ASHESI UNIVERSITY

A Tablet based tool to aid learning of mathematics for Basic 1 & 2 pupils in Berekuso

THESIS

B.Sc. Management Information Systems

Thesis submitted to the Department of Computer Science and Information Systems, Ashesi University in partial fulfillment of the requirements for the award of Bachelor of Science degree in Management Information Systems

Etonam .Y. Dotse

April 2019

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DECLARATION

I hereby declare that this thesis 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:

……………………………………………………………………………………………

Candidate's Name:

……………………………………………………………………………………………..

Date:

……………………………………………………………………………………………

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

Supervisor's Signature

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Supervisor's Name

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Date:

……………………………………………………………………………………………

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Finally, I wish to express special thanks to my Family and friends, who have supported me and seen me through my academic journey at Ashesi University.

Abstract

Over the past decade, the use of tablets in teaching basic school students has increased by 32.1%. [0] In this project, the researcher considers and analyses a tablet-based mathematics software and how feasible its implementation and use will impact the understanding of mathematics.

A quantitative and qualitative test was carried out on 20 primaries one and two students and the result shows an improved understanding of mathematics knowledge using the tablets. The effects, however, may depend on how long an instructor spends with the students and if the use of the tablet is led by a teacher.

This research paper should provide insight to some background work, related works in this domain, data collection approaches, application development and suggestions that will enable future researchers in this field to further enhance the development and adoption

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Chapter 1: Introduction

1.1 Introduction:

The United Nations Education, Scientific, and Cultural Organization (UNESCO) in 2008 recorded that in sub-Saharan Africa, a significant number of children between the ages of 5 and 16, have difficulty in learning mathematics. This problem is more prevalent in rural areas where technology is seldom used in Teaching.

To remedy this situation, some African governments (Kenya, South Africa, and Zimbabwe) have implemented I.C.T programs in rural areas, where laptops and computer laboratories have been provided. However, these technologies have been used for the improvement of the students understanding and ability to use modern day technology.

The West African Examinations Council (WAEC), states that over the past 10 years, performance in mathematics has been abysmal. Over the said period, about 47.23% of students who sat for the Basic Education Certificate Examination (B.E.C.E) failed to attain grades between 1 and 6. **Stanine** (Standard NINE) is a method of scaling test scores on a nine-point standard scale with a mean of five and a standard deviation of two. Grade 1 is the highest and Grade 9 is the lowest. [1] Even worse, 67.3% of students who sat for the West African Senior Secondary Certificate Examination (WASSCE) also failed to attain a passing grade of 55%. [1]

Research by the United Nations Education, Scientific, and Cultural Organization (UNESCO) has shown that students in basic schools are most interested in visual and participatory methods of learning mathematics compared to the traditional method of teaching: been used since formal education system was introduced in Ghana in 1961 [2]. Further research shows that students between the ages of 5 and 14 are more receptive to audiovisual modes of learning complex concepts, making smart devices such as phone, tablets, laptops, etc. an ideal form for teaching mathematics. [2]

Currently, mobile applications have been developed, which improve the study of mathematics for students in basic schools. This technology is deployed in some international schools in the country's capital. Notable amongst these schools are Galaxy international school, American international school, Alsyd international school amongst others. These mathematics teaching applications can enable students to self-tutor themselves with minimal or no effort from a third party via videos and modules.

1.2 Problem statement:

With an increasing number of students failing Mathematics at the basic and second cycle level of Education, it is important to consider causes, effects, and solutions to this predicament. It is worth noting that although frameworks and applications have been developed to aid students understanding of mathematics, most pupils in basic schools are not privy to these facilities or have the means to readily access them.

According to Fredua-Kwarteng (2004), the culture of learning Mathematics in Ghana can be attributed to the way the subject is taught and the way most students perceive the nature of the subject. [2]. Research conducted showed several reasons why students in Ghana have been performing abysmal in the subject and this trend keeps increasing. Notable amongst his reasons are as follows;

- "Students are more interested in copying content written on the board rather than engaging the teacher to gain a better understanding of what is being taught
- Students hardly read their mathematics textbooks and practice sample questions in them to gain mastery over the subject.

- Students are interested in going to libraries to read non-mathematical materials. Students may go to the library to read mathematics textbooks during examinations periods or when it is time for tests.
- Students find it worrisome discussing mathematical concepts during focus group discussions.
- Students learn mathematics by memorizing facts and theorems to answer examination and test questions after which these theorems and facts are forgotten.
- Students are comfortable with being receptors of mathematical knowledge in the classroom. Thus, they accept whatever the teacher teaches them irrespective of whether he is right or wrong.
- Most students do mathematics assignments and exercise not because they want to understand that concept, but they do it as a requirement for grades or to avoid getting punished at school
- Students have the notion that mathematics is about computations hence, mathematical concepts that do not involve calculations or computations are not taken seriously. Students are fond of asking how you calculate something instead of asking why you calculated it in that way.
- Students learn mathematics because it is required to pass a test. After passing the test, mathematics is no longer of importance to the students as they do not see its application in their daily lives or field of work.
- Students have come to believe that mathematics is only for brilliant students." [3]

1.3 Objectives:

The objective of this project is to consider and analyze a tablet-based mathematics software and how feasible its implementation and outcome impact the understanding of mathematics. This consideration would be carried out on a group of basic school students and teachers at the Berekuso basic school. This research paper is also aimed at gathering information on the role of a language of instruction and the culture of mathematics learning plays in the advancement of tablet-based mathematics in Ghana.

1.4 Research questions:

Three main questions this research will attempt to answer includes;

1. What effects does the use of tablet-based mathematics tool in basic school have on the students understanding of the subject?
2. What are the attitudes of basic school students towards the use of a tablet-based mathematics software?
3. What issues are involved in the implementation of a tablet-based technology for the study of mathematics in Berekuso?

1.5 Motivation:

As a basic school student, understanding mathematics had always been a problem as not studious, but because we were taught to understand mathematics as a theory, which has stood the test of time. With the emergence and use of technology in teaching and studying some subjects in Ghana, I am eager to see and experience how the use of technology would positively impact the advancement of mathematics in Ghana.

1.6 Hypotheses:

This research paper is being written under the assumption that

(i) Most children in rural areas in Ghana may not have used technology before

(ii) Most children in Ghana are bi-lingual, thus their mother tongue language and English

According to a paper written by Swicegood (2015), students have positive views of mathematics apps on tablets, but they would likely express a certain amount of worry about mathematics in general. [4]. In conducting this research, the researcher expects to see a general enthusiasm about the use of technology from both students and teachers alike. The researcher also expects to find that although some students may feel they are already good and adept with mathematics concepts, the use of approaching mathematics differently using technology would give such students a better understanding of the subject

Chapter 2: Literature Review

2.1 Introduction

Technology has become an integral resource in the lives of most people and professions in the world today. Technology today is used to facilitate and increase efficiency in different fields and sectors such as; health sciences, agriculture education, etc. However, not all individuals are privy to the use of technology, because of varying factors such as accessibility, culture, literacy, affordance, etc.

In the 21st century, it is very evident that there has been an outburst of technologies available to our disposal. As a result, there is a tendency for students in this century to have a relatively higher exposure to technology, as opposed to their tutors. Sarfo F.K and Ansong Gyimah conducted a survey with a sample size of 300 students in 4 selected schools [3]. In the survey, 60% of the students had access to computers and 40% did not. Their research concluded that primary school students in Ghana are more adept with the use of technology.

In this century, technology has become more important to our society. Mobile technologies such as mobile phones, tablets, etc have become more affordable and people now depend on them to conduct their day-to-day activities. Educational institutions are now able to purchase more of these technologies for their students especially schools with international affiliation. Schools outside this category may have to depend on external donors such as the government, Non-Governmental Organizations (NGO's), Parent Teacher Association (P.T.A) amongst others, to meet this growing need in their establishment.

As dependency on tablets and computers grow more and more, the need for technology education emerges [5]. To help remedy this situation, most basic schools operating in Ghana have computer labs which are used in teaching students some basic technology literacy.

Learning using technology accelerates and enriches basic skills of students; an interview conducted by David Dwyer, Vice President of advanced learning technologies for

Computer Curriculum Corporation, compared the use of computers for basic skill instruction with paper and pencil approaches and found increased performance and understanding in mathematics and reading literacy of 10 to 15 percent in the computer-using group [5]. Another finding that the study showed was an increase in efficiency. It also took students 30 percent less time to learn the same things with help from the computer [5].

Using tablet-based software's in teaching mathematics has been yielding good results in recent time and students are truly beginning to gain more from this technology. Key benefits of using technology in math education include:

- "Greater collaboration between students
- An increased focus on strategies and interpretation
- Fast and accurate feedback to students
- Increased motivation amongst students." [6]

Successful technology-based learning also relies heavily on the context of use. Classroom teachers play a significant role in facilitating student learning and aligning educational technology with content that is useful. This means that teachers play an important role in the successful performance of students.

2.2 History of mathematics and mathematics software in Ghana

A report submitted by the International Mathematical Union to John Templeton foundation in 2009 showed that Both primary and secondary level mathematics education are weak in most African countries, reducing the potential population (about 3 million students) of talented students who choose mathematics majors at the university level (15.23% or 450,000). [7]

The teaching and learning of mathematics in Africa is gradually reaching a point where technology would be the primary driver. Currently, certain mobile devices accompanied with pre-loaded mathematics softwares are being used in some parts of Africa. However, this may be, local context is essential when using technology to expand the educational horizon of the concepts of Mathematics in Africa.

Certain schools in Kenya have deployed a technology known as the "Kio Kit". The Kio Kit is a fully integrated education platform for digital education. A Kio Kit is made up of 40 Kio tablets, a "SupaBRCK" (a connected rugged microserver, with a dual-core Intel 64-bit processor, up to 5tb of hard drive space, redundant connectivity options), wireless tablet charging and a hardened, water-resistant, lockable case.

The Kio Kit runs on BRCK, a mobile Wi-Fi and storage device designed for power and connectivity-starved environments.

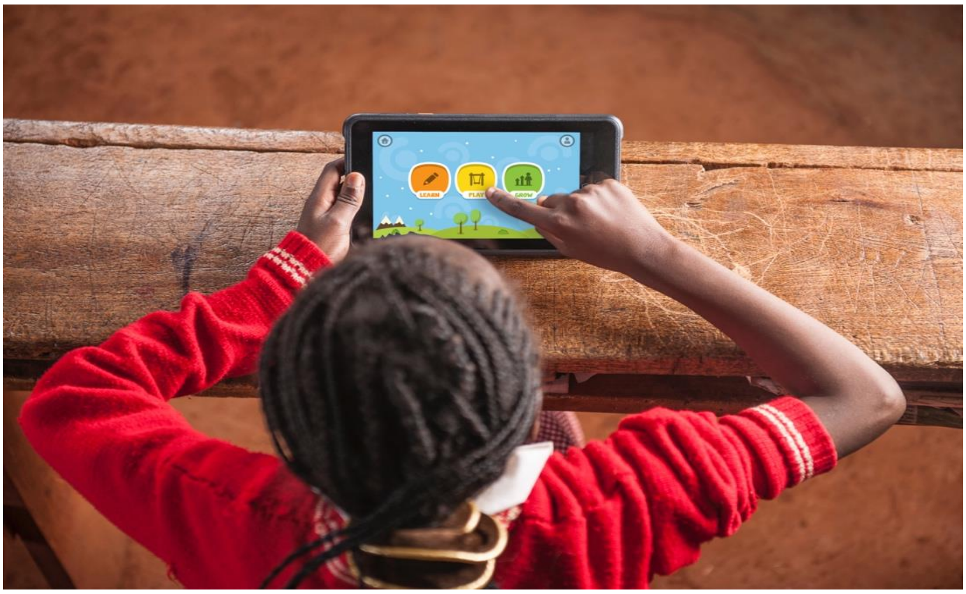


Figure 2.1: An image showing the Kio Kit

The tablets come pre-loaded with a mix of the Kenyan curriculum and international content. These tablets, however, do not have settings to prevent students from accessing non-educational content such as social media, sports, etc. However, the tablets can be updated with new materials when connected to BRCK, which is equipped with Wi-Fi, a sim card and Ethernet connectivity options.

Over the years, there has not been any significant difference or improvement with the use of the Kio Kit as opposed to the traditional method of teaching. Erik Hersman, the founder of the Kio Kit, admits to the poor success of the technology. He gives more insight into possible reasons why the Kio kit did not have as much impact on the study of mathematics as expected. Primarily because of the firm's concentration on the device itself and other hardware components which were near irrelevant to the study of mathematics rather than software that would aid students in learning mathematics. [8]

“We knew if we were going to look at education seriously, we need to look at this with a solutions-based approach because a device-based approach doesn’t work,” .“We spend a lot of time with teachers and the real ‘aha’ moment came when we started looking at the classrooms themselves and asked: ‘What’s not working here?’ Hersman said. [8]

In West Africa, specifically Ghana, "DreamBox” is used by several international schools.

Figure 2.2: A sample interface of the Dream box

Dream box is an online math learning system, designed for lower grade students. It delivers "learning units" where students learn *and* practice important mathematical concepts. DreamBox analyses a student's input on a click-by-click basis and uses this input to assign the most appropriate follow-up lessons. As a result, there are millions of different "paths" students can take through Dreambox's learning units. The core behind this software is its emphasis on conceptual and algebraic thinking. One of the major drawbacks to this software is that students are initially presented with only a limited selection of lessons to do. DreamBox will analyze the student's responses to those, and then present the student new lessons based on the analysis.

The tablet-based mathematics to be introduced would provide adequate knowledge to students on basic aspects of mathematics to enable students to complete the Ghana basic school syllabus. This system would also have relatable features such as local symbols, traditional pots, etc. That would aid students understanding and conceptualization of certain basic topics such as addition, story problems, etc. Tim Gowers' (2016) article gives insight into Simon Jennings' notion that "math is not a problem, it is the way it is taught that is".[9]

Chapter 3: Methodology

3.1 Introduction

The general aim of this study is to consider and analyze a tablet-based mathematics software and its implementation feasibility and effect on students understanding. This section describes the conceptual framework that the research study would be based on. Research methodology is important, as it outlines the path a researcher takes to conduct the research, collect and analyze data. This study is based on a mixed research methodology: quantitative and qualitative methods of research. Gay et al. (2006) state that: Qualitative research differs from quantitative research in two key ways:

- Qualitative research often involves the simultaneous collection of a wealth of narrative and visual data over an extended period, and
- as much as is possible, data collection occurs in a naturalistic setting. In other words, qualitative researchers try to study phenomena where they naturally occur. [10]

Quantitative research allows the researcher to understand in detail the problem being addressed, and to some extent generate hypotheses to be tested. With quantitative research;

- the emphasis is on facts and causes of behaviour (Bogdan & Biklen, 1998), [11]
- the information is in the form of numbers that can be quantified and summarized,
- the mathematical process is the norm for analyzing the numeric data and
- the result is expressed in statistical terminologies

3.2 Research Design

A research design is a plan of actions on how the research will answer the research question and collect measure and analyze the data [12]. In this study, quantitative methods would be used to collect data from students test scores. To achieve this, an experiment would be carried out on a selected number of basic school students. Some of these selected students would be traditionally taught mathematics; without the use of any technology. Another set of students would be taught mathematics with the use of tablets and its associated technologies. Both groups would be made to write the same test and the results collected and analyzed. To give more insight into the collected data, the quantitative method would be buttressed with some qualitative research methods, more specifically, observations. The researcher would add observation as a means of explaining some of the reasons why students may or may not understand mathematics concept better, given the introduction of tablet technology. Observational research may also prove useful, as it may throw light on a lurking variable responsible for the collected results that may be the subject of further research.

3.3 Sample selection and role of the researcher

For this research, the researcher selected a basic school close to Ashesi university primarily because of nearness and the relationship the university has with this basic school. In this basic school, a simple random sample would be conducted amongst lower primary students (primary 1 & 2) who would participate in the experiment. Twenty students would be selected randomly for the test. All twenty students would be invited to take part in the experiment, which will be conducted on the university campus (a few minutes' walk from the basic school). The experiments would be conducted in a classroom setting. The twenty students would be divided into two groups of ten. The first group would occupy one class and will be taught some mathematical concepts without any technological intervention, whereas the second group will be taught the same mathematical concepts using a tablet-based mathematics software.

3.4 Research setting

The setting will be on Ashesi University campus, Berekuso; however, the participants will be sampled from a basic school in the same township as the university. The research will be conducted in the month of January giving the researcher enough time to engage with the participants

3.5 Data Collection

This study will collect data on how basic school students, mostly, basic 1 and 2 students will use the tablet-based mathematics system in learning mathematics. This will be done through a controlled experiment involving selected students and accessing their performance before and after the use of the technology. Classroom observations will also be deployed as a means of supplementing the quantitative data to be obtained from their test scores.

3.6 Controlled experiment

A controlled experiment is a scientific test done under controlled conditions, meaning that just one (or a few) factors are changed at a time, while all others are kept constant. [13]. Using a controlled experiment has clear cut advantages over other forms of data collection methods with a project of this kind. With a controlled experiment;

- a researcher will gain insight into methods of instruction
- intuitive practice shaped by research
- a researcher can have control over variables
- can be combined with other research methods for rigor
- use to determine what is best for the population
- provides for greater transferability than anecdotal research

Students from St. Olaf University College in Minnesota, America, would be invited to help carry out the experiment (as they are running a similar test with US grade 1 students). The expected outcome of this experiment would be to obtain an understanding of which variables present or absent would affect the understanding of mathematical concepts for basic school students. It will also be an avenue to access how students use and understand tablet mathematics as a learning tool.

3.7 Observation

In observations, the researcher obtains data by simply watching the participants. In addition to observing the participants of the experiment, notes would also be taken as a documented version of what was observed. These notes would be taken and coalited for two main reasons;

1. They are a direct record of what the researcher and observers have seen, heard or noticed during the study
2. It shows the reflective information that captures the researcher's personal reactions to the observations, the researcher's experiences and thoughts during the study.

The implementation of the observation will be a direct and unstructured observation, where the observation of children in their natural environment (the classroom) will be in focus. With this technique, the observers will study the routine and the techniques of the students in their usage of tablets for the study of mathematics. To achieve this some questions will be taken into consideration when before conducting the observation:

- "What are we going to observe?
- How are we going to document the observations?
- How should we behave as observers?"

During the days scheduled for the research study, the researchers will observe the participants from a distance while writing down information in a notebook. The participants will be aware of the observers but will still be in their normal environment, so no distraction or pressure will be put on the participants.

3.8 Ethical Considerations

This study presents very little risk to participants in any way that pertains to experimental treatment or exposure to physical or psychological harm. Participants would be advised that procedures were adopted to retain anonymity and a consent form will require their parents' approval.

3.9 Data Analysis

For the use of both research methods (quantitative and qualitative), data analysis techniques would be employed as a way of analyzing primary data obtained. Comparisons of figures obtained would be crossed checked against similar experiments conducted by students from St. Olaf University College in Minnesota, America to test a similar hypothesis

For data collected through a qualitative approach, coding would be the most useful data analysis method. Coding is the technique which will help the researcher to find meaningful pieces from the gathered information. (Recker, 2013) [14]. The collected data from the observation will be coded using selective coding. In selective coding, concepts, keywords, and meanings are collected together to create meaning. [14]

3.10 Plan and goals of the research study

This research would focus on basic mathematics operations, primarily addition and subtraction. This is aimed at developing students' ability to manipulate single- and double-digit numbers effectively at their early stage of development. A pre-test and a post-test would be conducted at the beginning and end of the research respectively. These tests are to gauge the level of understanding and efficiency the participants have gained, as a result of partaking in this research. Sample pre-test and post-test questions would be;

2 + 3

5 + 2 =

15 + 2 =

21 + 13 =

These sample pre-tests and post-tests were set to meet the intellectual standards of primary 1 Students in Ghana.

Before participants begin to use the tablets, they would initially be taught using Lego-like artifacts called "turtles" to enable them to visualize, add and subtract using these artifacts. Other equipment, such as a placemat (an item that has a place to hold colored turtles in the form of a tower) will be used in conjunction with the turtles. By the end of the introductory period (the period before they start using the tablets), each student would have used all equipment necessary to prepare them for using the tablet-based mathematics software. The schedule below shows the delivery of content to the participants of this research within an hour of 9 meetings on different days;

Lesson 1: becoming familiar with the blocks

- introductions

Lesson 2: tower names

- The researcher presents examples of towers and the corresponding names
- volunteers ask to give the tower name for a given tower or asked to build a tower corresponding to a given tower name
- work on the tablets to establish the tower <-> tower name association

Lesson 3: measuring height with a tower

- begin with estimates: everyone shows the height of a box with fingers, everyone shows the height of a fiver, everyone shows the height of a turtle
- teacher presents an example of measuring an object by building a tower of the same height

- ask for volunteers to measure another given object
- work on the tablets to establish the tower measurement skill

Lesson 4: equal-height towers, parts I & II

- The researcher presents an example of a mixed tower with only boxes and fivers. In part II, use singletons.
- researcher creates another example of a mixed tower
- choose a volunteer to come and check their answer, and explain their reasoning
- tablet demo: building equal-height towers of just boxes and fivers
- work on the tablets to build/recognize equal-height towers

Lesson 5: addition from blocks

- introduce placemats
- volunteers create blue and red towers, everyone copies
- everyone builds the mixed tower at once
- everyone builds the black tower at once
- tablet demo: given blue and red towers, drag them to mixed spot, then build the black tower of the same height
- work on tablets to do these two-step problems

Lesson 6: addition without building the mixed tower explicitly

- teacher builds a blue tower and a red tower (no singletons)
- everyone tries to build a tower of the same height as the sum
- tablet demo: given blue and red towers, build the black tower directly (then see that it is correct because the blue and red move)
- work on tablets to do these one-step problems, moving from fivers to singletons

Lesson 7: addition from tower names

- everyone follows the leader: given a card prompt (like 10 5 2 + 5 1) build the blue tower in the correct place, build the red tower in correct place, combine blue and red, build the black tower to be the sum, report the name of the black tower as the 'answer'.
- tablet demo: same sequence of given a prompt, build the necessary towers, build the black tower, and say the tower name.
- work on tablets to do these three- or four-step problems.

Lesson 8: tower names and numbers

- Introduce 'short' notation for a fiver and some turtles
- Introduce notation when we also have boxes
- Work on tablets may also review addition from tower names

Lesson 9: addition from numbers

Like the lesson on addition from tower names but using two-digit numeric prompts.

3.11 Technology overview

The use of the Mathematics application is a two-phase process; the first process is to model the system using blocks (of certain heights) and the second phase is the use of the tablet-based software named "suuji". This two-phased process aims at introducing the participants (users) to physical units and to get them acquainted to what they will be doing on the tablet. The methodology of the first phase is as follows;

Blocks are used to build towers that represent numbers. The towers are of three kinds: blue, red, and black (e.g. "the blue tower height plus the red tower height makes the black tower height").

Each tower is composed of blocks, whose heights are 1, 5, 10, 50, and 100 millimeters.

The supply of blocks is limited so that there is at most one blue block of height 50, four blue blocks of height 10, for each student. As a result, creating a tower that is a specific number of millimeters tall (e.g. 153mm) can be done in only one way. Trying to do, for instance, 50, 50, 50, 1, 1, 1 doesn't work, because there would not be any three 50's of a given color. The process for performing a sum, e.g. 125 + 116, is as follows:

a) construct a blue tower of height 125

b) construct a red tower of height 116

c) take all the blocks in these two towers and stack them all together to make a mixed red-and-blue tower (which has the desired height, but not the correct constituent blocks to express the sum)

d) construct a black tower exactly as tall as the mixed tower, which therefore is composed of the correct constituent blocks

e) Describe this black tower as a number, i.e. 241.

The process for subtraction would be similar, as a missing addend (a number which is added to another) problem: 125 + (what red tower?) makes 241. Regarding the numeral itself: the number is initially written as three separated numbers, where the first number is associated with the number of 100 blocks, the second number is obtained by counting the pictures of the animals on the 10 and 50 blocks, and the third number represents the sum implied by a given combination of 1 and 5 blocks. Such an operational definition for these three-digit numbers does not assume an understanding of grouping in 10s or place value.

The blocks in a tower are of two kinds: the wooden blocks (10, 50, 100) and the plastic blocks (1, 5). The wooden blocks are easier to manipulate, and it is easier to compare two towers that are composed solely of wooden blocks than towers that include plastic pieces.

The methodology of the second phase is as follows;

The application will be built using React Native and Redux. The data is installed on the MySQL database. The application will be hosted on the Apache web server.

React Native is a JavaScript framework for building user interfaces. It can be used to build both Android and IOS applications because it allows for code reuse. This feature makes way for faster development of applications

Redux is a JavaScript library that manages the state of an application. It has three components; namely; Store, Actions, and reducer. The store component stores the state of the application, the action component returns the state of the application after receiving a trigger from the user. The reducer changes the state of the application based on the action parsed to it. When the reducer changes the state, it parses the new state to the store component, which renders it to the React Native component for display. Redux was chosen because data flows in a single direction.

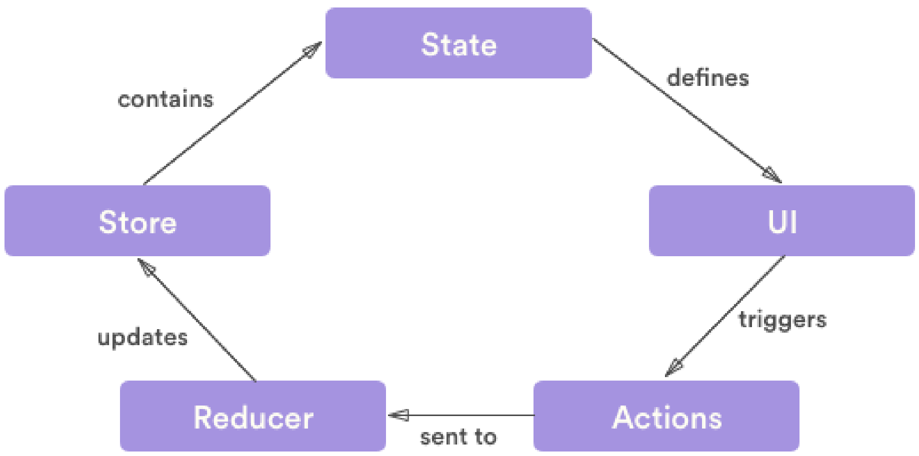


Figure 3.1: Redux flow architecture

Below is a code snippet to be used for the subitizing activity function;

```
subitize:
  params:
    generate:
      num_animals: [pick_from_range, 0.3, 3.9, 0.1]
      option_value_delta: 0.2
      option_value_seed: num_animals
      restriction_3: option > 0
      restriction_4: option < 4
      m1: num_animals
    create:
      tower_1: { name: m1 }
      tower_2: { name: 1 }
    modify:
      tower_1:
        position: [15, 0]
        misc:
          hide_tower_number: true
          backgroundColor: 'black'
      tower_2:
        position: [0, 0]
        misc:
          hide_tower_number: true
          is_option: true
          option_offset: 220
          option_width: 110
          backgroundColor: 'purple'
    event_handling:
      correctness: identical
      target: tower_2
      arg_1: tower_1
```

Figure 3.2: subitizing activity function

Below is a snippet to be used for the addition function;

```
addition_mix_and_match_with_ants:
  params:
    generate:⋯
    create:
      keypad_kind: 'buildTower'
      big_paren: true
      big_op: +
      arith_symbol: +
      equal_symbol: =
      tower_2_shadow: { name: tower_2_height }
      tower_1_shadow: { name: tower_1_height }
      tower_2: { name: tower_2_height }
      tower_1: { name: tower_1_height }
      tower_mixed: []
      tower_result: []
      tower_4: { name: mixed_tower_height }
      tile_success: { name: emoji_smile }
      tile_fail: { name: emoji_frown }
    modify:
      tile_success:
        position: [center,center]
        style: { opacity: 0.0 }
        misc:
          use_no_borders: true
      tile_fail:
        position: [center,center]
        style: { opacity: 0.0 }
        misc:
          use_no_borders: true
```

Figure 3.3: Addition function

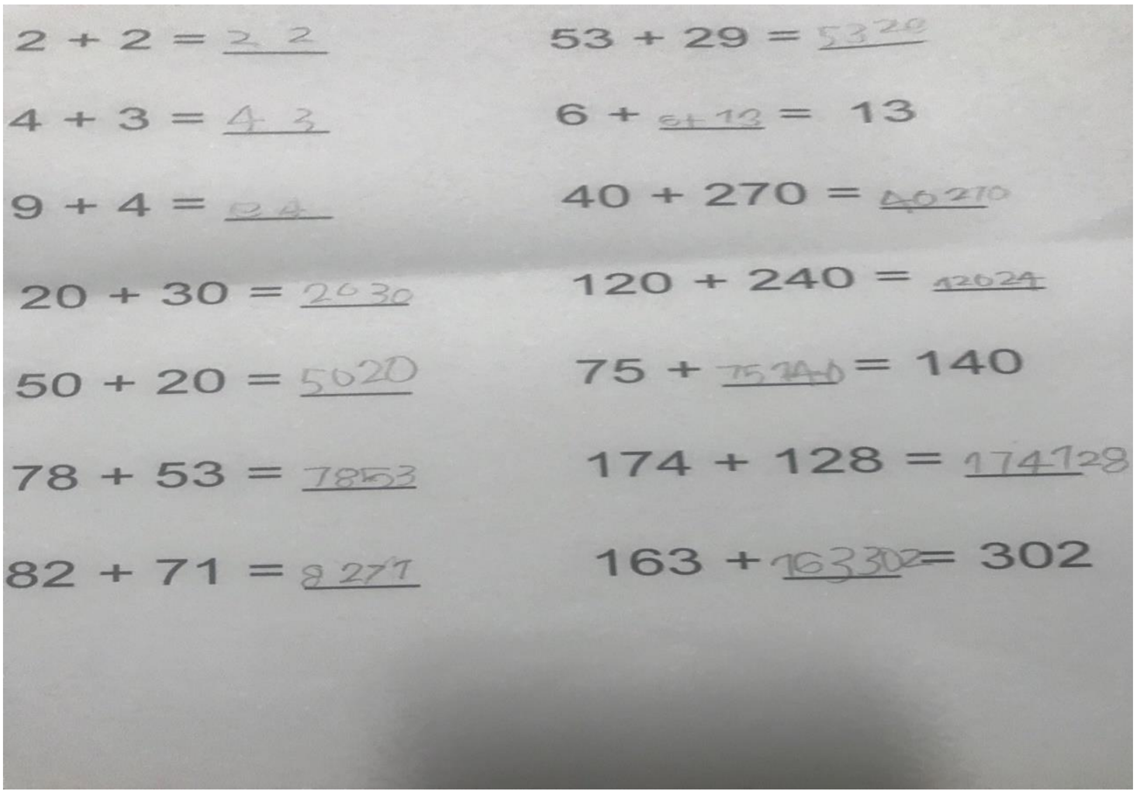
Chapter 4: Experiment and Data Analysis

4.1 Introduction

This chapter focuses on the procedures that were followed in conducting the experiment. This experiment discusses the various procedures, observations and topics taught during the process. The results section focuses on analyzing the data that were obtained during the experiment. These results were analyzed by doing a quantitative analysis between a pre-test and a post-test that were written before and after the experiment respectively and a conclusion will be drawn on them.

4.2 The Experiment

The experiment started on Thursday, January 10, 2019, with 26 children present. For familiarity purposes, an introduction session was held with the children, where each researcher introduced him or herself with a gesture. After this session, a standard pre-test for all students present was conducted. Below are the pre-test questions given to the subjects;



2 + 2 =	53 + 29 =
4 + 3 =	6 + ____ = 13
9 + 4 =	40 + 270 =
20 + 30 =	120 + 240 =
50 + 20 =	75 + ____ = 140
78 + 53 =	174 + 128 =
82 + 71 =	163 + ____ = 302

Figure 4.1: A sample pre-test question paper

The pre-test took 45 minutes of the one hour thirty minutes session, however, it seemed that the children took it seriously and, in some cases, involved huge numbers of tally marks. The most notable observation from the pre-test was the use of the tally method in calculating addition problems.

The experiment continued the next day but with a slightly different outlook. The results of the pre-test were ready and based on that, the 26 students were split into 2 groups; the first group was called "the traditional group" and the second group called "the suuji group". The split was done with due diligence, to ensure that each group had an almost even mix of good, average and poor students.

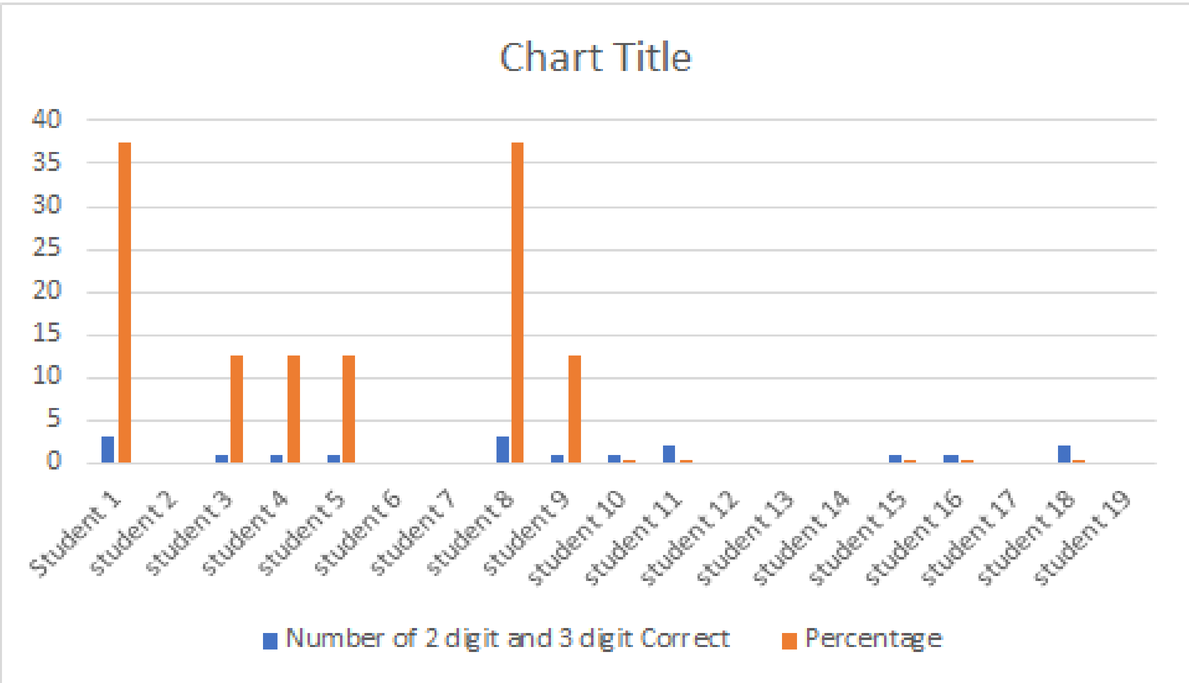


Figure 4.2: Pre-test scores chart

The traditional group had 16 students and the suuji group had 10 students. Due to the teaching method to be used by the suuji group, it was necessary to have a small class size, to enable an efficient one-on-one interaction with the students. 5 of the supporting researchers were assigned to the suuji group, with each of them teaching two students. A total number of 6 rotating researchers were assigned to the traditional group.

4.2.1 Traditional Group

In the traditional class, the first two days were to introduce the children to single-digit addition without carrying. Eg; 2+2, 4+3, 7+2 etc. These sessions were easy for all the children. The following session; the children were introduced to single-digit addition with carrying. Eg; 6+4, 9+9, 7+4, etc. These additions were also in the range of the subject's numeracy skills. About 2 of the children in this class struggled a bit with the carry but caught up with the rest of the class after several examples.

The researchers in this class, however, noticed the over-reliance of the tally method in doing calculations. This was a worry, as using the tally method may become overly complex for the pupils when doing double digit or triple digit additions.

For the next session, the pupils were introduced to double-digit addition. In this session, the pupils were relatively slower than they were in earlier sessions. The subjects were doing additions such as 10+10, 17+19, 30+13, etc. Noticing a few struggling students, the researchers decided to find out the range of counting numbers the students had been exposed to in their basic school. Basic 1 students were comfortable with adding numbers between 0 to 20, whereas basic two students were comfortable adding numbers between 0-99. At this point, the tally method looked tiresome for most students. To assist them, the researchers in charge of the traditional group introduced them to adding double digit numbers vertically. Eg.

  32

+41

____

____

Figure 4.3: A traditional group setting

The idea behind introducing this technique was to reduce the effort the students put into counting the tally marks. In the next session, the subjects were made to do the same double-digit additions but with carrying, with the resulting answer a three digit. E.g. 99+99, 86+24, 72+41 etc. This concept of double-digit addition with a three-digit answer was complicated and required several sessions for the students to grasp. Majority of the pupils struggled with the vertical arrangement and the order in which the addition should be done.

In the final two sessions, the pupils were made to do three-digit additions without carrying. Eg. 111+321, 461+121, 222+134 etc. Pupils who had mastery over the two-digit addition with carrying had almost no problem, solving additions involving three-digits.

4.2.2 Suuji group

In this session, the 10 students were put in groups of two, with each group assigned to one researcher. The researchers in the suuji group were Americans and had no idea of the local language (Twi). Owing to this, these researchers had to learn how to pronounce numbers 1-10 in twi.

The blocks were then introduced to the students, however, they seemed hesitant in playing with them as it seemed different from their everyday play materials.

Figure 4.4: Blocks to be used for the research

One of the researchers who could speak the local dialect had to explain to the students the intention of the activity. All the groups worked on using numbers in combination with the blocks, which prepared the way for later activities.

The researchers began trying to use Twi words for numbers, however, the children were a little surprised that the American researchers were trying to use those words, but they quickly acclimated, and seemed a little unsure themselves about some of the Twi words.

Using the images of animals to make separate parades, and then a single combined parade, seemed to be more difficult than expected, perhaps due to the language barrier. Also, this activity happened after the children had been in the classroom for quite a while continuously. The blocks subitizing (instantly recognize the number of numbers in a set) activity seemed to work well, after some preparation that had happened in the sub-groups.

During the next session, the first main topic was introducing measuring with towers. However, the researchers observed that the different sub-groups were moving at different speeds and that had to be rectified. A couple of children did not understand what to do right away. Due to this, the topic gradually shifted from measuring animals to measuring body parts, and shoes seemed to work well.

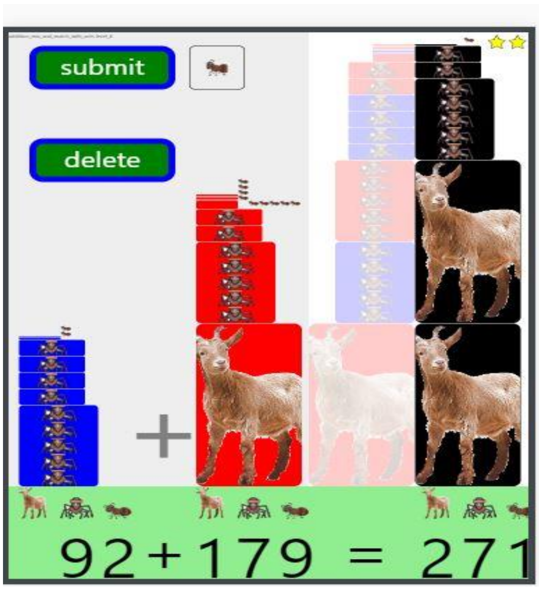


Figure 4.5: Addition with carrying interface

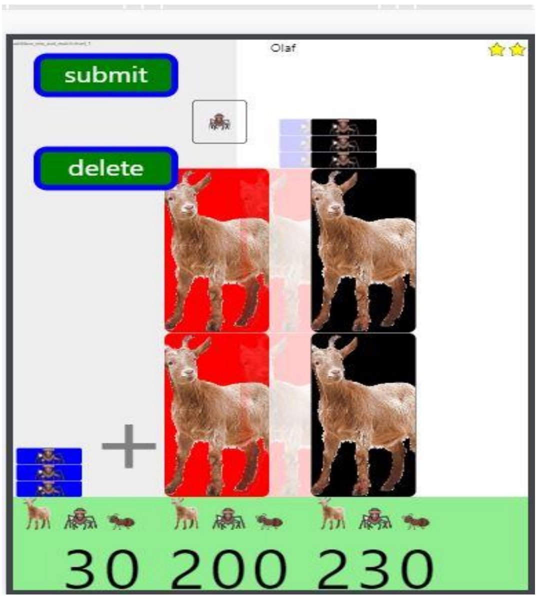


Figure 4.6: Addition without Carrying interface

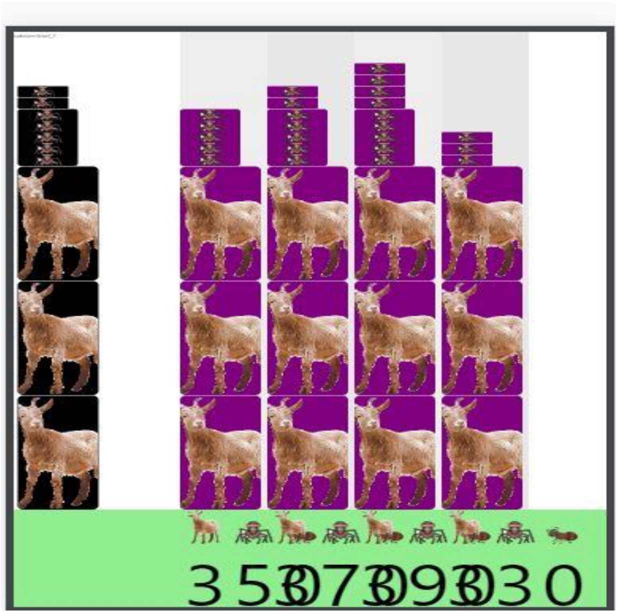


Figure 4.6: Subitizing activity

The researchers then switched to recording towers on worksheets with two columns, one for goats and one for spiders. After about 3 sessions, the children were introduced to the tablets for the first time.

Figure 4.7: Students using the tablet

Figure 4.8: students using the tablet

This session was the first day that we had sound on the tablets, which some of the kids enjoyed playing around with.

In the subsequent sessions, the first math activity was a review of measuring animals using black towers. The researchers observed that the children were not yet fluent in this activity and needed some explanation to catch on. They then moved to do a similar activity on the tablets, and that too seemed to take a little while; the interface of creating the tower and then submitting their answer was perhaps unfamiliar.

The next activity, combining a red tower with a blue tower, began without the benefit of any Twi speakers available to explain the idea to the children.

At this point, it was obvious that the language barrier was significant. When it was time for the children to combine towers, they started building towers of many kinds, using all available colors.

In the final weeks, the first activity the children did was to build physical towers without carrying. This was intended just as an introduction, recalling the use of the (tiny) spiders. When this concept was transitioned to carrying with ants on the tablet, it seemed to go slowly. The researchers then spent a long time working physically with the blocks on the worksheets. In the end, the researchers quickly carried out two activities on the tablet (subitizing and addition with blocks) that introduced the interface for building a tower given a number or mentioning a number given a tower.

4.3 Results

4.3.1 Pre-test Analysis

To gauge the mathematical proficiency of each of the participants of the experiment, a pre-test was conducted on the first day of the project. The following were the outcomes.

Student	# for 2 digit and 3 digit Correct	Percent Correct
Student 10	1	12.50%
Student 11	2	25.00%
Student 12	0	0.00%
Student 13	0	0.00%
Student 14	0	0.00%
Student 15	1	12.50%
Student 16	1	12.50%
Student 17	0	0.00%
Student 18	2	25.00%
Student 19	0	0.00%
Average	0.7	8.75%

Table 4.1: Pre-test scores for Suuji students

Student	# for 2 digit and 3 digit Correct	Percentage
Student 1	3	37.5
Student 2	0	0
Student 3	1	12.5
Student 4	1	12.5
Student 5	1	12.5
Student 6	0	0
Student 7	0	0
Student 8	3	37.5
Student 9	1	12.5
Average	1.1	13.89

Table 4.2: Pre-test scores for tradition students

Although the pre-test contained mixed questions involving single-digit addition with and without carrying double-digit addition with and without carry, and triple digit addition without carrying.

The researchers considered the number of right answers the pupils scored on double- and triple-digit addition. These types of questions (double- and triple-digit addition) were considered because they were the objectives of the experiment.

4.3.2 Post-test Analysis

After nine-sessions with the pupils, a post-test was conducted to examine the level of understanding of the students to determine which group had achieved the objectives for the duration of the project (3 weeks).

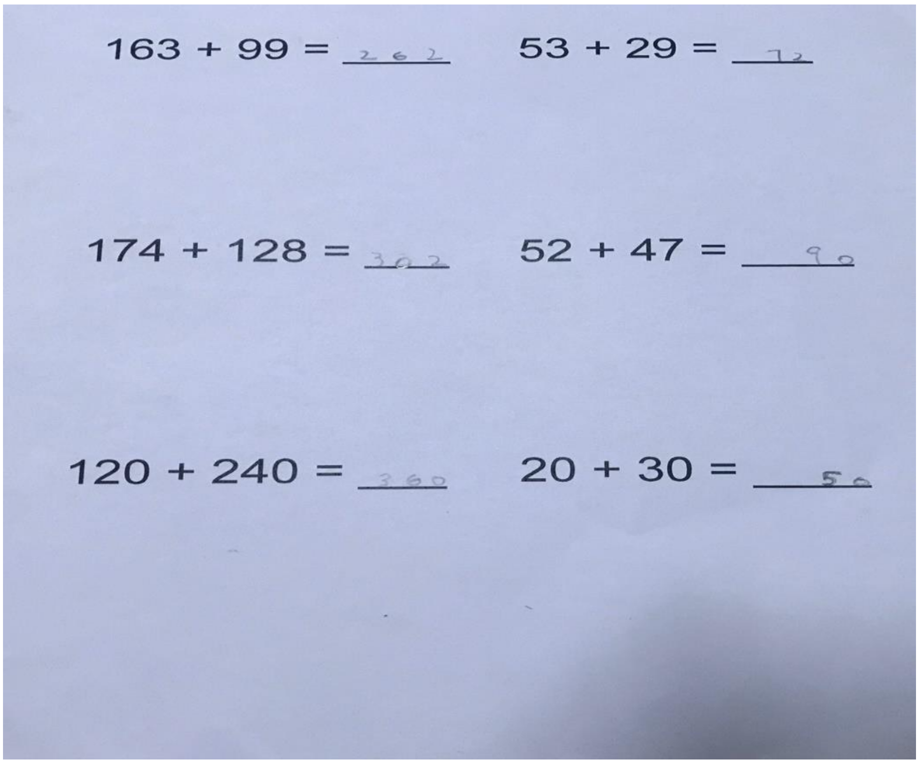


Figure 4.9: A sample post-test question paper

For this test, there were two types of papers labeled A and B. These test questions had the same difficulty level. The difference between papers labeled A and that labeled B were the order of the questions and the numbers used for the questions. The papers were distributed randomly. Also, for this test, students in the Suuji group wrote two tests; the first test involved them using the blocks as tools and the second test were different questions without the blocks serving as a medium.

The following were the post-test results by group;

		Q1-3+2 digit carry		Q2-3+3 digit carry		Q3 - 3+3 digit no ones		Q4 - 2+2-digit carry		Q5 - 2+2-digit carry		Q6 - 2+2 digit no carry				
Student	**Form**	**Correct**	**Off By**	**Q2Correct**	**Off By**	**Q3Correct**	**Off By**	**Q4Correct**	**Off By**	**Q5Correct**	**Off By**	**Q6Correct**	**Off By**	**Total number of Correct answers**	**Percent Correct**	**Percent Increase in Score**
Student 10	A	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	6	100.00%	
Student 11	B	Correct	0	Incorrect	3	Correct	0	Incorrect	2	Incorrect	12	Correct	0	3	50.00%	
Student 12	A	Incorrect	1865	Incorrect	276	Incorrect	332	Incorrect	244	Incorrect	138	Incorrect	106	0	0.00%	
Student 13	B	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	6	100.00%	
Student 14	A	Incorrect	11250	Incorrect	5	Correct	0	Incorrect	178	Incorrect	191	Incorrect	16	1	16.67%	
Student 15	A	Incorrect	1	Incorrect	3	Correct	0	Incorrect	8	Incorrect	15	Incorrect	10	1	16.67%	
Student 16	B	Correct	0	Correct	0	Correct	0	Incorrect	7147	Incorrect	891	Incorrect	36	3	50.00%	
Student 17	A	Incorrect	3	Correct	0	Correct	0	Incorrect	1	Incorrect	20	Correct	0	3	50.00%	
Student 18	B	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	6	100.00%	
Student 19	B	Incorrect	2588	Incorrect	309	Incorrect	129	Unanswered		Unanswered		Unanswered		0	0.00%	
Average		05/10		05/10		08/10		03/10		03/10		05/10		29/60	48.33%	39.58%
For A		1/5		2/5		4/5		1/5		1/5		2/5		11/30	36.67%	
For B		4/5		3/5		4/5		2/5		2/5		3/5		18/30	60.00%	

Table 4.3: Post-test scores for suuji st 1

		Q1 - 3+2-digit carry		Q2- 3+3-digit carry		Q3-3+3 digit no ones		Q4-2+2-digit carry		Q5-2+2-digit carry		Q6-2+2 digit no ones				
Student	Form	Correct	Off By	Correct	Off By	Correct	Off By	Correct	Off By	Correct	Off By	Correct	Off By	**Total number of Correct answers**	Percent Correct	Percent Increase in Score
Student 1	B	Incorrect	-198	Incorrect	-315	Incorrect	1780	Incorrect	630	Correct	0	Correct	0	2	33.33	
Student 2	B	Incorrect	589	Incorrect	-130	Incorrect	-290	Incorrect	630	Incorrect	-82	Correct	0	1	16.67	
Student 3	B	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	6	100	
Student 4	B	Incorrect	594	Incorrect	2872	Incorrect	2770	Incorrect	630	Correct	0	Correct	0	2	33.33	
Student 5	A	Incorrect	10891	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	5	83.33	
Student 6	A	Incorrect	101248	Incorrect	2900	Correct	0	Correct	0	Correct	0	Correct	0	4	66.67	
Student 7	A	Correct	0	Correct	0	Correct	0	Incorrect	10	Correct	0	Correct	0	5	83.33	
Student 8	B	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	6	100	
Student 9	A	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	Correct	0	6	100	
Average		4		5		6		5		8		9		37/54	68.52	54.63%
For A		2		3		4		3		4		4		20/24	83.33	
For B		2		2		2		2		4		5		17/30	56.67	

Table 4.4: Post-test scores for traditio 1

Table 4.4: Post-test scores for traditional students

4.3.3 Legend to the tables above

- Form – Type of question paper student answered
- Correct – right or wrong answer given by a student
- Off by – Difference between students given answer and the actual answer
- Percent correct – the number of correct answers divided by 6 multiplied by 100

4.3.4 Analysis for Suuji Group

In this group, 5 students wrote type A questions and 5 students wrote type B questions. Out of the 5 students that wrote the type A questions, only one student (student 10) had all answers right. All the other students in this group who wrote type A questions had questions 1 (3+2 digit with carrying), 4 (2+2 digit with carrying) and 5 (2+2 digit with carrying) wrong. The best answered in this question set was question 3 (3+3-digit carry). Only one student (Student 12) failed to answer this question correctly, missing the right answer by 332. Out of the 30 type A questions answered by the 5 students, 11 of them were answered correctly, giving a correctness percentage of 36.67%.

Out of the 5 students that wrote the type B questions, two students (Students 13 and 18) had all the answers right. The best-answered questions in this set were questions 3 (3+3-digit carry) and 1(3+2 digit with carrying). In both questions (3 and 1) one student (student 19) had both wrong missing both right answers by 2588 and 128 respectively. This student failed to get any of the answers right, having a correctness percentage of 0%. The worst answered questions were questions 4 (2+2 digit with carrying) and 5 (2+2 digit with carrying), with only two students (students 13 and 18) having both correct. These two students ended up with a correctness percentage of 100%. Out of the 30 type B questions answered by the 5 students, 18 of them were answered correctly, giving an average correctness percentage of 60%

4.3.5 Analysis for Traditional Group

In this group, 4 students wrote type A questions and 5 students wrote type B questions. Out of the 4 students that wrote the type A questions only one student (student 9) had all answers right leading to percentage correctness of 100%. The best-answered questions were questions 3 (3+3 digit carry), 5 (2+2 digit with carrying) and 6 (2+2 digit without carrying). These questions were answered correctly by all those who wrote this question set. Question 1 was the worse answered questions for those who wrote the A type questions. Two students (students 5 and 6) answered this question wrong, missing the right answer by 10891 and 101248 respectively. Out of the 24 type A questions answered by 5 students, 20 of them were answered correctly, giving an average correctness percentage of 83.33%.

Out of the 5 students that wrote the type B questions, two students (students 3 and 8) had all answers right. Questions 1 to 4 were the worse answered questions in this set. For each of these questions (Questions 1 to 4), only 2 students answered rightly. The best-answered question was question 6 (2+2 digit without carrying). All students had this question correct. Out of the 30 type A questions answered by 5 students 17 of them were answered correctly, giving an average correctness percentage of 56.67%.

4.4 Conclusion

20 students took part in the post-test, 10 students each from both the traditional and suuji group. The posttest had 6 questions comprising of three and two-digit addition problems with and without carry. From both the Suuji and traditional group, 3 students had answered all the 6 questions correctly. No student in the traditional group answered all questions wrongly however, 2 students from the suuji group had all answers wrong. From the above statistics, primarily the average for percentage correct and the percentage increase for both groups, the traditional group did better than the suuji group.

Chapter 5: Conclusion and Recommendations.

5.1 Introduction

This chapter touches on the results obtained from this research. The analysis from this paper gives insight to Parents, educational institutions, and students on the best way of studying and teaching mathematics and what factors to consider in selecting a technology-based approach or going traditional.

5.2 Conclusion

The aim of this research is to consider and analyze a tablet-based mathematics software and how feasible its implementation and outcome would be in Berekuso Basic School, Ghana.

From the results obtained from this research, it can be deduced that the use of a tablet-based mathematics software in teaching primary one and two students increases their understanding of the subject's concepts; given that the students are made to use such an approach for an extended period. From the research, a minimum of 30 hours will be required to achieve the full benefit of the tablet-based mathematics approach.

The results from the research showed a better performance in the traditional group than the suuji group because of the time constraint. Also, both groups have been exposed to the traditional method of teaching longer than the suuji group has been exposed to the table-based approach. Also, the traditional group was still being taught using the traditional method back at their school. This meant that they had double tutorials and more comfortable with this method, unlike the suuji group who were learning a completely new method. Meaning, the learning curve of new technology should be factored.

From the study, it was observed that students in the suuji group were very excited using the tablets. Although a handful of them have used some tablet technology before, they were excited to be using a tablet to do math problems. At the initial stages, the students felt the activities on the tablets were games and owing to that, they had an extra incentive for participation. At a point, students from the traditional group wanted to join those in the suuji group as they thought their friends in the suuji group were using the tablets for games. Also, the graphical images used in the technology made understanding addition easier. However, students in the traditional class had no extra motivation to give all their attention. Most of them felt the study was just like their classes in school. Although they did generally better than the suuji group their learning pace as a group was lower than that of the suuji group.

One of the major issues researchers may face in trying to deploy a tablet technology for the teaching of mathematics for primary one students in Ghana is training teachers to use the technology. Having to train teachers to learn how to use these technologies may be an extra cost to educational institutions. As a means of reducing their cost structures, some basic schools may decide to stick to the traditional method of teaching. Also, another issue that is likely to rise because of using a tablet-based technology is keeping up with the nationwide syllabus. In Ghana, the national mathematics syllabus has been designed with the traditional method of teaching as a focus point. Owing to this, using a tablet-based technology to teach primary one students mathematics may be difficult as each topic will have to be developed into the software.

5.3 Experiment limitations.

There were a few limitations that were encountered during the research. The most notable limitation that was encountered during this research was time constraint. The research was conducted within three weeks because of time constraints. This research had to be submitted within a semester. The time constraint could have influenced the results obtained because the subjects, especially the students in the suuji group did not have enough contact hours with the researchers to completely grasp the new concept.

5.4 Recommendations for future works

This project has a lot of opportunities that can be explored. In the future, other mathematical operations aside addition and subtraction could be added to the web application. This experiment can be extended to other primary schools to gain varied data for more extensive analysis. During the next experiment, the researcher should spend a minimum of 30 hours with the students that will use the tablets. Also, in a similar experiment, it should be set-up such that neither of the groups receive an advantage outside the experiment.

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Appendix

Sample pre-test questions

Name:_________

Class: _______

2 + 2 = ___	4 + 3 = ___
9 + 4 = ___	20 + 30 = ___
50 + 20 = ___	78 + 53 = ___
82 + 71 = ___	53 + 29 = ___
6 + ___ = 13	40 + 270 = ___
120 + 240 = ___	75 + ___ = 140
174 + 128 = _	163 + __ = 302

Sample post-test result

Name:_________

Class: _______

163 + 99 = ___

174 + 128 = __

120 + 240 = ___

53 + 29 = ___

52 + 47 = _____

20 + 30 = _____

Sample Permission letter to heads of basic school

4th December 2018

The Headmaster/Headmistress

Berekuso Basic School

Berekuso

Dear Sir/Madam,

Permission to Conduct Research Study

I am writing to request permission to conduct a research study at your institution. I am a final year Management Information Systems (MIS) student with Ashesi University undertaking a Thesis capstone. The study is titled Tablet-Based Tool to aid learning of Mathematics for Basic 1 students. I hope that the school administration will allow me to recruit 26 students from mainly Class 1 and a little from Class 2; from the school to anonymously take part in a research about the impact of using tablet-based application to teach and learn Mathematics.

If approval is granted, student participants will be taken to Ashesi University Campus for the learning sessions between 9am to 10:30am for the first week of January before school resumes and some sessions will take place at Berekuso Basic School (to be determined by you) after reopening. The survey process should take no longer than 14 hours in 3 weeks. The survey results will be pooled for the thesis project and individual results of this study will remain absolutely confidential and anonymous. Should this study be published, only pooled results will be documented. No costs will be incurred by either your school/center or the individual participants.

Your approval to conduct this study will be greatly appreciated. You may contact me on my email address: etonam.dotse@ashesi.edu.gh or telephone number: +233261775431 or my supervisor Mr. David Sampah (Computer Science Department Lecturer) at dsampah@ashesi.edu.gh | 0505848699.

Sincerely,

Etonam Dotse

Approved by:

____________________ ____________________ __________

Name Date Signature

cc: District Director of Education

Consent form for Research study

The purpose of this form is to provide you (as the parent of a prospective research study participant) information that may affect your decision as to whether to let your child participate in this research study. The person performing the research will describe the study to you and answer all your questions. Read the information below and ask any questions you might have before deciding whether to give your permission for your child to take part. If you decide to let your child be involved in this study, this form will be used to record your permission.

What the study is about: The purpose of this study is to learn whether students understand mathematics better when they use a tablet-based tool to assist in teaching and learning.

What we will ask your ward to do: If you agree to your ward partaking in this study, we will ask your ward to use a tablet with a mathematics software installed to study different mathematics concepts, after which he/she would be tested. This test is to assess the impact of a tablet-based mathematics software on a primary school student's understanding of mathematics concepts. For this experiment, the results will be stored in a database that can be accessed by only the researcher.

Risks and benefits: There are no identifiable risks associated with your ward participating in this experiment. The benefit of participating in this experiment however is, your ward will be exposed to ***another approach of being taught and studying mathematics (tablet-based mathematics)***

Compensation: Your ward will be provided with snacks during the research study.

Your Details and scores will be confidential: Your ward's details and scores in this experiment will be kept private. Research records will be kept in a secured database; only the researchers will have access to the records. In the event where the research paper will be published, anonymity would be ensured.

Taking part is voluntary: Your ward's participation in this study is completely voluntary. If you decide not to allow your ward to take part or to skip sessions of the experiment, it will not affect you or your wards current or future relationship with the researcher or the researcher's institution. If you decide to allow your ward take part, you are free to withdraw him/her at any time.

If you have questions: The researcher conducting this study is Etonam Dotse. Dr. Olaf Hall-Halt (Faculty), Jacob Cabbage, Bidit Sharma, Hugo Valent, Johannes Carlsen and Aaron Telander are faculty and students from St. Olaf university who would be supporting researchers in this study. Please ask any questions you have now. If you have questions later, you may contact Etonam Dotse on +233261775431 or Etonam.dotse@ashesi.edu.gh. If you have any questions or concerns regarding your wards rights as a subject in this study, you may contact the Institutional Review Board (IRB) on +233(302) 610 330 or access their website at http://apps.ashesi.edu.gh/irb/ .You may also report your concerns or complaints anonymously through irb@ashesi.edu.gh or by calling +233(302) 610 330. For further information you can contact my supervisor Mr. David Sampah, a faculty at Ashesi university via email on dsampah@ashesi.edu.gh. You will be given a copy of this form to keep for your records.

Statement of Consent: I have read the above information and have received answers to any questions I asked. I consent to my ward taking part in the research.

Your Signature ____________________________ Date _________________________

Your Name (printed)

____

This consent form will be kept by the researcher for at least three years beyond the end of the study.

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