory and play theory [6].

### 2.2. STAGES OF LEARNING IN CHILDHOOD

Piaget [7] proposes the following levels of child progression, but is quick to identify that while ages are given at each level this is just an estimation and that each person's advances at their own

distinct rate. Sensorimotor (from birth to two years) - Infants gain knowledge of the world through their senses and their motor activity. The infant progresses to the stage of participating in trial and error learning and basic problem solving.

The vital cognitive acquisition is actualization that the world is a permanent place and that, objects, places and people in it continue to exist even when they are out of view. Pre-operational (Two to seven years) - The child builds a representational system and uses symbols to identify objects, places and people. Children are basically still 'egocentric' as they do not comprehend that their visualization of the world is not shared by other people. Concrete operations (seven to eleven years) - Children are able to solve problems logically and are starting to comprehend and use ideas that relate to their direct environment.

The most vital cognitive skill as stated by [7] is the stage of reservation, where the understanding that two things that began the same remain similar even if they are made to appear different. Formal operations (from twelve to fifteen years to adulthood) - kids develop the capability to think in abstract terms and to deal with hypothetical scenarios. Children are usually capable of solving complex problems in an organized way.

Piaget [2] didn't fully and clearly relate his theory to education, in spite of the fact that later on researchers have made it clear how aspects of his theory can be implemented to teaching and learning. He has been very influential in the building up of educational policies and the teaching practice.

**Discovery learning** – It's the concept that children learn best by doing and actively exploring - was seen as central to the transformation of the primary school curriculum. As stated by [7], assimilation and accommodation needs active learners and not passive learners, this is because problem-solving skills can't be taught they must be discovered. Within a classroom learning should be centered on the student and then achieved through active discovery learning.

## 3. RESEARCH METHODOLOGY

The methodological approach including the research design, instruments used, study location, and target population.

### 3.1. RESEARCH DESIGN

The research was an experiment in the form of a learnability test. It used children as the test subjects to find faults in the given application software interfaces that were used in the test. The applications used in the tests were selected according to their popularity with children of the given ages in Kenya.

The experiment was undertaken in a HCI based setting. HCI is basically the study of the interaction between people, computers and tasks.

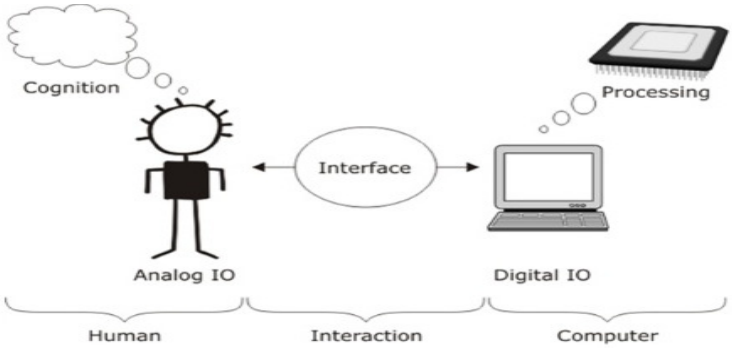


Figure 1: Basic HCI model. Source: [8]

HCI sees software as a tool for doing some job. For a tool to be usable it must: be easy to learn how to use, allow the user to do the job smoothly, be easy to remember how to use, not cause mistakes, and be pleasant to use. There are various disciplines in HCI this being: psychology, sociology, art, design, engineering, linguistics, philosophy, physiology, anthropology, ergonomics and artificial intelligence.

The aim of HCI as an area of research in computing is to: Improve the usability of software - Make software easier to learn and use - (not always in harmony); Improve the effectiveness of software -Make software better at doing the work it does; Improve the task-efficiency of software -Improve the efficiency of the user's achievement of their task (i.e. not the efficiency of the program code being used as a tool in that task but the steps and structure of how the user makes it do the job.); Improve the safety of software -A well designed interface reduces errors. Sometimes errors can be dangerous; improve the functionality of software -Making systems better equipped with the tools necessary for tasks (e.g. providing searching and sorting functions as standard).

### 3.2 STUDY LOCATION

The research was conducted in Nairobi, Kenya's ICT hub [11].

### 3.3 TARGET POPULATION

The research was focused on children of two age groups ranging from 8 to14 years and those from 15 to19 years, because children at different ages learn differently thus have different learnability issues [10]. According to [11] who were investigating children's mental health and understanding children behavior. A young child to adolescent teenagers' ages range from 5 years to 19 years. As stated by [12], adolescence is the changing duration that happens between childhood and adulthood and it encompasses ages twelve to nineteen years. This is the stage in which a child has psychological development. Thus a 19 year old is considered a child in the learning process and from the pilot study conducted by the researcher a significant number of 19 year olds are still in secondary schools.

### 3.4 SAMPLING

The research was an experiment as mentioned earlier -in the research design, thus required only 20 participants to attain the necessary data required for the assessment and analysis of the applications.

### 3.5 INSTRUMENTS

Research data was collected by the use of questionnaires and Morae 3.3.3 –a usability software. This took place in three stages of learnability testing: Heuristic evaluation (by use of the 10 heuristic guidelines designed by [13] of the application software used, analysis of PiP video recording of the participants and thirdly recording and analysis of two questionnaires through the use of the Morae 3.3.3 software.

The questionnaires were used to collect the data required to understand the first objective which was: Evaluating the current learnability principles of the mobile-wireless IS applications that vary with different ages of children and to also get demographics in this case being: age; level of education and level of computer knowledge. The questionnaires (two questionnaires) were administered through a computer by use of the Morae software.

### 3. 6 SOFTWARE USED IN THE TESTING

The four applications used in the testing process were selected because they were the most popular apps used by children according to [14]. The Facebook app ranked number 1 in the world as the most downloaded app in the world, Whatsapp messenger was ranked number 6 in the world –It was the second most popular app for teens in Kenya after Facebook according to the pilot study done by the researcwithin the classroom her. The original angry birds and subway surfer were ranked third and fourth most downloaded gaming apps in the world but were selected by the researcher as opposed to the first two gaming apps since they were the most popular in the region.

These popular application software are used in the most popular system software used in mobile-wireless information systems (tablets and smart phones) these being android operating systems and iOS as the platform.

### 3.7 DATA ANALYSIS

Data collection was through Morae 3.3.3 which is a usability software that records a picture-in-picture (PiP), video recording, eye-tracking and sound recording. The application by use of the Picture-in-Picture functionality facilitated the researcher in recording the participants' screen activities which assisted the researcher during analysis to go through the recordings repeatedly to find problems and to also further find problems that were not previously seen. The software is composed of 3 components i.e. Morae Recorder; Morae Observer and Morae Manager.

### 3.8 ETHICAL BACKGROUND

Ethics can be referred to as the rules governing the conduct of individuals or groups. One of the issues is the shambolic take on computer ethics by governments, the society and academics. The main approach in ethics isn't, as the formalist would have it, "rules that I should obey" but rather, "intentions that I should adopt" [15].

The researcher was aware that there was a possibility that the participants being children may feel pressure to perform and could have been worried about being slow in learning or understanding the system and applications or suffer inferiority complex knowing that they are under

observation. The research constantly assured the children that it was for fun and entertainment especially the younger children who played video games. The children are left by their parents with the teachers as their guardians and so the researcher was given consent by the teachers and was supervised by the teachers during the conduction of the tests which was mostly done in the staffroom or outside the head teacher's office.

## 4. DATA ANALYSIS AND PRESENTATION

Two questionnaires were administered during the test this being at the start of the experiment and at the completion of the experimental procedure. The first questionnaire was solely used for demographics while the second questionnaire was used to solve the specific objectives.

The demographics results were attained from the first questionnaire that was administered to the participants in the beginning of the test. This was to help in validation of the multi-stage sampling used by the researcher which included: stratified sampling (gender being the strata) and systematic random sampling and making sure it was accurately done.

Table 2. Data of the younger cohort in the learnability testing according to the first questionnaire answered.

| **PARTICIPANTS** | **GENDER** | | **AGE** | **EDUCATION** | **ANGRY BIRDS** | | **SUBWAY SURFER** | | **INITIAL EXPERIENCE WITH COMPUTER** |
|---|---|---|---|---|---|---|---|---|---|
| | M | F | | PRI | YES | NO | YES | NO | 1-10 |
| YOUNG CHILD 1 | | X | 13 | X | | X | | X | 5 |
| YOUNG CHILD 2 | X | | 12 | X | X | | | X | 3 |
| YOUNG CHILD 3 | X | | 15 | X | X | | | X | 4 |
| YOUNG CHILD 4 | | X | 11 | X | | X | | X | 2 |
| YOUNG CHILD 5 | X | | 15 | X | X | | X | | 3 |
| YOUNG CHILD 6 | | X | 8 | X | X | | | X | 4 |
| YOUNG CHILD 7 | X | | 11 | X | X | | | X | 4 |
| YOUNG CHILD 8 | | X | 11 | X | X | | X | | 5 |
| YOUNG CHILD 9 | X | | 9 | X | X | | X | | 5 |
| YOUNG CHILD 10 | X | | 9 | X | X | | | X | 4 |

Table 3. Data of the older age group in the learnability testing according to the first questionnaire.

| PARTICIPANTS | GENDER | | AGE | EDUCATION | WHATSAPP | | FACEBOOK | | INITIAL EXPERIENCE WITH COMPUTER |
|---|---|---|---|---|---|---|---|---|---|
| | M | F | Years | SEC | YES | NO | YES | NO | 1-10 |
| OLD CHILD 1 | X | | 16 | X | | X | X | | 5 |
| OLD CHILD 2 | X | | 17 | X | X | | X | | 9 |
| OLD CHILD 3 | | X | 16 | X | | X | | X | 3 |
| OLD CHILD 4 | X | | 19 | X | | X | X | | 1 |
| OLD CHILD 5 | | X | 18 | X | X | | X | | 3 |
| OLD CHILD 6 | | X | 19 | X | X | | X | | 3 |
| OLD CHILD 7 | X | | 16 | X | | X | X | | 5 |
| OLD CHILD 8 | X | | 16 | X | | X | X | | 3 |
| OLD CHILD 9 | X | | 16 | X | | X | X | | 1 |
| OLD CHILD 10 | X | | 17 | X | X | | X | | 3 |

Morae 3.3.3 video recordings of the participants taking the test revealed a clear observation of how they truly felt and saw the test. It was observed that some of the participant took the test as an exam and so felt like it was either 'passing' or 'failing' and thus answered the question with 'yes' and 'easy' mostly, although the video recordings showed otherwise (unbiased observation) of the test.

Some of the participants found difficulty in performing certain tasks and thus the researcher used markers in the video analysis to mark the area of difficulty and used the recordings for heuristics evaluation. The first questionnaire administered by the Morae 3.3.3 software was for demographic e.g. gender, age, level of education, experience with software and so on.

### 4.1 HEURISTICS EVALUATION

Heuristic evaluation based on Jakob Neilensen's [13] heuristics evaluation guidelines was used to evaluate the interfaces of the applications used by the participants for the learnability testing. As stated by [13] 2 to 3 analysts normally assess the system with by use of the ten established heuristic evaluation guidelines, taking note of their observations and often ranking them in order of severity.

The 10 heuristic evaluation guidelines are listed below:

i. **Visibility of the systems state** - Are users kept informed about system progress with appropriate feedback within reasonable time?

ii. **Match between the system and real life** - Does the system use concepts and language familiar to the user rather than system-oriented terms? Does the system apply real-life conventions and show information in a natural and logical order?

iii. **User control and freedom** - Can users do what they want when they want?

iv. **Consistency with conventional standards** - Do design elements such as objects and actions have the same meaning or effect in different situations?

v. **Error prevention** – Good designs should prevent users from making errors.

vi. **Recognition rather than recalling** - They're design elements such as actions, objects and options visible

vii. **Flexibility and efficiency of use** - Are task methods efficient and can users customize frequent actions or use short cuts?

viii. **Aesthetic and with minimalist design** - Do the dialogues contain irrelevant or unnecessary information?

ix. **Help users to recognize, to diagnose and recover from errors** – These are error messages displayed in plain language (without codes), do they accurately describe the problem and suggest a solution?

x. **Help and documentation** - Is appropriate help information supplied, and is this information easy to search and focused on the user's tasks?

The heuristics were evaluated using the standard usability severity ratings. The following 0 to 4 Likert scale was used in rating the severity of usability problems:

**0** = I don't agree that this is a usability problem at all
**1** = Cosmetic problem only: need not be fixed unless extra time is available on project
**2** = Minor usability problem: fixing this should be given low priority
**3** = Major usability problem: important to fix, so should be given high priority
**4** = Usability catastrophe: imperative to fix this before product can be released

Table 4. Summary of Facebook app heuristic evaluation

| **Heuristics** | **Evaluation 1** | **Evaluation 2** | **Evaluation 3** | **Overall rating** |
|---|---|---|---|---|
| Visibility of the systems state | Good | Good | Good | Good Rating 0 |
| Match between the system and the real world | Good | Good | Good | Good Rating 0 |
| User control and freedom | Bad | Good | Good | Good Rating 1 |
| Consistency with conventional standards | Good | OK | Bad | OK Rating 2 |
| Error prevention | Good | Bad | Good | Good Rating 1 |
| Recognition not recall | Good | Good | Good | Good Rating 0 |

| | | | | |
|---|---|---|---|---|
| Flexibility and efficiency of use | Good | Good | Good | Good Rating 0 |
| Aesthetic and minimalist design | OK | Good | Bad | OK Rating 2 |
| Help users to recognize, to diagnose and recover from errors | Good | Good | Good | Good Rating 0 |
| Help and documentation | Good | Good | Good | Good Rating 0 |

### 4.1.1 DISCUSSION

From the Facebook app heuristics evaluation, the researcher found tangible user interface issues on the Facebook mobile application for example: Consistency with conventional standards guidelines was a major issue as there were a couple of hidden menus with the logging out located in one of the hidden menus which was hard to find for even for regular Facebook users who usually use the Facebook main site; it was also evident in the location of other icons which were not consistent with the main site. There were other violations in other guidelines which include; user control and freedom, error prevention and lastly aesthetic and minimalist design. These guideline evaluations have been summarized in Table 4 above showing the evaluation of three evaluators. Thus it was evident that there was need to improve this application software to help users in performing their tasks.

Table 5. Summary of WhatsApp messenger heuristic evaluation by use of the standard ratings from 0 to 4.

| **Heuristics** | **Evaluation 1** | **Evaluation 2** | **Overall rating** |
|---|---|---|---|
| Visibility of the systems state | Bad | Bad | Good Rating 3 |
| Match between the system and the real world | Bad | Good | Good Rating 2 |
| User control and freedom | Bad | Good | Good Rating 2 |
| Consistency with conventional standards | Bad | Bad | OK Rating 3 |
| Error prevention | Bad | Bad | Good Rating 3 |
| Recognition not recall | Good | Bad | Good Rating 3 |
| Flexibility and efficiency of use | Good | Good | Good Rating 0 |
| Aesthetic and minimalist design | Bad | Good | OK Rating 2 |
| Help users to recognize, to diagnose and recover from errors | Good | OK | Good Rating 2 |
| Help and documentation | Good | OK | Good Rating 1 |

### 4.1.2 DISCUSSION

From the heuristic evaluations of the WhatsApp messenger the researcher was able to get significant user interface problems thus giving evidence that the application had a degree of difficulty to users performing some tasks. Visibility of the systems state, Match between the system and real life, and others basically 9 out of the 10 heuristic guidelines were violated by the application as shown in table 5. Thus it was evident that there was need to improve this application software to help users in performing their tasks.

## 5. SUMMARY OF FINDINGS

i) Younger children try and fail repeatedly but still want to try/play until they pass. It was observed that the younger children were constantly trying to complete the tasks given regardless of the number of failed attempts. This was observed in the recorded video footage and is illustrated in figure 2 which shows their attempts and task completion. The children were so engaged in the game that they never considered failing to attain the goal as important, in the end fun was what they were seeking. At the same time none of the children wanted to hand over the computer to the next participant when it was time in fact they were surprised that they had already played for the allocated time as they never realized time was moving. This is clearly displayed in figure 2. This means that the games were so engaging that the users/players never cared about the number of times that they had to try in order to finally succeed in attaining their given goal.

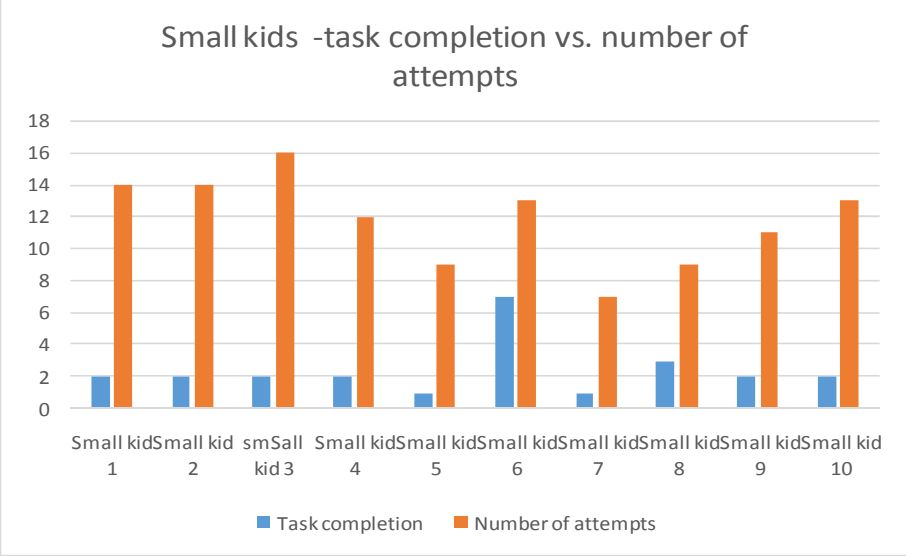


Figure 2. Graphical presentation of the number of attempt in comparison to the number of task completed by young children.

ii) 48% of the errors committed by older children were affected by the generalizability and consistency principle. Thus some participants were unable to locate some tools within the application software interfaces due to lack of consistency this was in violation of the Consistency with conventional standards guideline in the heuristics evaluation as mentioned

in the previous chapter in the heuristics evaluation. The inability to locate certain tools and functionalities in the interfaces cost the participants some time in attaining their given tasks in good time. These two learnability principles were the ones that majorly affect the participants during their performance of the various tasks as shown in figure 2. Thus navigation and location of icons to perform certain tasks was the major issue in the older childrens' learnability.

iii) Learnability of application software used by older children can be improved by improving mechanisms of locating functions and tools. Applications used by older children this mostly being social apps can be improved by increasing various ways in which they can discover or find out where certain primary functionalities are positioned.

iv) The researcher observed that there was a relationship between the level of computer experience and the number of errors committed by the participants as it has been illustrated in figure 3 which displays the relationship between the two. Users with a higher level of computer experience had fewer errors than users who had a lower computer experience. Meaning as users continually improve their computer skills, they generally improve their learnability skills of these mobile applications.

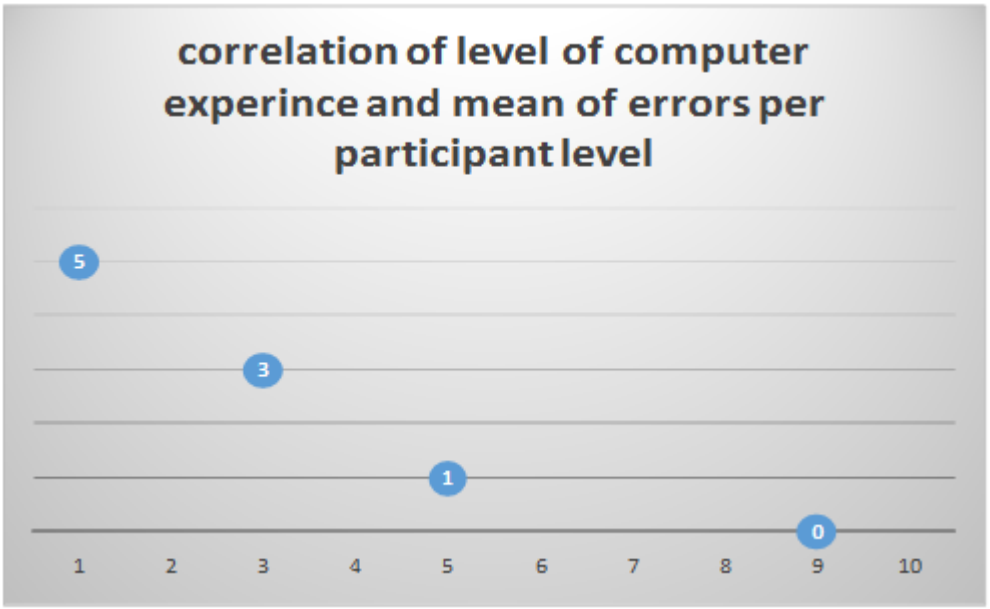


Figure 3. Correlation of the level of computer experience against average errors committed as per participants.

## 5.1 Extension Of The Existing Learnability Principles

It is evident from the discussion of the findings of this study that the principles of learnability should be applied differently for children at different ages.

**Discoverability:** It is the ability of a user to locate something (a functionality or a tool) that they need to complete a certain task efficiently. As stated by [16], discoverability is a very important

part in the learning of an application, although applications have both primary and secondary tasks for example, eReader is an iPad application which primary task is to read text and secondary tasks may include adjusting brightness, type size and so on. Instead of making both core and secondary functions just as discoverable at all times, a successful strategy would be to provide a sneak peek into the secondary functionalities. Not only does this enable users to focus on the main task, but it may simplify things for designers to make maximum use of the limited screen size [17]. Making features discoverable doesn't mean they have to be visible at all times. Another option is anticipating when users will require a given feature and display it at that moment [18].

## 6. CONCLUSION

Discoverability has evolved as part of an attempt to improve the user-friendly aspect of computers but has never been part of the learnability principle and yet according to the researcher's findings it is a very vital part of a user's learning of application software. Three of the five existing learnability principles i.e. familiarity, generalizability and consistency are all derived from consistency thus in essence there are only three learnability principles these being: predictability, synthesizability and consistency. Discoverability adopts some of the aspects of predictability and familiarity principle characteristics thus some discoverability features in applications are based on these characteristics thus forming the part of the principle characteristics [17].

The findings of the research (this being discoverability as a principle of children's learnability) will play an important role if implemented in the design of application software for children. By enabling children to learn how to use new or even previously used applications faster and thus perform tasks to a given level of proficiency.

## 7. FUTURE RESEARCH

In the future research could be done to investigate if discoverability is applicable to adults at different ages especially those of sixty years and over as it does to children. Research should also be done as mentioned earlier in chapter one in the background to study that according to [19], mobile information systems have much potential to facilitate older adults in their day to day activities.

In rural areas in Kenya testing should be done to the children to see if the findings are similar to what was found in urban areas thus providing proof that the initial findings can be applied to the whole country (Kenya). Although rural areas in Kenya face various challenges that vitally affect children's education and learning as a whole that needs to be taken into consideration before advanced issues are addressed.

In Kenya, the national project related to this research (free laptops to class one pupil's project) might not take effect soon although there seem to be specifics that have yet to be figured out, but there's still some important points to be made. Laptops exclusively will not solve structural and social issues in existence. This being a shortage of trained teachers, irregular power supplies and many children suffering from malnutrition [20].

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