UNIVERSITY OF CAPE COAST

AN INVESTIGATION INTO THE USE OF ANGELA REILLY HARDEN'S

MATH LAB GAMES IN THE TEACHING AND LEARNING OF LINEAR

ALGEBRA AT THE SENIOR HIGH SCHOOL LEVEL

PATIENCE AGBO

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BY

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Dissertation submitted to the Department of Science Education, Faculty of

Education, University of Cape Coast in partial fulfilment of the requirements for

the award of Masters of Education Degree, in Mathematics Education.

JULY 2011

# DECLARATION

**Candidate's Declaration**

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

Candidate's Signature ………………………..        Date……………....

Candidate's Name: Patience Agbo

**Supervisor's Declaration**

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

Supervisor's Signature ………………………..        Date……………....

Supervisor's Name: Dr. Eric M. Wilmot

# ABSTRACT

The aim of this study was to determine the effect of Angela Reilly Harden linear algebra games as a means of consolidating the learning of linear algebra at SHS form one of Armed Forces and Osei Kyeretwie Senior High School. One hundred and twenty first year students were randomly selected for the study. Sixty students were selected for the control and sixty students for the experimental groups. For both groups, a test was applied as a pretest before the instruction.

Both groups were exposed to the traditional classroom teaching. The control group took an additional traditional instruction supported by teacher. The experimental group was exposed to computer assisted instruction. A posttest was administered to determine the effect of the treatment on the two groups. Both qualitative and quantitative techniques were used in the gathering of the data. The qualitative data were collected through the responses on teachers' and students' questionnaire while the quantitative data were collected from the results of the pretest and posttest. The Statistical Package for Social Sciences Software was use to make descriptive analysis of the data and hypothesis testing.

The findings of the study showed that the students who were exposed to Angela Reilly Harden linear algebra games did not have any significant urge over their counterparts exposed to the conventional classroom instruction. Based on the research findings recommendations were made on the need to develop relevant CAI packages for teaching in Ghanaian secondary schools.

# ACKNOWLEDGEMENTS

# DEDICATION

To my three sons: Emmanuel Adusei, Kennedy Adusei and Bernard Adusei.

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## CHAPTER ONE

## INTRODUCTION

This chapter covers the background to the study, statement of the problem, purpose and significance of the study. It further deals with the research questions, hypothesis, limitation and delimitation of the study.

### Background to the study

Mathematics the world over plays a pivotal role in the lives of students. It is a bridge to science, technology and other subjects offered in any formal educational system. Mathematics introduces a sweeping unification of language and interface concepts that makes possible a new level of automation in algorithmic computation, interactive manipulation and dynamic presentation as well as a whole new way of interacting with the world of data.

Students encounter problems as they try to understand mathematical concepts and skills. Since the conventional method of teaching mathematics encourage encourages the use of blackboard illustration, most students who are unable to learn in abstract terms or fear the use of figures consider mathematics as difficult for young teenagers. However, an improved method of instructions such as CAI makes it possible to help students to learn mathematics concepts easily.

Challenges abound on the teaching and learning of mathematics. These arise as a result of increased enrolment and the large classes that imply wide range in ability and performance of students. There is also the challenge on the need to create enjoyable classroom mathematical activities, and the current emphasis that puts the teacher as a manager of the learning environment and facilitator rather than a disseminator of knowledge and mathematical meaning. Learning of mathematics is becomes difficult as a result of negative attitude of students, lack of appropriate teaching methodology, inadequate assignments to students and inadequate coverage of syllabus on the part of teacher.

In Ghanaian Senior High Schools, teachers still rely solely on the conventional mode of lesson delivery that is, resorting to the use of chalkboard illustrations. This is usually considered as the acceptable norm used by teachers in cases where computations must be done during lesson delivery.

There are a lot of internet cafés in our communities. Most parents have personal computers at home which can be used by students at their leisure time. These days most schools have computer laboratories with internet. Almost all telecommunication service providers in the country now have internet facilities on their mobile networks. This has made access to internet available to most children in our schools today. Therefore, students who use mobile phones can as well access the internet without necessarily resorting to desk top or laptop computers.

**Statement of the problem**

Most students believe that mathematics is a difficult subject to study. Some students believe that is best studied by a gifted few. Most female

students try to avoid mathematics. Performance in mathematics in secondary school education in Ghana remains poor. Consequently the Ghanaian senior secondary school examination (WASSCE) mathematics results continue to cause concern to all the stakeholders in the education sector. Therefore, there is a serious and urgent need for intervention.

Linear algebra as a topic in mathematics involves a lot of abstract thinking. It involves the use of variables and numbers together. The use of the algebra concepts is applied in different mathematical topics at the senior secondary school level. As students find it difficult to relate the idea of variables and numbers to events happening around them on daily bases, it makes them feel that mathematics is a difficult subject to learn. The researcher believes that an intervention in linear algebra will go a long way to affect the general learning of mathematics.

Due to lack of interest in mathematics, Ghanaian students do not spend much of their leisure time in practicing what they have learnt in the classroom. The researcher has observed that students spent much of their time at the internet cafés browsing, playing games and watching films. The researcher believes that students will easily welcome an interventional activity which falls within their interest area and the benefits are likely to spill over to other subject areas.

ICT is a core subject in the SHS curriculum. Most ICT teachers restrict students to the learning of how to use the Microsoft Word in typing and then a little into the use of the internet. The researcher believes that ICT lessons

should go further into the use of the World Wide Web and its application to the learning of mathematics specifically linear algebra.

## Purpose of the Study

The researcher intends to expose students to Angela Reilly Harden's math lab games and to find out to what extent the game could consolidate the learning of Linear Algebra at SHS 1.

The study seeks to find out the extent to which students in the experimental group (technology-enhanced algebra instruction) developed extra skills like accuracy, speed, academic achievement, motivation and self assessment over their counterparts in the controlled group (conventional algebra instruction). The project intends to determine the extent to which Angela Reilly's Harden Math lab games could boost students' confidence to use the web for learning. The project seeks to determine whether Angela Harden Reilly's Math lab games could be used to consolidate the learning of linear algebra in SHS form one.

## Objectives of the study

The project seeks to investigate the efficacy of Angela Reilly Harden's math lab games as a consolidatory activity in the learning of linear algebra at SHS 1 General Art classes of Osei Kyeretwie SHS and Armed Forces SHS. The objectives of the study are:

1. To determine if the experimental group had an advantage over their colleagues who were treated with the conventional approach in terms of academic achievement.

2. To determine if the use of the ARH games motivated the experimental group students to learn more during leisure hours.

3. To determine if students would be able to work faster after using the ARH games.

4. To determine if the use of the ARH games make the experimental group students more accurate than their counterparts who used the conventional approach.

5. To determine if the ARH games can help students to do self-assessment.

## Research Questions

The following research questions are raised to guide the study.

1. To what extent do the ARH games help to improve students' learning of linear algebra in terms of the following qualities?

    i.  academic achievement,

    ii.  accuracy,

    iii.  speed,

    iv.  Self assessment,

    v.  motivation.

## Hypotheses

The researcher formulates following null hypotheses to guide the study.

Hypothesis 1: There is no significant difference in the mean achievement on the pretest scores of students who were taught using the Angela

Reilly Harden's Linear Algebra games and those taught using the conventional method.

Hypothesis 2: There is no significant difference in the mean achievement on the posttest scores of students who were taught using the Angela Reilly Harden's Linear Algebra games and those taught using the conventional method.

Hypothesis 3: There is a significant difference in the pretest and posttest mean scores of students who were taught using the Angela Reilly Harden's Linear Algebra games and those taught using the conventional method.

**Significance of the study**

The project intends to make the learning of algebra very simple by using an interesting set of simple computer games like Angela Harden Reilly's Linear Algebra games as part of the teaching and learning process. The study seeks to motivate students to develop mathematics concepts on linear algebra and to consolidate topics taught in classroom.

This project is to motivate students to make good use of their leisure time playing Linear Algebra games, practise what has been learnt in class or to use the spare time in solving assignments.

This project intends to make linear algebra very simple by using some interesting, simple computerized mathematical games designed by Angela Reilly Harden as part of the teaching and learning process.

The use of computer games in learning seeks to encourage girls and weak students to get involved in solving mathematical problems. The use of

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the games seeks to eliminate fear that students harbor about mathematics as a subject.

The project seeks to make students understand Linear Algebra problems better. The project seeks to encourage students develop skills such as accuracy, speed and ability to do self assessment.

## Delimitation

The study limits itself to the teaching and learning of Linear Algebra in Senior High Schools. The study limits itself to first year students who passed the Basic Education Certificate Examination and gained admission to the selected SHS. The rationale for choosing this group of students is that linear algebra is one of the courses to be learnt in the first term at the SHS 1. The intervention is to serve as a consolidation of what students are exposed to in the classroom.

## Limitation

One limitation of the study is that not too many Senior High Schools have computer labs that are and access to the internet. The researcher had only few schools to choose from. Fear of introducing virus into the computers in the computer made the researcher introduced antivirus into the computers. The antivirus programme made some computer run very slowly. The ARH games worked with time. If a computer runs slow the actual speed at which the ARH game is expected to run is also slowed down.

Seeking permission from school authorities for students to be used in conducting the experiment was a problem. The intervention stage of the project appeared to affect the regular running of the schools' programme. The

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headmasters were a bit hesitant to allow the researcher to have access to the student during some of the scheduled days. The researcher rescheduled the days used to contact students. This was frustrating and time consuming. The researcher missed some of the students used for the test because the agreed contact time kept on changing. Most mathematics teachers in the various schools were also uncooperative as the demonstrated unwillingness to sacrifice their mathematics lessons for the experiment. Poor supervision meant students could copy from one another during the posttest.

For the games to run well on each of the computers used for the experiment, the researcher had to install special soft wares on each of the computers. This activity was time consuming as computers with smaller memory size and slower processor speed took a long time to accept the programme. As the ARH game was time bound disparity in the speed of different computers meant inconsistency in the expected responses from students using the computers.

This installation was a stressful procedure limiting the researcher to working on fewer computers. Few computers implied that some students waited for their colleagues to play the games before having their turn. The days set for the experiment was fixed. More computers meant more practising time for the students in the experimental group.

## Definition of terms

The following definitions used in the project might not be the same as what is commonly acceptable but are used to bring out meanings as defined below.

Computer-assisted instruction (CAI) is a term which refers to drill-and-practice, tutorial, or simulation activities given to students as a supplement to conventional or teacher directed instruction.

Computer-based education (CBE) and computer-based instruction (CBI) refer to any kind of computer use in educational settings, including drill and practice, tutorials, simulations, instructional management, supplementary exercises, programming, database development, writing using word processors, and other applications. These terms may refer either to stand-alone computer learning activities or to computer activities which reinforce material introduced and taught by teachers.

### Organization of the study

The study was set out in five chapters. Chapter One is the introduction and it deals with the background to the study, statement of the problem, purpose of the study, research questions, and significance of the study, delimitation and limitations of the study.

Chapter Two deals with the literature review which gave theoretical and empirical guidance to the study. Chapter Three discusses the research methodology, which encompasses the research design, population, sample and sampling procedure, research instruments, pilot testing of research instruments procedure for data collection and data analysis plan.

Chapter Four deals with the presentation and discussion of results of analysis. The final chapter, Chapter Five contains summary of findings, conclusion, recommendations and suggestions for further study.

# CHAPTER TWO

## REVIEW OF RELATED LITERATURE

This chapter covers the review of related literature. It is organized under the following subheadings: The use of microcomputers and student achievement, the use of computer assisted games and development of speed, retention of learning, effects on lower achieving versus higher achieving students, effects of CAI on slow learners, CAI and different curricula areas, why students like CAI, Cost effectiveness of CAI, games and simulations, computer games and motivation, challenge and complexity of mathematical games, effect of competition and reward structure in algebra games, formative self assessment in students using computerized algebra games, corrective activities in formative assessment, feedback in computerized algebra games, fun in computerized algebra games, reflecting and debriefing in games, the internet, educating the student using the internet games, innovation and change in learning technology and finally, effectiveness of CAI compared with the conventional method of teaching, computer games and accuracy.

### The use of microcomputers and student achievement

According to (Drowns, Kulik, and Kulik, 1985), there was a time when computers were a luxury item for American schools, but that time has clearly passed. According to research done by Capper and Copple 1985; Edwards, (1975); Rapaport and Savard, 1980, student achievement through the use of

CAI was good, yet found the conventional mode of instruction to be superior, and still others have found no difference between them.

Other researchers and reviewers compared the achievement effects produced by all forms of computer based instruction (sometimes alone and sometimes as a supplement to traditional instruction) as compared with the effects of traditional instruction alone. While the research support is not as strong as that indicating the superiority of CAI, the evidence nevertheless indicates that CBE approaches as a whole produce higher achievement than traditional instruction by itself. (Drowns 1985; Braun 1990 ; Kulik, Bangert, and Williams 1983; Roblyer 1988).

This group of findings supports the conclusion drawn by Hannafin in his 1996 study to the effect that "while both traditional and computer-based delivery systems have valuable roles in supporting instruction, they are of greatest value when complementing one another" (p. 32).

**The use of computer assisted games and development of speed**

According to a new study in Current Directions in Psychological Science, a journal of the Association for Psychological Science, regular gamers are fast and accurate information processors, not only during game play, but in real-life situations as well.

In the study, psychological scientists from the University of Rochester, Dye, Green and Bavelier (2009), looked at all of the existing literature on video gaming and found some surprising insights in the data. For example, they found that avid players got faster not only on their game of choice, but on a variety of unrelated laboratory tests of reaction time.

Many skeptics agree that gamers are fast, but that they become less accurate as their speed of play increases. Dye and colleagues find the opposite: Gamers don't lose accuracy (in the game or in lab tests) as they get faster. The scientists believe that this is a result of the gamer's improved visual cognition. Playing video games enhances performance on mental rotation skills, visual and spatial memory, and tasks requiring divided attention.The scientists conclude that training with video games may serve to reduce gender differences in visual and spatial processing, and thwart some of the cognitive declines that come with aging. (Dye, Green, Bavelier. 2009.)

As well as enabling students to achieve at higher levels, researchers have also found that CAI enhances learning rate. Student learning rate is faster with CAI than with conventional instruction. Some students learned the same amount of material in less time than the conventionally instructed students. In others, they learned more material in the same time. While most researchers don't specify how much faster CAI students learn, the work of Capper and Copple (1985) led to the conclusion that CAI users sometimes learn as much as 40 percent faster than those receiving traditional, teacher-directed instruction. (Capper and Copple,  Edwards,  Kulik, Bangert, and Williams 1983; Rapaport and Savard 1980; White 1959)

**Retention of learning**

If students receiving CAI learn better and faster than students receiving conventional instruction alone, do they also retain their learning better? The answer, according to researchers who have conducted comparative studies of learning retention, is yes. In this research, student scores on delayed tests

indicate that the retention of content learned using CAI is superior to retention following conventional instruction alone (Capper & Copple (1985); Kulik & Bangert 1985).

## Effect on lower-achieving versus higher-achieving students

These comparisons show that CAI is more effective with lower-achieving students than with higher-achieving ones. Again, both lower and higher achieving students benefit from CAI. However, the comparatively greater benefits experienced by lower-achieving students, like those experienced by younger students, are largely due to the need that groups have for elements common to the majority of CAI programs – extensive drill and practice, privacy, and immediate feedback and reinforcement. Bangert 1985; Edwards 1975; Kulik et al 1985;  Roblyer 1988).

## Effect of CIA on slow learners

Research conducted with learning disabled, mentally retarded, hearing impaired, emotionally disturbed, and language disordered students indicates that their achievement levels are greater with CAI than with conventional instruction alone. In some of this research, handicapped CAI students even outperformed conventionally taught, non handicapped students (Bahr and Rieth 1989; Bialo and Sivin, 1980)

.

## CAI and different curricular areas

A few researchers undertook to compare the effectiveness of CAI in different curricular areas. Their findings, though not conclusive, indicate that CAI activities are most effective in the areas of science and foreign languages, followed, in descending order of effectiveness, by activities in mathematics, reading, language arts, and English as a Second Language, with CAI activities in exceptionally slow learners found to be largely ineffective. (Capper and Copple 1985; Kulik et al. (1985); Roblyer, Castine, and King 1988).

## Why students like CAI

An earlier section of this report offers research evidence showing that CAI enhances student attitudes toward several aspects of schooling. Some researchers took these investigations a step further by asking students what it is about CAI that they like. The following is a list of reasons given by students for liking CAI activities and/or favoring them over traditional learning. These student preferences also contribute to our understanding of why CAI enhances achievement.

Students say they like working with computers because computers are infinitely patient, never get tired, never get frustrated or angry, allow students to work privately, never forget to correct or praise, are fun to work with as well as being a good source of entertainment. Computers offer individualize learning, are self-paced and do not embarrass students who make mistakes. Computers make it possible to experiment with different options, give

immediate feedback and are more objective than teachers. Computers are impartial to race or ethnicity, are great motivators, give a sense of control over learning, are excellent for drill and practice and call for using sight, hearing, and touch. Computers teach in small increments, help students improve their spelling. Computers also help us to work rapidly - closer to the rate of human thought. (Bialo and Sivin 1980; Robertson, Ladewig, Strickland & Boschung 1987).

Many of these items point to students' appreciation of the immediate, objective, and positive feedback provided by computer learning activities by comparison with teacher-directed activities. As Robertson, Ladewig, Strickland, and Boschung (1987) point out: "This reduction in negative reinforcement allows the student to learn through trial and error at his or her own pace. Therefore, positive attitudes can be protected and enhanced" (p. 314).

## Cost effectiveness of CAI

While cost considerations are not a major focus of this report, it is worth noting that some of the research on effectiveness also addressed the cost-effectiveness of CAI and other computer applications. Ragosta, Holland, and Jamison (1982) concluded that equal amounts of time of CAI reinforcement and the more-expensive one-to-one tutoring produced equal achievement effects. Niemiec, Sikorski, and Walberg (1996) also found CAI activities significantly more cost-effective than tutoring and suggested that computers be used more extensively in schools. And in their 1986 study of costs, effects,

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and utility of CAI, Hawley, Fletcher and Pele (1986) noted that the cost differences between CAI and conventional instruction were insignificant and concluded that "the microcomputer-assisted instruction was the cost effective alternative of choice" for both grades addressed in the study (p. 22).

## Games and simulations

According to Ricci, Salas, and Cannon-Bowers (1996), computer-based educational games generally fall into one of two categories: simulation games and video games. Simulation games model a process or mechanism relating task-relevant input changes to outcomes in a simplified reality that may not have a definite endpoint. They often depend on learners reaching conclusions through exploration of the relation between input changes and subsequent outcomes. Video games, on the other hand, are competitive interactions bound by rules to achieve specified goals that are dependent on skill or knowledge and that often involve chance and imaginary settings (Ramdel, Morris, Wetzel, & Whitehill, 1992).

One of the first problems areas with research into games and simulations is terminology. Many studies that claim to have examined the use of games did not use a game (e.g., Santos, 2002). At best, they used an interactive multimedia that exhibits some of the features of a game, but not enough features to actually be called a game. A similar problem occurs with simulations. A large number of research studies use simulations but call them games (e.g., Mayer, Mautone & Prothero, 2002). Because the goals and features of games and simulations differ, it is important when examining the potential effects of the two media to be clear about which one is being

examined. However, there is little consensus in the education and training literature on how games and simulations are defined.

Garris, Ahlers & Driskell (2002) argued that it is not too improper to consider games and simulations as similar in some respects, keeping in mind the key distinction that simulations propose to represent reality and games do not. Combining the features of the two media, Rosenorn and Kofoed (1998) described simulation/gaming as a learning environment where participants are actively involved in experiments, for example, in the form of role-plays, or simulations of daily work situations, or developmental scenarios.

Gredler (1996), combines the most common features cited by the various researchers, and yet provide clear distinctions between the three media. According to Gredler,

> Games consist of rules that describe allowable
> player moves, game constraints and privileges (such
> as ways of earning extra turns), and penalties for
> illegal (non permissible) actions. Further, the rules
> may be imaginative in that they need not relate to

This definition is in contrast to a simulation, which Gredler (1996) defines as "a dynamic set of relationships among several variables that (1) change over time and (2) reflect authentic causal processes" (p. 523). In addition, Gredler describes games as linear and simulations as non-linear, and games as having a goal of winning while simulations have a goal of discovering causal relationships. Gredler also defines a mixed metaphor

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referred to as simulation games or gaming simulations, which is a blend of the features of the two interactive media: games and simulations.

**Computer games and motivation**

According to Garris, Ahlers, & Driskell, (2002), students who use computer games are enthusiastic, focused and engaged, they are interested in and enjoy what they are doing, they try hard, and they persist over time. Furthermore, they are self-determined and driven by their own volition rather than external forces. These authors defined motivation as "the direction, intensity, and persistence of attentional effort invested by the trainee toward training" (p. 297). Similarly, according to Malouf (1987), continuing motivation is defined as returning to a task or a behaviour without apparent external pressure to do so when other appealing behaviours are available. And more simply, Story and Sullivan (1986) commented that the most common measure of continuing motivation is whether a student returns to the same task at a later time.

With regard to video games, Asakawa, Gilbert, (2003) argued that, without sources of motivation, players often lose interest and drop out of a game. According to Rieber (1996) and McGrenere (1996), motivational researchers have offered the following characteristics as common to all intrinsically motivating learning environments: challenge, curiosity, fantasy, and control (Davis & Wiedenbeck, 2001; Lepper & Malone, 1987; Malone, 1981) and others also included fun as a criteria for motivation.

Locke and Latham (1990) also commented on the robust findings with regards to goals and performance outcomes. They argued that clear, specific

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goals allow the individual to perceive goal-feedback discrepancies, which are seen as crucial in triggering greater attention and motivation. Clark (2001) argued that motivation cannot exist without goals. The following sections will focus on fantasy, control and manipulation, challenge and complexity, curiosity, competition, feedback, and fun.

### Challenge and complexity of mathematical games

Challenge, also referred to as effectance, compentence, or mastery motivation (Bandura, 1977; Csikszentmihalyi, 1975; Deci, 1975; Harter, 1978; White, 1959), embodies the idea that intrinsic motivation occurs when there is a match between a task and the learner's skills. The task should not be too easy nor too hard, because in either case, the learner will lose interest (Malone & Lepper, 1987). Clark (2001) describes this effect as a U-shaped relationship. Stewart (1997) commented that games that are too easy will be dismissed quickly. According to Garris et al. (2002), there are several ways in which an optimal level of challenge can be obtained. Goals should be clearly specified, yet the probability of obtaining that goal should be uncertain, and goals must also be meaningful to the individual. Linking activities to valued personal competencies like speed and accuracy, embedding activities within absorbing fantasy scenarios, or engaging competitive or cooperative motivations could serve to make goals meaningful (Garris, et al., 2002).

### Effect of competition and reward structure on algebra games

Studies on reward structure on algebra games have mixed results. A study by Porter, Bird, and Wunder (1990 -1991) examining competition and reward structures found that the greatest effects of reward structure were seen

in the performance of those with the most pronounced attitudes toward either competition or cooperation. The results also suggested that performance was better when the reward structure matched the individual's preference. According to the authors, implications are that emphasis on competition will enhance the performance of some learners but will inhibit the performance of others (Porter, Bird, & Wunder, 1990-1991).

Yu, (2001) investigated the relative effectiveness of cooperation with and without inter-group competition in promoting student performance, attitudes, and perceptions toward subject matter studied, computers, and interpersonal context. With fifth-graders as participants, Yu found that cooperation without inter-group competition among the learning groups also tended to be more effective and efficient when cooperation did not take place in the context of inter-group competition.

## Formative self assessment in students using
## computerized algebra games

For a student to do a correct formative assessment, three concepts must be considered: ability of students to recognize the desired goal, students having evidence about their present position, and some understanding of a way to close the gap between the two.

Chappuis &  Chappuis (2007/2008) said that a key point on the nature of formative assessment is that "there is no final mark on the paper and no summative grade in the grade book" (p. 17). The intent of this type of assessment for learning is for students to know where they are going in terms

of learning targets they are responsible for mastering, where they are now, and how they can close any gap. "It functions as a global positioning system, offering descriptive information about the work, product, or performance relative to the intended learning goals" (p. 17). Such descriptive feedback identifies specific strengths, then areas where improvement is needed, and suggests specific corrective actions to take.

Educators have varying opinions on homework ranging from how much to assign to what kind (e.g., acquisition or reinforcement of facts, principles, concepts, attitudes, or skills), for whom, when to assign it, and whether or not it should be graded. Not all of their homework practices are grounded by research. In Rethinking Homework, Vatterott (2009) stated:

> Viewing homework as formative feedback changes our perspective on the grading of homework. Grading becomes not only unnecessary for feedback, but possibly even detrimental to the student's continued motivation to learn. With this new perspective, incomplete homework is not punished with failing grades but is viewed as a symptom of a learning problem that requires investigation, diagnosis, and support. (p. 124)

Guskey (2007/2008) pointed out that formative assessments will not necessarily lead to improved student learning or teacher quality without appropriate follow-up corrective activities after the assessments. These activities have three essential characteristics. They present concepts

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differently, engage students differently in learning, and provide students with successful learning experiences. For example, if a concept was originally taught using a deductive approach, a corrective activity might employ an inductive approach. An initial group activity might be replaced by an individual activity, or vice versa. Corrective activities can be done with the teacher, with a student's friend, or by the student working alone. As learning styles vary, providing several types of such activities to give students some choice will reinforce learning.

### Feedback in computerized algebra games

Feedback in algebra games enables learners to quickly evaluate their progress against the established game goal. This feedback can take many forms, such as textual, visual, and aural (Rieber, 1996). According to Ricci, Salas & Cannon-Bowers, (1996), within the computer-based game environment, feedback is provided in various forms including audio cues, score, and remediation immediately following performance. The researchers argued that these feedback attributes can produce significant differences in learner attitudes, resulting in increased attention to the learning environment.

### Fun in computerized algebra games

Quinn (1994, 1997) argued that for games to benefit educational practice and learning, they need to combine fun elements with aspects of instructional design and system design that include motivational learning, and interactive components. According to Malone (1981) three elements (fantasy, curiosity, and challenge) contribute to the fun in games. While fun has been cited as important for motivation and, ultimately, for learning, there is no empirical

evidence supporting the concept of fun. This might be because fun is not a construct but, rather, represents other concepts or constructs. Relevant alternative concepts or constructs are play, engagement, and flow.

Play is entertainment without fear of present or future consequences; it is fun (Resnick & Sherer, 1994). According to Rieber, Smith, and Noah (1998), play describes the intense learning experience in which both adults and children voluntarily devote enormous amounts of time, energy, and commitment and, at the same time, derive great enjoyment from the experience; this is termed serious play (Rieber, Smith, & Noah, 1998). According to Rieber and Matzko (2001) serious play is an example of an optimal life experience.

When a student enjoys playing an algebra computer games which turns out to be challenging, time flies without the student noticing it. Csikszentmihalyi (1975; 1990) defines an optimal experience as situation in which a person finds himself when he is involved in an activity that nothing else seems to matter. This is termed as flow or a flow experience. When completely absorbed in an activity, he or she is 'carried by the flow,' hence the origin of the theory's name (Rieber & Matzko, 2001).They further commented that a person may be considered in a flow during an activity when experiencing one or more of the following characteristics: Hours pass with little notice; challenge is optimized; feelings of self-consciousness disappear; the activity's goals and feedback are clear; attention is completely absorbed in the activity; one feels in control; and one feels freed from other worries (Rieber & Matzko, 2001).

According to Davis and Wiedenbeck (2001), an activity that is highly intrinsically motivating can become all-encompassing to the extent that the individual experiences a sense of total involvement, losing track of time, space, and other events. Davis and Wiedenbeck also argued that the interaction style of a software package is expected to have a significant effect on intensity of flow. However, Rieber and Matzko (2001) contended that play and flow differ in one respect; learning is an expressed outcome of serious play but not of flow.

Engagement is defined as a feeling of directly working on the objects of interest in the worlds rather than on surrogates. According to Davis and Wiedenbeck (2001), this interaction or engagement can be used along with the components of Malone and Lepper's (1987) intrinsic motivation model to explain the effect of an interaction style on intrinsic motivation, or flow. Garris, Ahlers, & Driskell, (2002) commented that training professionals are interested in the intensity of involvement and engagement that computer games can invoke, to harness the motivational properties of computer games to enhance learning and accomplish instructional objectives.

### Reflection and debriefing in games

Brougere (1999) argued that a game cannot be designed to directly provide learning. A moment of reflexivity is required to make transfer and learning possible. Games require reflection, which enables the shift from play to learning. Therefore, debriefing (or after action review), which includes reflection, appears to be an essential contribution to research on play and gaming in education (Brougere, 1999; Leemkuil, de Jong, de Hoog &

Christoph 2003; Thiagarajan, 1998). According to Garris et al. (2002), debriefing is the review and analysis of events that occurred in the game. Debriefing provides a link between what is represented in the simulation or gaming experience and the real world. It allows the learners to draw parallels between game events and real-world events. Debriefing allows learners to transform game events into learning experiences. Debriefing may include a description of events that occurred in the game, analysis of why they occurred, and the discussion of mistakes and corrective actions. Garris et al. (2002) argued that learning by doing must be coupled with the opportunity to reflect and abstract relevant information for effective learning to occur.

### Computerized mathematical games

Computerized mathematical games are described as computer-assisted drill program in mathematics which is an example of one of the ways the teacher optimizes the time for practice and rate of progression through drill material already designed in the computer.

Drill and practice has a place of long standing in the history of mathematics teaching, especially in arithmetic. At one time it was the major means of instruction. Today it is still part of mathematics curriculum, although usually accompanied by concrete experiences or explanations of underlying mathematical principles. Almost everyone accepts some form of practice as necessary. The reason, according to educators and lay people alike, is that practice makes perfect. Along with drill and practice come increases in speed and accuracy, which are two widely accepted criteria of computational proficiency.

Most teachers are satisfied when children can execute calculations speedily and accurately. According to Thorndike (1992), every bond formed should have a link with already formed bonds and the other bonds yet to be formed, every ability should be practiced in the most effective possible relations with other abilities. The reward that served to strengthen the practiced bonds was obtained when arithmetic problems are simple and interesting. The generalization method proved most effective in promoting learning with drills and practice as the method of consolidation concepts in linear algebra.

**The internet**

Sometimes, students need extra help to grasp all the concepts they learn in school and at other times, students need some extra enrichment. This is why one-on-one tutoring on the internet is important. Computer games are dedicated towards helping the child to achieve the highest standards. One is likely to encounter two kinds of things on the internet; that is people and information. The internet is medium for accessing a vast amount of information. Although the internet is a wonderful resource, it's not perfect. One cannot find information on everything by using the internet alone. Other sources of information may be found at a library or from a teacher or professor. One of the key motivators of information technology is its ability to provide appropriate challenges for learners of all abilities. Lepper, Woolverton, Mumme and Gurtner (1993) as cited in Lajoie & Derry, (1993) shared this view when they talked about how individuals are challenged by a

series of activities that they perceive to be meaningful and especially when learners are very often uncertain about their outcome.

Finally, Cox (1997) mentioned a lot of other factors that rewarded the use of the computer for lesson delivery. These he explained as self esteem and he perceived IT skills as vocationally relevant, since users recognize the need to and appreciate the opportunity to acquire the skills needed for many jobs. For these reasons where positive effects of IT are noted they can be justified theoretically using behaviourist, Cognitive and social constructivist theories of motivation and learning.

Learning with computer demands attitudinal change in teachers, who by their position, play a major role in developing the mental attributes of the students. The teacher is no longer the sole source of knowledge since the internet has made it more convenient to access information from all parts of the world. The teacher only becomes a facilitator to support students learning. The student, on the other hand, actively participates in what form and how knowledge is imparted. More than any other teaching method, independent leaning requires a collaborative effort between student and teacher unbounded by the conventional limits of time, space, and single-instructor.

Studying alone helps a lot more of people to benefit from formal education. Web studies as self directed learning are firmly grounded in both theory and practice. Candy (1991) discussed how undergraduate courses can be encouraged for life long leaning by redesigning traditional courses to focus on self directed rather than teacher directed learning. A mathematics teacher

can assign linear algebra questions on the Angela Reilly Hardens games to students and expect them to send their answers back to him through the mail.

Knowles (1950) stated that in self directed learning the teacher should direct the learning experience not just an information provider. This implies that the teacher is the focus around which initiating an internet open learning can be possible and effective.

<center>**Educating the student using internet games**</center>

The Internet allows teachers and parents to provide differentiated practice for students to develop fact fluency. Many sites also provide scaffolded practice, allowing students to practice individual times tables or mixed practice so that students can build fluency by practicing specific problem areas.

The inclusion of game in education represents a shift away from the instructivist model of instruction, where students primarily listen to one in which students learn by doing (Garris, Ahlers, & Driskell, 2002). With active participation in mind, Moreno and Mayer (2002) suggest that because some media may enable instructional methods that are not possible with other media, it might be useful to explore instructional methods that are possible in immersive environments but not in others. Simulation in educational computing is a widely employed technique to teach certain types of complex tasks. The purpose of using simulations is to teach a task as a complete whole instead of in successive parts, where learning the numerous variables

simultaneously is necessary to fully understand the whole concept (Tennyson & Breuer, 2002).

**Innovations and change in learning technology**

The use of computer games in a classroom learning situation is a novelty in Ghana. Its benefits can be fully felt if it becomes a common practice in our educational set up. The term innovation has become a complex one talking on a variety of meaning in a variety of situations. The (Center for Educational Research and Innovation [CERI], 1969) stated "we understand innovations to mean those attempts at change in an educational system that are consciously and purposefully directed to necessarily mean something new but it is something better and can be demonstrated as such. This is because "it is one of the best ways to react in our rapidly changing society" (p. 5)

An innovation can be something borrowed from another society or an invention. Invention, according to DeFluer and Dennies (1994) "is the process by which an individual or group puts together element that already exists in the culture into some new pattern" (p. 332). When many individuals decide to adopt the innovation and it comes into common use in a society, we say that diffusion of the innovation has occurred.

Not all new concepts should be adopted or accepted fully. There are some mathematics computer games that have little educational benefit. Koonz and Weihrich (1990) suggested, "whenever innovations are based solely on bright ideas, this may be very risky and mostly they are not successful" (p. 1). They listed some factors that may cause the resistance. One of these is the use of computer literates. Though the computer was a powerful tool and user

friendly, the impact cannot be felt until one has access to use. The innovation brings about change and we live in a world of change. If a company is to survive today, it must be able to react to changing conditions by changing itself. In fact, it must anticipate environmental changes by altering its own policies and structure in time to meet these new conditions. The attitude to change is therefore an important aspect of innovation without which the bright idea may die.

The increase use of computers requires that teachers of education as well as students change and become computer-literates. Internationalization will continue, and teachers in different countries must learn to communicate and to adapt to each other. This way, they will exchange ideas and knowledge that may be beneficial to each group and in a way contribute to quality teaching and leaning which inevitably, is the ultimate goal of every institution in the world. George and Jones (1996) stated "individuals within an organisation may be inclined to resist change because of uncertainty, selective perception, and force of habit". (p. 606). People are hesitant and anxious about what the outcome of the change will be and this may force them to kick against the idea. Workers might be given new tasks or they might lose their jobs; if workers perceive few benefits they may resist the purpose behind the change; and the difficulty of breaking old habits adopting new styles of behaviour indicates how resistant habits are to change. Kennedy (1988) also suggested that "it is not just enough for people to act differently in the course of the change but in addition they may be required to change the way they think

about certain issues, which according to him "is a deeper and more complex change". (p. 329).

**Effectiveness of CAI compared with the conventional method of teaching**

Blitz (1972) reported no significant difference in students' scores due to the methods of instruction when comparing the effects of CAI (computer aided instruction) to a programmed text approach.

In 1976, Shirey found no significant difference between a treatment groups using computer assisted instruction methods and conventional method of instruction. These studies indicated that, the computer assisted instruction methods were as effective as those in the teacher directed approach.

Vinsonhaler and Bass (1972), reviewing computer-based drills that pre-dated microcomputers in the classroom, concluded that CAI drill and practice at the elementary school level was more effective than conventional instruction in raising standardized test scores in the majority of 30 experimental comparisons at ten sites. King (1975) compared the effects of three graphic levels on the learning of the sine-ration concept of 45 students at a naval training centre. Although the performance of the animated graphics group appeared higher, no significant differences were found between the three groups on a posttest.

Research in mathematics education has shown that the computer facilitated the learning of concepts and computations of statistical formulas (McCoy, 1996). Students of mathematics courses were more motivated, self-confident, joyful and the subject became more meaningful with CAI (Rochowicz, 1996, Funkhouser, 1993).

Szabo (2001) study showed that much research has been focused on the effectiveness of CAI, which is demonstrated through improved test scores (Williams & Brown, 1990). Effectiveness has also been measured through "heightened affective responses, or better attitudes, reduced learning time, higher course completion rates, an increased retention duration, and finally cost" (Williams & Brown, 1990, p. 214).Generally the effectiveness of CAI has been determined by comparing CAI with conventional classroom instruction (Clark, 1985).

Nickerson (1995) points out that while technology does not promote understanding in and of itself, it is a tool that can help students view learning as a constructive process and use simulations to draw students' attention. It provides a supportive environment that is rich in resources, aids exploration, creates an atmosphere in which ideas can be expressed freely, and provides encouragement when students make an effort to understand (delMas, 1999).

Researchers have also found that CAI enhances learning rate i.e., students learned the same amount of material in less time than the traditionally instructed students or learned more material given the same amount of time. (Cotton, 2001). Moreover, students receiving CAI also retain their learning better (Cotton, 2001). Most researchers concluded that the use of CAI leads to more positive student attitudes than the use of conventional instruction. This general finding has emerged from studies of the effects of CAI on student attitudes as cited by Cotton (2001).

Computer-assisted-instruction increases motivation by providing a context for the learner that is challenging and stimulates curiosity (Malone,

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1981). Activities that are intrinsically motivating also carry other significant advantages such as personal satisfaction, challenge, relevance, and promotion of a positive perspective on lifelong leaning (Keller & Suzuki, 1988; Kinzie, 1990).

Providing students with choice over their own learning provides leaner-controlled instruction, which contributes to motivation. Increased motivation in turn increases student learning (Kinzie, Sullivan and Berdel, 1988). Also, program-controlled instruction, as opposed to learner-controlled, may get in the way of the learner by requiring the learner to study all of the given subject matter rather than only the elements the learner needs (Mayer, 1964). Further, learner-controlled instruction makes it possible for individuals to make certain choices in an activity and to affect certain outcomes. As a result, the individual feels competent and self-determining, and the activity has greater personal meaning and intrinsic interest (DeCharms, 1986; Lepper, 1985).

### Computer games and accuracy

According to Victor Epand in his article EzineArticles.com, recent studies carried out at a medical centre in New York, have actually shown that the vast majority of surgeons who do regularly play computer games actually have a much better success rate and accuracy rating than their colleagues who play games either very rarely or not at all. They found that those surgeons who, on average, play three hours video gaming per week managed to work almost thirty percent faster than those who did little or no gaming, and were over forty per cent more successful in operations. (Victor Epand).

The authors' neural simulations shed light on why action gamers have augmented decision making capabilities. People make decisions based on probabilities that they are constantly calculating and refining in their heads, Shawn, Green, Pouget, and Bavelier (2010) explain. The process is called probabilistic inference. The brain continuously accumulates small pieces of visual or auditory information as a person surveys a scene, eventually gathering enough for the person to make what they perceive to be an accurate decision.

According to Shawn, Green, Pouget, and Bavelier (2010)

> Decisions are never black and white. The brain is always computing probabilities. As you drive, for instance, you may see a movement on your right, estimate whether you are on a collision course, and based on that probability make a binary decision: brake

Action video game players' brains are more efficient collectors of visual and auditory information, and therefore arrive at the necessary threshold of information they need to make a decision much faster than non gamers.

# CHAPTER THREE

## METHODOLOGY

This chapter deals with explanation of a methodological outline that spells out how the researcher continued to distinguish what is required to achieve the purpose of the study. This chapter entails in detail how the study was fashioned out. It consists of the research design, population and sampling, data collection instrument, procedure for collection and analysis of data.

### Research Design

This was a study on senior high school year one arts class. It follows the mixed method research paradigm as proposed by Onwuegbuzie (2004). This paradigm called for a combination of traditional qualitative and quantitative research. An experimental research design was used to determine whether ARH games could be used to consolidate the learning of linear algebra in SHS form one. In this research design, the researcher manipulated one of the independent variable under a controlled condition. The study involved an experimental and a control group. The experimental group was exposed to treatment conditions by practising with the ARH games. The control group was exposed to learning linear algebra through the traditional classroom setting method.

There was a pretest, intervention and a posttest. These were followed by administration of questionnaire to both students and teachers.

**Population and Sample**

The target population was all students in Armed Forces and Osei Kyeretwie Senior High School. The reachable population was the General Arts students in the two SHS totaling hundred and twenty as the sample size. The sample selected for the test was sixty Form One students of Osei Kyeretwie SHS for the control group and sixty Form One students of Armed Forces Technical SHS for the experimental group.

**Sampling Procedure**

Purposive sampling technique was used to select the school for the study. Armed Forces SHS was selected because the school had a computer lab which was connected to the internet. After the necessary permission had been sought, Form One students from the General Arts class of each school was used for the tests. There were four General Arts classes in both schools. The General Arts students were selected based on their perceived dislik for maths. An intact class made up of 60 students was selected from both schools. Armed Forces SHS students were made up of twenty six females and thirty four males, whiles Osei Kyeretwie SHS students were made up of twenty two females and thirty eight males. The average age of all the students used for the test was fifteen years. The Form One class was used as they have come from JSS directly and have not had more lessons in algebra. Ten mathematics teachers from each school volunteered to assist the researcher control the students during the project. There were three females and seven males from

Armed Force SHS, whiles two females and eight males from OKESS took part in the supervision. The ages of the ten teachers ranged between thirty to fifty years. The teachers from both schools were first degree certificate holders who teach core maths in their various schools.

## Research instrument

The instruments for this research were in five different packages. They were pretest, the instructional instrument which is a three day lesson plan, the consolidation activities which is the ARH games for experimental group and traditional classroom teaching for the control group, the posttest and lastly the questionnaire for both teachers and students.

The test instrument, Maths Performance Test (MAPET), were general aptitude tests on linear algebra. It had ten subjective questions and five multiple choice questions. For the sake of reliability a pilot testing of the instrument was administered to 10 Form One students of Opoku Ware School in Kumasi, to make sure the test items did not contain inexcusable errors and were relevant to the purpose of the study. The researcher selected the tests from the SHS 1 mathematics book. The figures were altered to prevent students from guessing the source. Both pretest and posttest questions contain the same number of questions only that the content of test item deferred from each other.

The questionnaire was designed by the researcher for four categories of respondents. They were teachers of the experimental group, teachers of the control group, students of experimental group and finally students of the control group. Teachers answered eight questions and students answered 10

questions. The questions touched such areas as self assessment, speed, motivation, accuracy and academic achievement. All the questionnaires were the fixed response type in the Likert scale format.

The Computer Assisted Instructional Package (CAIP) on linear algebra was a self-instructional, interactive package that lasted for 1 hour 30 minutes a day for 3 days for each student. The topics covered in the ARH games included equation match, algebra aquarium, solving addition equations (beat the clock), solving subtraction equations (beat the clock), solving multiplication equations (beat the clock), solving division equations (beat the clock), solving two-step equations (beat the clock), algebra balance scales (positive only), algebra balance scales (positive and negative), equation balancer, equation buster, solving one-step equations (battleship), order up and distribute it (rags to riches) and algebra four (like connect four).

In selecting the ARH game, four methodological phases were strictly followed: analysis, design, implementation and validation. In analysis stage, students' cognitive skills to be improved were considered as a baseline for the choosing the software. At the design stage, storyboards, scripts, frameworks and other aspects of the software such as sound and simplicity of operation were also considered. The game was user-centered in design. It factored in aspects like the opinion, interests, needs, emotions, thoughts and ability of the user. Validation was done by the developers.

To enter into the ARH game, the user has to type "Angela Reilly Harden's linear algebra games" into the text bar of google web site. Once in the game the user has to register with his name before having full access to the

game. The game allows the user to solve unlimited number of linear algebra questions within sixty minutes. Finally the game determines the number of questions which have been correctly answered, the speed of the user and his rate of accuracy.

## Data collection

Consistent with the mixed method paradigm, this study collected data by using both quantitative and qualitative techniques. Quantitative data were collected through pretest and posttest. Qualitative data were collected through the response of teachers' and students' questionnaire. In all, twenty questionnaires for teachers were sent out and all of them collected. After the posttest teacher used twenty minutes to answer their questionnaire which was collected immediately. One hundred and twenty questionnaires were sent to the students and all one hundred and twenty questionnaires were retrieved. Students used twenty minutes to answer the questionnaires after they had finished the posttest and was retrieved on the same day. The duration for both pretest and posttest was forty minutes. The time used by each student in solving the questions was recorded on his answer sheet by the teachers. The researcher determined students accuracy by how correctly they answered the questions.

## Analysis of data

In the descriptive statistics, the raw data from the pretest and posttest scores were used to form a distribution. The students were put into three ability groups based on their performances in the pretest. The researcher used the 16.0 edition of Statistical Package for Social Sciences (SPSS) software to

calculate the mean, standard deviation, minimum and maximum scores. The SPSS was used to derive a histogram showing the skewness and normality of the distribution.

At 5% level of significance, the independent sample t-test was used to compare the pretest scores of the two schools (control and experimental). ANCOVA was used to compare the mean pretest and posttest scores of the two schools (control and experimental) to find out whether the use of the Angela Reilly Harden's Linear Algebra games could be used as a consolidation activity in the learning of linear algebra.

Qualitative analysis format was used in analyzing the questionnaire for both teachers and students. The questions were on the speed with which students solved linear algebra questions, how a method could motivate students to learn more, how accurate students were in answering questions and how a method used in a school could enhanced academic achievement. The questions also sought to find out whether students could do self assessment. The researcher presented the views of both teachers and students with respect to how they answered the questions.

# CHAPTER FOUR

## RESULTS AND DISCUSSION

This chapter is dedicated to analysis and interpretation of both qualitative and quantitative data. The study used qualitative methods to explore and analyze issues raised in the questionnaire. Quantitative method was used to analyze the results of pretest and post test scores. The project is expected to determine whether Angela Reilly Harden's Math lab games could be used to consolidate the learning of linear algebra in SHS form one. In view of this the project sought to find out if the introduction of the Angela Reilly Harden's Math lab games could lead to students having a deeper knowledge of the topic under review, giving more accurate answers, working at a faster pace, being able to do self assessment and being motivated to learn linear algebra on their own.

The instruments used to gather data were the pretest, post test and questionnaire. The Statistical Package for Social Sciences Software was used for descriptive analysis and for obtaining statistics used for hypothesis testing. The SPSS helped in transforming the data into measures of mean, standard deviation, variance and p-value.

**Pretest**

Hypothesis 1: There is no significant difference in the mean achievement on the pretest scores of students who were taught using the Angela Reilly Harden's Linear Algebra games and those taught using the traditional method.

A descriptive statistics of the experimental and control groups (pretest) was calculated. A Levene's test of equal variance was also conducted. Table 1 and 2 shows the outcome of the test.

**Table 1: Descriptive statistics of the experimental and control groups (Pretest)**

| Schools Category | N | Mean | Standard Deviation | Standard Error |
|---|---|---|---|---|
| Experimental | 60 | 6.53 | 2.931 | .378 |
| Control | 60 | 9.23 | 3.638 | .470 |

**Table 2: Independent sample t – test on the pretest scores**

| | Levene's test for equality of variances | | t-test for equality of means | | | |
|---|---|---|---|---|---|---|
| equal variances assumed | F | Sig | t | df | mean diff | p – value |
| | 7.090 | .009 | 4.477 | 118 | 2.700 | 0.00 |
| equal variances not assumed | | | | | | |

The independent t-test shows that in the experimental group, the mean score of pretest was 6.53 while the pretest of the control group was 9.23. The difference between the means was 2.700 in favour of the control group. The standard deviation of the experimental group was 29.31 and it was 36.38 for

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the control group. The p<0.001 was less than the alpha value (0.05), this shows a significant difference. The t-value was 4.477 leading to an effect size of 0.145. According to Cohen (1988) this represents a small effect. That is the difference in mean though significant is small. This means the independent variable explains 14.5% of the variable in the dependent variable.

In Table 3 the pretest scores of both experimental and control groups were put into three groups (ie 0–7, 8–12, and 13–20). The number of students who scored the respective marks in the two schools as well as their corresponding percentages is presented Table 3. Students who scored marks between 0–7 constituted low performers in both schools. Students who scored marks between 8–12 constituted medium performers. Students who scored 13–20 marks constituted high performers.

**Table 3: Distribution of pretest scores of both experimental and control groups**

|  |  | Experimental | | Control | |
| --- | --- | --- | --- | --- | --- |
|  | Score | Frequency | Percentage | Frequency | Percentage |
| Low: | 0 – 7 | 45 | 75% | 20 | 33.3% |
| Medium: | 8 – 12 | 12 | 20% | 28 | 46.7% |
| High: | 13 – 20 | 3 | 5% | 12 | 20% |
| **Total** |  | **60** | **100%** | **60** | **100%** |

Sixty students took part in the pretest in each schools. In the experimental school, 45 students representing 75% scored low marks between 0–7 marks. Twelve students representing 20% scored medium marks between 8–12 marks. 3 students representing 5% scored high marks between 13–20 marks. For students in the control group, 20 students representing 33.3%

scored low marks between 0–7 marks constituting the low performance. 28 students representing 46.7% scored medium marks between 8–12 marks constituting the medium performance. 12 students representing 20% scored high marks between 13–20 marks constituting the high performance.

Table 4 is a summary of pretest scores showing mean and standard deviation for students in the experimental and control groups.

**Table 4: Summary of descriptive statistics on pretest scores of experimental and control groups**

| Summary | Experimental | Control |
| --- | --- | --- |
| N | 60 | 60 |
| Mean | 6.53 | 9.23 |
| Standard deviation | 29.31 | 36.38 |
| Maximum score | 15 | 17 |
| Minimum score | 1 | 3 |

From the pretest, the experimental group demonstrated remarkable weakness in solving linear algebra questions compared to their counterparts in the control group. The difference in the mean was 2.70 in favour of the control group.

Figure 1 is a graphical presentation of frequency and pretest scores of the experimental group.

Mean = 6.53
Std. Dev. =2.931
N = 60

**Scores**

**Figure 1 :  Histogram showing pretest scores of the experimental group**

Figure 2 is a graphical presentation of frequency and pretest scores of the

control group.



Mean = 9.23
Std. Dev. = 3.638
N = 60
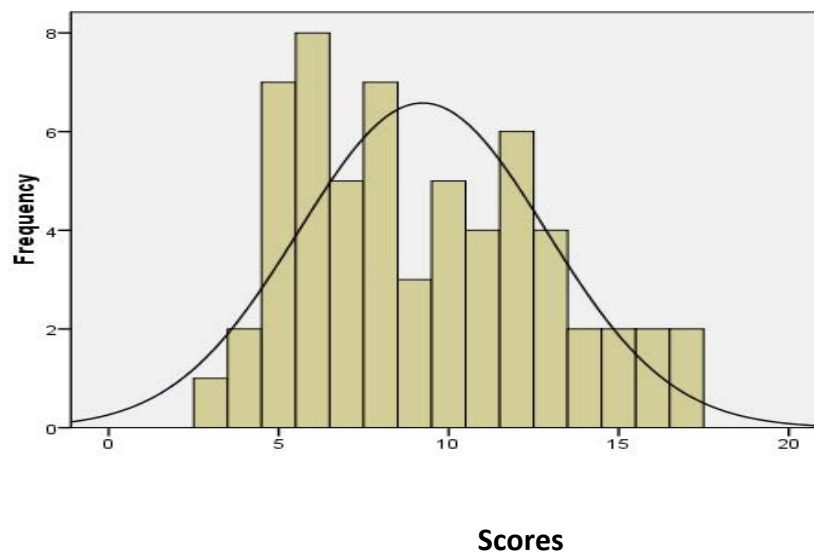
**Scores**

**Figure 2 :   Histogram showing pretest scores of the control group**

Comparing the two graphs, it can be observed that the histogram for the experimental group is slightly skewed to the right. This is an indication that, generally few of the students in the experimental group performed above average while most of the students performed below average in the pretest. The histogram of the control group in the pretest is slightly normal, an indication that most of the students performed averagely in the class.

During the pretest, the mean score of students in the experimental group was 6.53 while that of the control group is 9.23. The difference in the mean was 2.70 in favour of the control group. This difference in mean is very significant. To determine the magnitude of the difference the effect size was computed using the eta squared (d). As discussed earlier, the effect size obtained was 0.145. According to Cohen (1988), this represents a small effect meaning the independent variable explains 14.5% of the variable in the dependent variable.

**Posttest**

Hypothesis 2: There is no significant difference in the mean achievement on the posttest scores of students who were taught using the Angela Reilly Harden's Linear Algebra games and those taught using the traditional method.

An independent t-test was used to compare the posttest of the two schools (experimental and control). At 5% level of significance, an independent t-test was used. From the Levene's test of equal variance conducted, there was no significant difference in the variances. Hence, equal variance was assumed. Table 4 shows the outcome of the test.

**Table 5: Descriptive statistics of the experimental and control groups (Posttest)**

| Schools Category | N | Mean | Standard Deviation | Standard Error |
|---|---|---|---|---|
| Experimental | 60 | 12.60 | 3.426 | 0.442 |
| Control | 60 | 11.75 | 3.533 | 0.549 |

**Table 6: Independent sample t – test on the posttest scores**

| Sample | Levene's test for equality of variances | | t-test for equality of means | | | |
|---|---|---|---|---|---|---|
| equal variances assumed | F | Sig | t | df | mean diff | p – value |
| | .021 | .884 | 1.622 | 118 | 1.033 | .108 |
| equal variances not assumed | | | | | | |

Since the calculated P-values for the control and experimental groups, or for the 2-factor interaction is 0.108 and is greater than the conventional 0.05 (5%), then the corresponding null hypothesis cannot be rejected.

This shows that the difference in the means of the posttest score of the two groups was not significant. This shows that the performance of the two schools at the posttest stage was almost the same.

In Table 7, the posttest scores of both experimental and control groups were put into three groups (ie 0–7, 8–12, and 13–20). The number of students who scored the respective marks in the two schools as well as their corresponding percentages was also presented. Students who scored marks

between 0–7 constituted low performers in both school. Students who scored

marks between 8–12 constituted medium performers. Students who scored 13–

20 marks constituted high performers

**Table 7: Distribution of posttest scores of both experimental and control groups**

| Level | Scores | Experimental | | Control | |
|---|---|---|---|---|---|
| | | Frequency | Percentage | Frequency | Percentage |
| Low: | 0 – 7 | 4 | 6.7% | 9 | 15% |
| Medium: | 8 – 12 | 24 | 40% | 22 | 36.7% |
| High: | 13 – 20 | 32 | 53.3% | 29 | 48.3% |
| **Total** | | **60** | **100%** | **60** | **100%** |

During the pretest, 32 students were found in the high performing

group in the experimental school while 29 students were found in the high

performing group in the control school. 24 students were in the medium

performing group or average performers while the control school had 22. The

experimental school had 4 students were found in the low performing group

while the control school had 9 students in the low performing group. From the

posttest the experimental group demonstrated remarkable improvement in

solving linear algebra questions compared to their counterparts in the control

group.

Table 8 is a summary of posttest scores showing mean and standard

deviation for students in the experimental and control groups.

**Table 8:   Summary of descriptive statistics on posttest scores of experimental and control groups**

| Summary | Experimental | Control |
|---|---|---|
| N | 60 | 60 |
| Mean | 12.60 | 11.57 |
| Standard deviation | 3.426 | 3.553 |
| Maximum score | 18 | 19 |
| Minimum score | 5 | 3 |

Figure 3 is a graphical presentation of frequency and posttest scores of the experimental group.
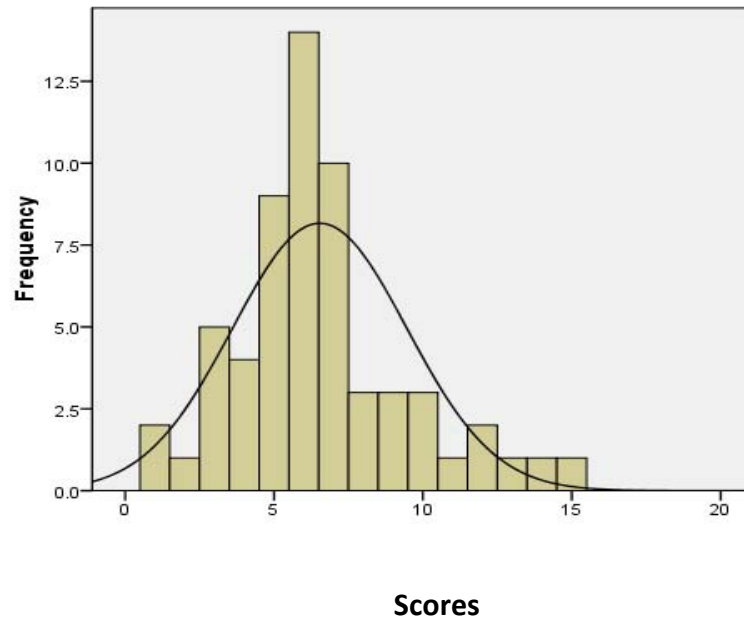


Mean = 12.6
Std. Dev. =3.426
N = 60
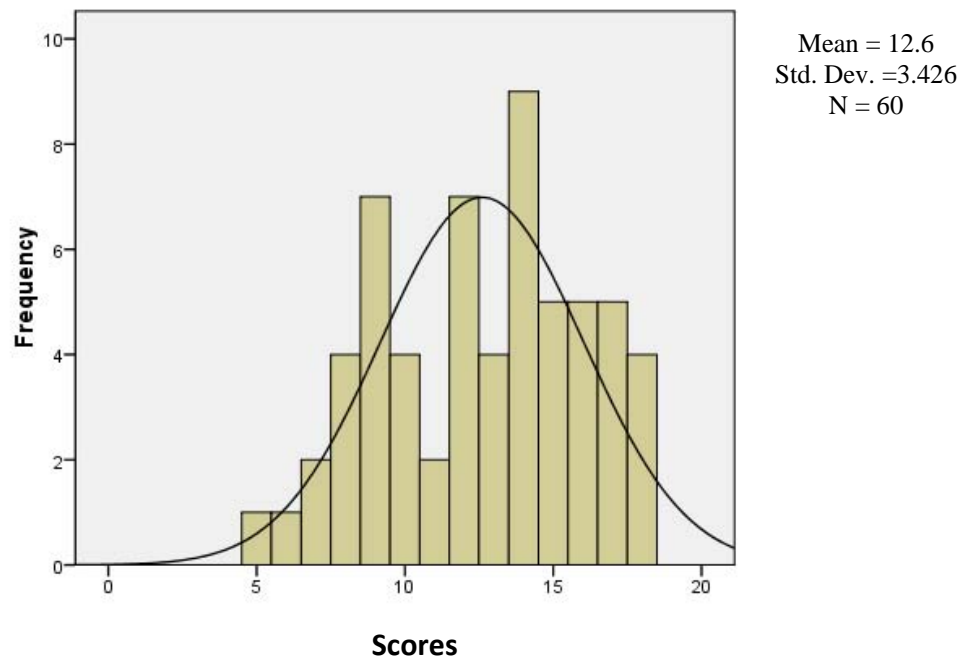
**Figure 3:  Histogram showing post test of experimental group**

Figure 4 is a graphical presentation of frequency and posttest scores of the control group.
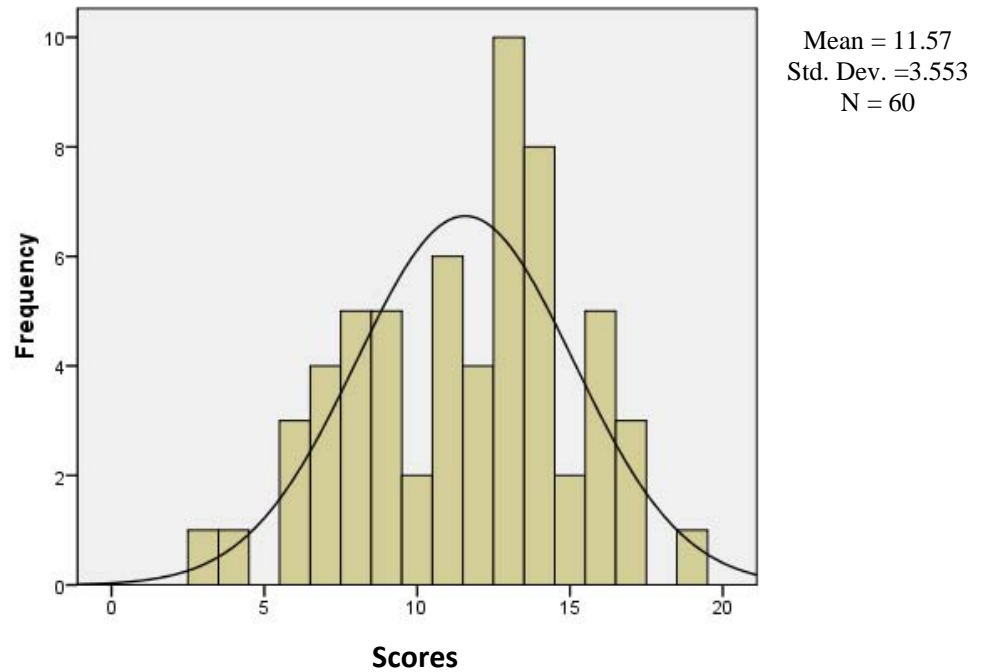


**Figure 4:   Histogram showing posttest of control group**

Comparing the two graphs, it can be observed that the histogram of the both the experimental and the control group are slightly skewed to the left. This is an indication that, after the intervention, students in both schools were able to solve linear algebra questions well.

**Comparing the mean scores of pretest and posttest for both schools**

Hypothesis 3:  There is a significant difference the pretest and posttest mean scores of students who were taught using the Angela Reilly Harden's Linear Algebra games and those taught using the conventional method.

An analysis of covariance test (ANCOVA) was used to compare the pretest and posttest mean scores of the two schools (experimental and control). Tables 9 and 10 show the outcomes of the tests.

**Table 9: Levene's test of equality of error variances dependent variable: scores for posttest**

| F | df1 | df2 | Sig. |
|---|---|---|---|
| .001 | 1 | 118 | .970 |

From Table 9, it was shown that, the underlying assumption of homogeneity of variance for the one-way ANCOVA has been met – as evidenced by F(1, 118) = .001, p = .970. That is p(.970) > α (0.005).

**Table 10: Tests of between-subjects effects dependent variable: scores for posttest**

| Scores | Type III Sum of Squares | df | Mean Square | F | Sig | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 522.722ª | 3 | 174.241 | 21.356 | .000 | .356 |
| Intercept | 918.265 | 1 | 918.265 | 112.546 | .000 | .492 |
| Group | 17.858 | 1 | 17.858 | 2.189 | .142 | .019 |
| Pretest | 480.725 | 1 | 480.725 | 58.920 | .000 | .337 |
| Group*Pretest | 2.489 | 1 | 2.489 | .305 | .582 | .003 |
| Error | 946.445 | 116 | 8.159 | | | |
| Total | 18990.000 | 120 | | | | |
| Corrected Total | 1469.167 | 119 | | | | |

In Table 10, the results shows as follows: The group source (labelled Group*Pretest) evaluates the null hypothesis 3. The results of the analysis indicated that this hypothesis should be rejected, F(1, 116) = 58.920 , p > 0.05.

This is an indication that the Angela Reilly Harden's Maths Lab games could not bring about any significant improvement in consolidating the learning of linear algebra at SHS 1. After the posttest, the two groups (experimental and control) were found to be homogeneous.

## Results of students' questionnaire

Students from both schools were asked ten similar questions that were based on the study. Areas covered included academic achievement, speed, motivation, accuracy and self assessment. The experimental group answered questions based on the ARH games as a consolidation exercise and the control group also answered questions based on the traditional method of teaching and learning of linear algebra.

### The method which made students score more marks

Under achievement students were asked to find out the extent to which the method they have been exposed to has helped them to understand concepts in linear algebra. They were asked if the method helped them to follow the right procedure in solving linear algebra questions.

Table 11 shows the views of students on the difficulty that they faced when solving questions (item 4).

**Table 11:** **A distribution showing the method which was difficult to use in solving linear algebra questions**

|  | Traditional method | | ARH method | |
| --- | --- | --- | --- | --- |
| Response | Frequency | % | Frequency | % |
| Strongly agree | 6 | 10.0 | 5 | 8.3 |
| Agree | 22 | 36.7 | 6 | 10.0 |
| Disagree | 28 | 46.7 | 20 | 33.3 |
| Strongly disagree | 4 | 6.7 | 29 | 48.3 |
| **Total** | **60** | **100.0** | **60** | **100.0** |

From the table 10% of the students from the control group strongly agreed that solving algebra questions with the use of the traditional method was very difficult. Only 8.3% of their counterparts from the experimental group strongly agreed that the the use of the ARH in solving algebra questions was difficult. In all, 28 (46.7%) of the students in the control group indicated that learning linear algebra using the traditional method is difficult. The result shows that 48.3% of the students from the experimental group strongly agreed that the AHR games makes solving linear algebra questions rather easy. While only 6.7% of their counterparts in the control group said learning algebra with the use of the traditional method is easy. In all 49(81.6%) of students in the experimental group found it easy solving linear algebra questions using ARH games.

Students were asked if the respective method helped them to understand the concepts in linear algebra (item 7). The result is presented in Table 10.

**Table 12:   A distribution showing the method which made understanding of linear algebra concept easier**

|  | Traditional method | | | ARH method | |
|---|---|---|---|---|---|
| Response | Frequency | % | | Frequency | % |
| Strongly agree | 6 | 10.0 | | 25 | 41.7 |
| Agree | 12 | 20.0 | | 26 | 43.3 |
| Disagree | 26 | 43.3 | | 5 | 8.3 |
| Strongly disagree | 16 | 26.7 | | 4 | 6.7 |
| **Total** | **60** | **100.0** | | **60** | **100.0** |

From the table, 41.7% of the students from the experimental group strongly agreed that the ARH games enable them to fully understand the concepts in linear algebra. While 43.3% of the students from the experimental group agreed that the ARH games assisted them to understand the concepts. For those in the control group, 42 (70%) said that they find it difficult understanding the concepts in linear algebra when they use the traditional method. In all, only 9(15%) of the experimental group found problems in understanding the concept in linear algebra when using the ARH games.

**The method which enabled students to use the right steps**

**to solve linear algebra questions**

Under accuracy, students were asked if they were able to use the correct steps to solve the linear algebra questions. The results are organised in Table 13.

**Table 13: A distribution showing the method which helped students to use the correct steps in solving linear algebra questions**

|                   | Traditional method |       | ARH method |       |
| ----------------- | ------------------ | ----- | ---------- | ----- |
| Response          | Frequency          | %     | Frequency  | %     |
| Strongly agree    | 15                 | 25.0  | 12         | 20.0  |
| Agree             | 22                 | 36.7  | 26         | 43.3  |
| Disagree          | 19                 | 31.7  | 15         | 25.0  |
| Strongly disagree | 4                  | 6.7   | 7          | 11.7  |
| **Total**         | **60**             | **100.0** | **60**  | **100.0** |

From the table 61.7% of the students in the control group confirmed that the traditional method enabled them to follow the right procedure. Those who disagreed were 31.7%. The remaining 6.7% strongly disagreed to that. Some of them added that the traditional method does not help them to systematically follow the right procedure.

In all, 63.3% of the students in the experimental group said that the ARH games teach them the right procedure to follow in solving linear algebra questions. There were 22 (36.7%) of the students who were still not convinced that the game had taught them the correct procedure to follow in solving questions.

**The method which motivated students to study more on their own**

Under motivation the questionnaire sought to find out how interactive the two approaches were to the students and which method students enjoyed working with. Lastly, the questionnaire tried to find out which of the approaches encouraged self learning by students (item 1)

Table 14 displays the distribution of the responses to this item.

**Table 14: Frequency distribution showing the method which was more interactive**

| | Traditional method | | ARH method | |
|---|---|---|---|---|
| Responses | Frequency | % | Frequency | % |
| Strongly agree | 7 | 11.7 | 34 | 56.7 |
| Agree | 12 | 20.0 | 20 | 33.3 |
| Disagree | 22 | 36.7 | 4 | 6.7 |
| Strongly disagree | 19 | 31.7 | 2 | 3.3 |
| **Total** | **60** | **100.0** | **60** | **100.0** |

In all, 19 (31.7%) of the students in the control group were of the view (agree and strongly agreed) that the traditional method is interactive. While 54 (90%) students of the experimental group found the ARH games to be interactive.

The response to item 3 which was to find out which of the methods was enjoyable to work with was organized in Table 15.

**Table 15: Frequency distribution showing the programme which students found enjoyable to work with**

| | Traditional method | | ARH method | |
|---|---|---|---|---|
| Response | Frequency | % | Frequency | % |
| Strongly agree | 16 | 26.7 | 25 | 41.7 |
| Agree | 15 | 25.0 | 30 | 50.0 |
| Disagree | 17 | 28.3 | 2 | 3.3 |
| Strongly disagree | 12 | 20.0 | 3 | 5.0 |
| **Total** | **60** | **100.0** | **60** | **100.0** |

From the table 55(91.7%) of the students in the experimental group agreed or strongly agreed that they enjoyed working with the ARH games. Only 8.3% of the students in the experimental group did not enjoy working with the ARH games. In the control group, 26.7% strongly agreed that the traditional method was fun to work with and 25% agreed to it. As many as 29(48.3%) disagreed and said that the traditional method was not enjoyable to work with.

Item 5 was to find out which of the two programmes motivated students to study on their own during their free time. The distribution of the responses is shown in Table 16.

**Table 16: Frequency distribution showing the programme which motivates students to learn during their leisure time**

| Response | Traditional method | | ARH method | |
|---|---|---|---|---|
| | Frequency | % | Frequency | % |
| Strongly agree | 18 | 30.0 | 31 | 51.7 |
| Agree | 8 | 13.3 | 17 | 28.3 |
| Disagree | 14 | 23.3 | 10 | 16.7 |
| Strongly disagree | 20 | 33.3 | 2 | 3.3 |
| **Total** | **60** | **100.0** | **60** | **100.0** |

From the table, more than half of the students (56.6%) in the control school said they would rather do other things than using their spare time to solve linear algebra questions. On the part of students in the experimental school, 80% of the students responded that the ARH games motivated them to do further study during leisure hours.

The method which made students solve linear algebra questions faster

Students had to answer questions on which of the method enabled them work faster (item 6).

Table 17 shows a distribution of the responses given by the two groups.

**Table 17: Frequency distribution showing the method which helps student to solve problems faster**

| | Traditional method | | ARH method | |
|---|---|---|---|---|
| Response | Frequency | % | Frequency | % |
| Strongly agree | 17 | 28.3 | 36 | 60 |
| Agree | 19 | 31.7 | 15 | 25 |
| Disagree | 20 | 33.3 | 6 | 10 |
| Strongly disagree | 4 | 6.7 | 3 | 5 |
| **Total** | **60** | **100.0** | **60** | **100.0** |

From the table, the students in the control group had divergent opinions as to the extent to which they agree or disagree to the statement on ability to solve linear algebra questions faster using the traditional method. While 36(60%) of them said they were able to solve questions faster, 24(40%) responded that they were slow in solving questions as they used the traditional method.

Most of the respondents from the experimental group (85%) said that the ARH computer games enhanced the speed with which they solved linear algebra questions. The game gives the student a specified time frame to be used in solving a set of questions. If one is unable to solve a question, the question goes off and he/she has lost the game.

**The method which enabled students to do self assessment**

Under self assessment students were asked whether they were able to determine their own marks without the assistance of a teacher. They were also asked whether the method they use assist them to know when they went wrong (item 2). Their responses are represented in Table 18.

**Table 18: Frequency distribution showing the method which helps students to assess themselves**

| | Traditional method | | ARH method | |
|---|---|---|---|---|
| Response | Frequency | % | Frequency | % |
| Strongly agree | 2 | 3.3 | 60 | 100 |
| Agree | 5 | 8.3 | 0 | 0 |
| Disagree | 19 | 31.7 | 0 | 0 |
| Strongly disagree | 34 | 56.7 | 0 | 0 |
| **Total** | **60** | **100** | **60** | **100** |

From the table, 88.4% of the students in the control group said that the traditional method could not help them determine their marks. Only 11.6% of the students in the control group said that the traditional method enabled them to determine their marks. From the students in the experimental group all the 60 students said that the ARH games scored the work they did on the computer.

Item 10 seeks to find out which method helped students to determine the time they have used to solve a question in linear algebra. The result is presented in Table 19.

**Table 19:  Frequency distribution showing the method which enables students to detect the time used in solving a set of questions**

| Response | Traditional method | | ARH method | |
|---|---|---|---|---|
| | Frequency | % | Frequency | % |
| Strongly agree | 0 | 0 | 40 | 66.7 |
| Agree | 2 | 3.3 | 13 | 21.7 |
| Disagree | 20 | 33.3 | 6 | 10 |
| Strongly disagree | 38 | 63.3 | 1 | 1.7 |
| **Total** | **60** | **100** | **60** | **100** |

No students in the control group could determine the exact time used in solving liner algebra questions with the use the traditional method. A smaller percentage (3.3%) said they were able to determine the time they used in solving the questions.

Most of the respondents from the experimental group 88.4% said that the ARH computer games enabled them to get the exact time used in solving linear algebra questions. The game gives the student a specified time frame to be used in solving a set of questions.

Item 8 is to find out which of the methods enabled students to tell when they went wrong. Almost all students in the control group (93.4%) said they could not tell when their answers and approach were wrong as they used the traditional method. The result is represented in Table 20.

**Table 20: A distribution of responses indicating the method which enables students to determine if they are going wrong**

|  | Traditional method | | ARH method | |
| --- | --- | --- | --- | --- |
| Response | Frequency | % | Frequency | % |
| Strongly agree | 2 | 3.3 | 48 | 80 |
| Agree | 2 | 3.3 | 12 | 20 |
| Disagree | 15 | 25 | 0 | 0 |
| Strongly disagree | 41 | 68.3 | 0 | 0 |
| **Total** | **60** | **100** | **60** | **100** |

All students in the experimental group agree that the ARH games could tell them when they went wrong. The game has been designed such that it tells the student the time used in solving the question, the shorter methods to apply and it also tells the student what he/she has done wrong. It has some sound which beep to signal the correctness or otherwise of the progress of work of the student. The student becomes his/her own teacher when playing the game. The game can progress in difficulty till the student can play no more. It can suit any level of students who endeavour to play.

**Results of teachers' questionnaire**

Teachers in the two schools (control and experimental) were asked questions based on students performances in their respective schools. The questions were on the speed with which students solved linear algebra questions, students' motivation to solving questions, how accurate their students were and how a method used in their school has enhanced academic achievement. In all, the teachers were asked eight questions.

<p style="text-align:center"><strong>The method which made students score more marks</strong></p>

Under achievement teachers in the two schools were asked how well students understood the concept of linear algebra based on the method used by a group of students. They were asked if the methods helped the students to follow the right procedure in solving linear algebra questions.

Item 1 was to find out which set of students answered linear algebra questions with much understanding. The results are displayed in Table 21.

**Table 21:  Frequency distribution showing the methods which help students to practise with much understanding**

|  | Control group teachers | | Experimental group teachers | |
| --- | --- | --- | --- | --- |
| Response | Frequency | % | Frequency | % |
| Strongly agree | 3 | 30 | 6 | 60 |
| Agree | 4 | 40 | 3 | 30 |
| Disagree | 2 | 20 | 1 | 10 |
| Strongly disagree | 1 | 10 | 0 | 0 |
| **Total** | **10** | **100** | **10** | **100** |

From the table, 60% of the teachers who taught students in the experimental school strongly agreed that the ARH games has greatly contributed to making their students solve linear algebra questions with much understanding. In addition, 30% (disagree and strongly disagree) of the teachers in the control group said the traditional method has not in any way helped their students. Only one teacher in the experimental school said that the ARH games were not helpful to their students.

Item 4 was to find out which group frequently approached their teachers for further explanation on the concept of linear algebra. The results are organized in Table 22.

**Table 22: The distribution showing which method required less support from teachers**

|  | Control group teachers | | Experimental group teachers | |
| --- | --- | --- | --- | --- |
| Response | Frequency | % | Frequency | % |
| Strongly agree | 4 | 40 | 0 | 0 |
| Agree | 4 | 40 | 1 | 10 |
| Disagree | 1 | 10 | 5 | 50 |
| Strongly disagree | 1 | 10 | 4 | 40 |
| **Total** | **10** | **100** | **10** | **100** |

The results show that 80% of teachers in control school were positive that their students approached them for further assistance during the programme. Only 10% of the teachers in the experimental school said their students approached them for some form of assistance.

Item 5 was to find out which set of student expressed difficulty in solving linear algebra questions. In all 55.5% of teachers in the control school indicated that their students had problems using the traditional method to solve linear algebra questions. The result is displayed in Table 23.

**Table 23: A distribution showing the method that students expressed difficulty in its application to solve linear algebra related questions**

| Response | Control group teachers | | Experimental group teachers | |
|---|---|---|---|---|
| | Frequency | % | Frequency | % |
| Strongly agree | 3 | 33.3 | 0 | 0 |
| Agree | 2 | 22.2 | 1 | 10 |
| Disagree | 2 | 22.2 | 5 | 50 |
| Strongly disagree | 2 | 22.2 | 4 | 40 |
| **Total** | **10** | **100** | **10** | **100** |

Only 10% of the teachers in the experimental school agreed that their students find it difficult using the ARH games to solve linear algebra questions. As high as 90% of the teachers in the experimental school said the ARH games were very helpful to their students.

**The method which enabled students to use the right steps to solve linear algebra questions**

Under accuracy teachers had to indicate which of the programmes encouraged students to use minimum steps. Teachers answered questions on how accurate students were during the pretest and during the posttest (item 6).

Item 6 was to find out the approach which offered student the opportunity to solve linear algebra questions using minimum steps. The result is displayed in Table 24.

**Table 24: A frequency distribution showing the method that required fewer steps in solving linear algebra questions**

|  | Control group teachers | | Experimental group teachers | |
| --- | --- | --- | --- | --- |
| Response | Frequency | % | Frequency | % |
| Strongly agree | 1 | 10 | 5 | 50 |
| Agree | 1 | 10 | 3 | 30 |
| Disagree | 5 | 50 | 1 | 10 |
| Strongly disagree | 3 | 30 | 1 | 10 |
| **Total** | **10** | **100** | **10** | **100** |

From the table, 80% of the teachers in the experimental school said that their students used minimum steps in solving linear algebra questions. While 80% of their counterparts in the control schools said their students used the maximum steps in solving similar questions. Only 10% of the teachers in the control school said that their students used the minimum steps in solving linear algebra questions.

Item 7 was to find out whether the level of accuracy was high in the post-test. The result is shown in Table 25.

**Table 25: A distribution showing the method which leads to higher level in accuracy during the posttest**

|  | Control group teachers | | Experimental group teachers | |
| --- | --- | --- | --- | --- |
| Response | Frequency | % | Frequency | % |
| Strongly agree | 2 | 20 | 6 | 60 |
| Agree | 4 | 40 | 2 | 20 |
| Disagree | 2 | 20 | 1 | 10 |
| Strongly disagree | 2 | 20 | 1 | 10 |
| **Total** | **10** | **100** | **10** | **100** |

During the posttest 60% of the teachers in the experimental school strongly agreed that the ARH games had brought a remarkable improvement in the ability of the students in the experimental group to solve linear algebra questions. In addition, 20% of the teachers in the same group agreed to an improvement in their students' performance due to the ARH games. While 20% of the teachers in the control school strongly agreed that their students have remarkably improved in solving linear algebra questions as a result of the use of the traditional method to learn linear algebra.

The method which motivated students to study more on their own

Under motivation teachers were asked to compare the type of programme students enjoyed working with.

Item 8 was to find out which programme did the students enjoy working with. The result is shown in Table 26.

**Table 26: A distribution showing the method that students enjoyed using in solving algebra questions**

|  | Traditional method teachers | | ARH computer games teachers | |
| --- | --- | --- | --- | --- |
| Response | Frequency | % | Frequency | % |
| Strongly agree | 2 | 20 | 6 | 60 |
| Agree | 3 | 30 | 4 | 40 |
| Disagree | 2 | 20 | 0 | 0 |
| **Strongly disagree** | **3** | **30** | **0** | **0** |
| **Total** | **10** | **100** | **10** | **100** |

From the table, 60% of teachers in the experimental school strongly have the assertion that students enjoyed working with the ARH games in solving linear algebra questions. Another 40% of the teachers in the same

school also agreed to same assertion. While 20% of the teachers in the control school strongly agreed that their students enjoyed using the traditional method and 30% strongly disagreed that students enjoyed working with the traditional method.

The method which made students solve linear algebra questions faster

Under speed teachers were asked to indicate which method enabled students to work very fast.

Item 2 was to find out the set of students who were able to solve questions very fast. The result is shown in Table 27.

**Table 27: A distribution showing the method which promoted a faster working rate among students**

|  | Control group teachers | | Experimental group teachers | |
| --- | --- | --- | --- | --- |
| Response | Frequency | % | Frequency | % |
| Strongly agree | 2 | 20 | 6 | 60 |
| Agree | 3 | 30 | 3 | 30 |
| Disagree | 4 | 40 | 2 | 20 |
| Strongly disagree | 1 | 10 | 0 | 0 |
| **Total** | **10** | **100** | **10** | **100** |

After the consolidation activities, the table indicated 90% of teacher in the experimental school were positive that their students were very fast in finishing linear algebra exercises. While 50% of teachers in the control schools agreed that the time used by their students was good. As many as 50% of the teachers in the control school agreed that their students were rather slow in solving linear algebra questions with the use of the traditional method.

## Discussion

### Academic achievement

Considering the posttest scores of the two groups alone the project showed that the experimental group which had been treated using the Angela Reilly Harden's games had no advantage in terms of academic achievement over their counterparts who were treated with the traditional method. This finding agree with earlier findings of Blitz (1972),Shirley (1976) and Edyburn (1982) that there is no significant difference between treatment groups using computer assisted instruction methods and traditional method of instruction.

Considering the ability groups of students in the experimental group, the project showed that most of the slow learners showed significant improvement after they were treated with the Angela Reilly Harden's games during the intervention stage. This goes to confirm the earlier finding of Bahr and Rieth (1989), Bialo and Sivin (1980), Slocum (1988), Schmidt (1985), Woodward, Carnine, and Gersten (1988) that CAI can help slow learners.

On the part of the teachers, 90% of those in the experimental school said the ARH games have been of immense help to their students. While 70% of the teachers in the control school said that the traditional method was beneficial to their students.

While 80% of the teachers in the control school said their students could not use the minimum steps in solving linear algebra questions, 80% of the teachers in the experimental school said their students were able to use the required minimum steps to solve linear algebra questions.

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After the intervention, 80% of the teachers in the control school said most of their students still approached them for assistance in solving linear algebra questions as compared to 90% of the teachers in the experimental school who said their students were independent in solving linear algebra questions after they have been exposed to the ARH games. The study revealed that 90% of the students in the experimental school said their students found it easy to use the ARH games to solve linear algebra questions, where as 44.4% of the teachers in the control group said their students found it difficult using the traditional method to solve linear algebra questions.

## Motivation

When students play the ARH games they get used to the games and would use their leisure time to play the games. This is in line with the earlier work of Davis and Wiedenbeck (2001) which says that an activity that is highly intrinsically motivating can become all-encompassing to the extent that the individual experiences a sense of total involvement, losing track of time, space, and other events.

Most of students in the experimental school (91.7%) said they enjoyed working with the ARH games and only 43.3% of the students in the control school enjoyed working with the traditional method in solving linear algebra questions. Due to the challenging nature of the ARH games, 80% of the students in the experimental school said they could use their leisure time to play the ARH games and learn more concepts on linear algebra by themselves.

43.3% who have been taught using the traditional method could use it in solving questions during their leisure time.

The teachers in the experimental school said the ARH games were fun to play with. All the teachers in the experimental group said that their students enjoyed working with the ARH games. 30% of the students in the control group said their students like using the traditional method.

The project has demonstrated that, students are motivated to learn more through the use of the Angela Reilly Harden's Math lab games. This goes to confirm the work of Bialo and Sivin 1980, which states that, CAI makes students infinitely patient. Students who use CAI never get tired to learn. Students never get frustrated or angry. CAI allows students to work privately. The software never forgets to correct or praise students where it is due and games on the CAI are fun and entertaining. It also promotes individualize learning. Students are not embarrassed when they make mistakes and the program gives them immediate feedback.

**Speed**

The project showed that regular players of the Angela Reilly Harden's games develop speed and are fast and accurate information processors, not only during game play, but in real-life situations as well. This goes to confirm the study of psychological scientists from the University of Rochester, Matthew Dye, Shawn Green and Daphne Bavelier, who said that avid players got faster not only on their game of choice, but on a variety of unrelated laboratory tests of reaction time. It also confirms the work of Capper and

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Copple (1985) that CAI users sometimes learn as much as 40 percent faster than those receiving traditional, teacher-directed instruction.

## Accuracy

It came out during the project that students in the experimental school were more accurate in solving linear algebra questions than their counterparts who had not been exposed to the ARH games. This is in line with the earlier findings of Bavelier (2010) that, the brain of people who play computer games continuously accumulates small pieces of visual or auditory information. This eventually makes that person more accurate in decision making. Students in all the two schools were able to use the correct steps to solve liner algebra questions. Teachers in both schools said that accuracy rate among students was very low prior to the intervention. But after the intervention, the teachers said that accuracy rate of the students in the control school has shot up to 60% due to the use of the traditional method in solving linear algebra questions. Teachers in the experimental school said that the ARH games have helped their students as 80% of them were accurate. This goes to confirm the earlier work of Victor Epand (2010), which states that regular players of computer games actually have a much better success rate and accuracy rating than their colleagues who play games either very rarely or not at all.

## Self assessment

All students in the experimental school said the ARH games could be used in scoring all the linear algebra questions they had solved on the computer. Only 11.6% of the students in the control school said they could score the work they had done themselves. 88.4% of the students in the

experimental school said that the ARH games could help them to determine the exact time they had used in solving linear algebra questions. Only 3.3% of the students in the control school could determine the time they used in solving linear algebra questions. All the students in the experimental school said the ARH games could show them where they went wrong. Meanwhile 93.3% of the students in the control school said that the traditional method used in solving linear algebra questions could not prompt them when they went wrong.

# CHAPTER FIVE

## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter gives an overview of the research problem, the methodology used and a summary of the key findings. It is followed by the conclusion in which the researcher confirmed or disconfirmed the hypothesis or questions. In the conclusion, the researcher indicated her overall opinion of the study; bringing out general findings of the study. The researcher follows it up with recommendations which are based on the key findings. The researcher finally recommends areas for further research work.

### Summary

The project sought to test the efficacy of the Angela Reilly Harden's linear algebra games as a CAI to be used to consolidate the learning of linear algebra at SHS1 general art classes of Osei Kyeretwie SHS and Armed Forces Technical SHS.

The study used two set of form one students from both Osei Kyeretwie SHS and Armed Forces Technical SHS. In all 120 students were used for the test (60 from each school).

Both quantitative and qualitative techniques were used in the gathering of data. Quantitative data were collected through the use of pretest and posttest. Qualitative data were collected through the response of teachers' and students' questionnaire.

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In the descriptive statistics, the raw data from the pretest and posttest scores were regrouped into frequency tables and graphs. The researcher used the Statistical Package for Social Sciences Software to transform the data into measures of mean, standard deviation, minimum and maximum score. The SPSS was also used to derive a histogram showing the skewness and normality of the distribution.

At an alpha level of 5% significance an independent t-test was used to compare the pretest scores of the two schools as well as the posttest scores of the two schools (control and experimental). An eta squared (d) test by Cohen 1988 was further conducted to show the effect size. Since the test items for pretest and posttest were not the same, the pretest and posttest scores of the same school and of the different schools were not compared. Qualitative analysis format was used in analyzing the questionnaire for both teachers and students.  ARH math lab games proved to be very effective to be used as a consolidation activity and to improve the learning of linear algebra.

### Conclusions

Students' reaction time improved with the use of the ARH games. The programme allows the student a specific time frame to be used in solving a question and when the time expires the player has lost the chance to solve the question. As the students make effort to get questions solved, he/she develops the skill of solving linear algebra questions faster than those receiving traditional, teacher-directed instruction. Regular players of the Angela Reilly Harden's games develop speed which could be used not only during game play, but in real-life situations as well.

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Students exposed to ARH games have more of an internal locus of control or sense of self-efficacy than conventionally instructed students. The ARH games affect the students` knowledge level in a positive way. Teaching linear algebra through the use of the ARH games can increase the academic achievement of students. Students learn better through auditory means, visual means or better still through the hand on approach which can be provided by internet games. The ARH games do not only offer a challenge but offers the individual a wide range of options and levels to start from and develop systematically. The ARH games were found to be more interactive than the traditional method. Students enjoyed working with the ARH games in solving linear algebra questions. Retention of content learned using ARH games is superior to retention following traditional instruction alone. The use of the ARH games lead to more positive student attitudes than the use of conventional instruction. Students are encouraged to learn during their leisure periods.

The research showed that the ARH games encouraged students to do self assessment. Students received much more feedback about their progress through the use of the ARH games. The quizzes and practice problems allow students to assess their progress even before the teacher comes in. The practice programming problems allowed students to make gradual improvements in their learning. Students are able to score their own work without any assistance from the teacher.

The ARH games offer the student the opportunity of being taught through a simulated teaching program. If the student fails to understand an

aspect of a lesson, he/she can easily review that part of the lesson which was misunderstood with just a simple click of a mouse. The programme also gives the player the exact steps and a definite answer. Hence, students exposed to the ARH games use minimum steps in solving linear algebra questions. ARH games help students to be more accurate.

## Recommendations

The role of computers as an educational tool in the twenty-first century cannot be overemphasized. The researcher has therefore made these recommendations to encourage senior high school, form one students to benefit from CAI.

(a)     Linking all senior high schools to the internet.

The researcher found out that most schools had computer labs but had no internet facilities. This hinders students from enjoying internet based computer games. The researcher recommends to the Ghana Education Service to provide internet facility for all SHS. With this facility in place, schools can share research projects. Work done by good schools could be sent to other schools for analysis and study. This will enable knowledge to be shared. Weak students could be motivated by their counterparts whose works are rated as good. In service training can be run for teachers on the net. Ghana Education service can employ special teachers to teach selected courses on the net for students to log on and participate in. This can reduce the rate of failure in the subjects like Math, Science and English which record more failure cases each year. Continuous assessment mark of students can be sent to WAEC on time.

General communication within the school, from the school to other schools and then from the school to stakeholders would improve considerably.

(b)     Introduction of computer based games into lessons at the SHS level.

In this global world that information technology is the norm of the time, it is in place that students should be exposed to different forms of learning material and not necessarily what is in recommended text books alone. The schools can buy computer games and have them installed in the computers in the computer laboratory. This facility now becomes a new library where updated learning materials could be made available for further study of students who want to expand their scope of learning.

(c)     Encouraging competition on the net.

The class teacher can go to the net, discover and recommend more challenging games to students. Marks can be awarded to students who score high marks. When this happens, students will be motivated to learn on their own with less intervention by the class teacher.

(d)     Students send assignments to class teachers through the email.

To make students acquainted with doing class work on the internet, the researcher recommends that class teachers should demand that students should type their work and send their assignments to their class teacher on the mail. This will get students to realize that the internet is not for only reading of mails or playing of fun games but as a study companion. Once this concept is developed at this stage, they will develop the concept of using the World Wide Web for further study. This will make Ghanaian students learn at the same level as their counterparts in other countries.

(e)     Students to work on the computer in groups

Since the findings of this study showed that students who worked on the computer cooperatively performed better than those who work on the computer singly, students should be encouraged to develop social interaction in the use of computer. In addition, the finding implies that the number of computers to be procured for the schools does not have to be on individual students' basis. A class of 60 would not need more than 20 computers systems for instructional needs.

## Suggestions for future researchers

The researcher believes that the number of students used for the research had a stronger influence on the results. It is recommended that a nationwide survey which includes not less than twenty selected school from each region be used for further study. When more schools are used it will give a fair representation of the views of students and teachers of the issues under review. The researcher recommends that the same research should be conducted on other subject areas to see if it gives the same results. Teachers in other subject areas could introduce their students to games in their field of study and test if it offers an opportunity to consolidate leant topics.

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## APPENDIX A

NAME OF SCHOOL: Armed Forces Sec Tech SHS

AVERAGE AGE:        16 +

REFERENCE:          1. Angela Reilly Harden's South West JHS 2010/2011

                    2. teachers.usd497.org/areillyh/algebragames.html

CLASS:              SHS 1

CLASS SIZE:         60

DAY:                Monday 26/10 /09

TIME:               08:30am to 09:15 am

DURATION:           45 Minutes

TOPIC:              Algebraic Expressions (Consolidation activity)

SUBTOPIC:           addition and subtraction of linear algebra using

                    (beat the clock)

OBJECTIVES:         By the end of the lesson, the student will be able to:

                    (1) search for the software (Angela Reilly Harden linear

                    algebra games) with the help of the internet,

                    (2) follow the instruction on the software screen

                    (Angela Reilly Harden linear algebra game),

                    (3) use the software to solve for addition and

                    subtraction of linear algebra.

RPK:                (1) Students understand the concept of subtraction and

                    addition of linear algebra.

                    (2) Students are familiar with the use of the internet.

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T. L. M.:     Projector to direct the students in using the software

         (Angela Reilly harden linear algebra game)

         Computers with access to the internet

T. L. A.:

**Introduction**

Introduce students to how to enter into the program (Angela Reilly harden

linear algebra game) with the use of the internet.

Students observe Google on the screen and imitate what they see teacher does.

1. Search for Angela Reilly Harden linear algebra game using the search

engine Google.

2. Select Angela Reilly Harden linear algebra game with the list the search

engine.

3. Select/click solving addition and subtraction equation (beat the clock).

4. Follow the screen instruction by typing user name and password.

Guide students on how to follow the instructions on the software to practice.

1. Enter into the practice mode.

2. Click start in the practise mode.

3. Click on check after keying in the right answer.

4. Click on score after the game closes at the end of one minute.

5. Detect the correct and wrong answers and check for missed problems by

clicking on "missed problems".

**<u>Activity one</u>**

Students practise on their own.

1. Students search for the software Angela Reilly Harden linear algebra game on their own.

2. Students enter their name and password to start using the software (Angela Reilly Harden linear algebra game).

3. Students answer questions in the practice mode for ten minutes. After each minute students should record marks scored at the end of each round, accuracy, missed questions (10 attempts).

**<u>Activity two</u>**

Students work in competition mode.

1. Switch to competition mode.

2. Try to solve many questions within the one minute time frame.

3. Students answer questions in competitive mode for ten minutes. After each minute students record marks scored at the end of each round, accuracy, missed questions (10 attempts).

EVALUATION EXERCISE:

In competition mode.

1. Students work in competition mode.

2. Students work for ten minutes and leave the computer room.

3. Teacher goes round to record marks and rate of accuracy.

REMARKS

NAME OF SCHOOL: Armed Forces Sec Tech SHS

AVERAGE AGE:     16 +

REFERENCE:     1. angela reilly harden's/south west jhs 2010/2011

                  2. teachers.usd497.org/areillyh/algebragames.html

CLASS:       SHS 1

CLASS SIZE:     60

DAY:        Tuesday 27/10 /09

TIME:        08:30am to 09:15 am

DURATION:     45 Minutes

TOPIC:      Algebraic Expressions (Consolidation activity)

SUBTOPIC:     Multiplication and division of linear algebra using

               (beat the clock)

OBJECTIVES;     By the end of the lesson, the student will be able to:

(1) search for the software (Angela Reilly Harden linear

algebra games) with the help of the internet,

(2) follow the instruction on the software screen

(Angela Reilly Harden linear algebra game),

(3) use the software to solve for addition and

subtraction of linear algebra.

RPK:        (1) From Google, students can search for the software

(Angela Reilly Harden linear algebra games) on the

internet.

(2) Students can follow the instruction on the software

screen (Angela Reilly Harden linear algebra game).

(3) Students are familiar with the use of the internet.

T. L. M.:　　　　　　Projector to direct the students in using the software

(Angela Reilly harden linear algebra game)

Computers with access to the internet

T. L. A.:

**Introduction**

Students observe teacher enter into Google on the screen and imitate what they

see teacher does. Eg.

1. Search for Angela Reilly Harden linear algebra game using the search

engine Google.

2. Select Angela Reilly Harden linear algebra game with the list the search

engine.

3. Select/click solving multiplication and division equation (beat the clock).

4. Follow the screen instruction by typing user name and password.

Guide students on how to follow the instructions on the software to practice.

1. Enter into the practice mode.

2. Click start in the practise mode.

3. Click on check after keying in the right answer.

4. Click on score after the game closes at the end of one minute.

5. Detect the correct and wrong answers and check for missed problems by

clicking on "missed problems".

**<u>Activity one</u>**

Students practise on their own.

1. Students search for the software Angela Reilly Harden linear algebra game on their own.

2. Students enter their name and password to start using the software (Angela Reilly Harden linear algebra game).

3. Students answer questions in the practice mode for ten minutes. After each minute students should record marks scored at the end of each round, accuracy, missed questions (10 attempts).

**<u>Activity two</u>**

Students work in competition mode.

1. Switch to competition mode.

2. Try to solve many questions within the one minute time frame.

3. Students answer questions in competitive mode for ten minutes. After each minute students record marks scored at the end of each round, accuracy, missed questions (10 attempts).

EVALUATION EXERCISE:

In competition mode.

1. Students work in competition mode.

2. Students work for ten minutes and leave the computer room.

3. Teacher goes round to record marks and rate of accuracy.

REMARKS:

## PRE-TEST

Student ID:…………..…………………………………………….
School:……………………………………………………….
Class:…………………………………………………..………..

Duration: 40 minutes
Answer all questions

Find the value of a in the following

1. $6(5a + 1) - 8(3a - 3) = 4(a - 3) - 7a + 18$

2. $(\dfrac{-1}{2})a - (- 3) - 8 = 5$

3. $12 + \dfrac{a}{2} = 2(a - 1)$

4. $- 4(1 - 3a) - 3(a + 8) = -10a$

5. $5a - 4 - 2a + 1 = 8a + 2a$

6. $\dfrac{(a - 2)}{3} - 3 - (- 9) = \dfrac{(2 - a)}{2}$

7. $14 - a + \dfrac{1}{4} = a + \dfrac{1}{2} - 12$

8. $a - \dfrac{1}{4} = 15$

9. $7a + 5 - 3a + 1 = 2a + 2$

10. $\dfrac{3}{4}(a + 2) - 1 = 4 - 3a$

Simplify the following
11. $2[-3(t - 2y) + 4y]$

12. $3x + 7y - 2x + 6a$

Solve the following
13. $5x - 2(x - 5) = 4x$

14. $7 - (2 - 3x) = x + 2$

15. $6x + 12 = 2x - 16$

Change the following statements into algebraic expressions

Choose one option

16. The quotient of a number and 6 is 18

a. $n + 6 = 18$
b. $n \times 6 = 18$
c. $n \div 6 = 18$

17. A number divided by 2 is $\dfrac{1}{4}$

a. $n \div 2 = \dfrac{1}{4}$      b. $n \times 2 = \dfrac{1}{4}$      c. $2 = n \div \dfrac{1}{4}$

18.     $-15$ times a number is equal to $-45$

   a. $-15x - 45 = f$      b. $-15f = -45$      c. $-15 \div -45 = f$

19.     4 times a number is negative 64

   a. $4 \times -64 = w$      b. $4w = -64$      c. $4 - w = -64$

20.     A number divided by $2\dfrac{3}{4}$ is $\dfrac{5}{6}$

   a. $2\dfrac{3}{4} \div \dfrac{5}{6} = p$      b. $2\dfrac{3}{4} \div p = \dfrac{5}{6}$      c. $p \div 2\dfrac{3}{4} = \dfrac{5}{6}$

**POST-TEST**

Student ID:……………..………………………………………….

School:…………………………………………………………….

Class:………………………………………………………………..

Duration:  40 minutes

Answer all questions

Find the value of a in the following

1.　　$-8\,t + 10\,t +\ 2(3 - 9\,t) = 8(t - (-3))$

2.　　$9 - (t + 8) = -2(3 - t) - 4(1 - 3t)$

3.　　$3(t\ - 3) - 2(t + 2) = -4\,t +\ 6\,t$

4.　　$12\,t + 30 = -3\,t + 2(5 - 2\,t)$

5.　　$-2(3\,t + (-4)) + 4 = 2\,t - 8 - (4\,t - 5)$

6.　　$4(t + 2) - 2 = 5(-2\,t + 4) + 3\,t - 2$

7.　　$-9t + t\ -\dfrac{1}{4} = 3(\,3t - 1)$　　　　8.　$7t + 5 - 3t + 1 = 2t + 2$

9.　　$t\ -\dfrac{1}{5} = 2.5$　　　　　　10.　$\dfrac{1}{2}(t + 2)\ - 6 = -\,1\,(-\,1 - 3t)$

Simplify the following

11.　　$4[-5(t - 2y) + y]$　　　　　12.　　$x + 3y - 2x + a - 2y$

Solve the following

13.　　$3x - 4(x - 5) = 4x$　　　　　14.　　$9 - (6 + 3x) = x + 2$

15.　　$-8x + 14 = 2x - 16$

Change the following statements into algebraic expressions

Choose one option

16.　　A number minus 11.5 equals 20.8

99

a. $k - 11.5 = 20.8$  b. $11.5 - k = 20.8$  c. $k - 20.8 = 11.5$

17. 75 decreased by a number is equal to 8.

a. $8 = 75 - y$  b. $8 - y = 75$  c. $75 + 8 = y$

18. A number increased by 28 is 51

a. $z - 28 = 51$  b. $51 + 28 = z$  c. $z + 28 = 51$

19. 7 more than a number is equal to 20

a. $20 + d = 7$  b. $d \times 7 = 20$  c. $d + 7 = 20$

20. Twice a number is 73

a. $2x = 73$  b. $x + 2 = 73$  c. $73 - x = 2$

## APPENDIX D

### QUESTIONNAIRE FOR MATHEMATICS TEACHERS
### EXPERIMENTAL GROUP

This questionnaire is supposed to provide data to be used in a research. Please kindly answer the questions as frankly as possible. Your confidentiality is assured.

**SCHOOL: ………………………………………………………**

Tick ( ✓) the appropriate option.

i.    Sex:        Female                Male

ii.    Age:

Below 30 yrs     30 – 40     41 – 50     Above 50 yrs

iii.    Educational Qualification:

Diploma     First Degree     Second Degree

Tick (✓ ) as many options as applicable.

iv.    Which year groups do you teach in senior high school?

Form one     Form two     Form three

v.    Which of the following aspects do you teach?

Core maths     Elective maths

Tick ( ✓) one option for each statement.

| Statement | Strongly Agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. Students practiced with much understanding using computer games. | | | | |
| 2. Students were able to solve linear algebra questions very fast. | | | | |
| 3. Minimum steps were used in solving linear algebra | | | | |

| | | | | |
|---|---|---|---|---|
| questions. | | | | |
| 4. Students frequently approached teacher for further tuition. | | | | |
| 5. Most student expressed difficulty in using computer games to solve questions in algebra. | | | | |
| 6. Students used minimum steps in solving  linear algebra questions | | | | |
| 7. Level of accuracy was high in the post-test. | | | | |
| 8. Students enjoyed solving questions using the computer games. | | | | |

**QUESTIONNAIRE FOR MATHEMATICS TEACHERS**
**CONTROL GROUP**

This questionnaire is supposed to provide data to be used in a research. Please kindly answer the questions as frankly as possible. Your confidentiality is assured.

**SCHOOL: ………………………………………………………………**

Tick ( ✓) the appropriate option.

i.   Sex:          Female                    Male

ii.  Age:
     Below 30 yrs        30 – 40yrs      41 – 50 yrs      Above 50 yrs

iii.  Educational Qualification:
      Diploma          First Degree      Second Degree

Tick ( ✓) as many options as applicable.

iv.  Which year groups do you teach in senior high school?
     Form one          Form two          Form three

v.   Which of the following aspects do you teach?
      Core maths                  Elective maths

Tick ( ✓) one option for each statement.

| Statement | Strongly agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. Students practised with much understanding using the traditional method. | | | | |
| 2. Students were able to solve linear algebra questions very fast. | | | | |
| 3. Minimum steps were used in solving linear algebra questions. | | | | |
| 4. Students frequently approached teacher for further tuition. | | | | |

| | | | | |
|---|---|---|---|---|
| 5. Most student expressed difficulty in using the traditional method to solve questions in algebra. | | | | |
| 6. Students used minimum steps in solving  linear algebra questions | | | | |
| 7. Level of accuracy was high in the post-test. | | | | |
| 8. Students enjoyed solving questions using the traditional method. | | | | |

## QUESTIONNAIRE FOR STUDENTS
## EXPERIMENTAL GROUP

This questionnaire is supposed to provide data to be used in a research. Please kindly answer the questions as frankly as possible. Your confidentiality is assured.

**SCHOOL: ………………………………………………………**
Tick ( $\checkmark$ ) the appropriate option.

i.      Sex:            Female                    Male

ii.     Age:     ………………………………………….

iii.    Form:    ……………………………………

Tick ( $\checkmark$ ) one option for each statement to indicate your degree of agreement to each statement.

| Statement | Strongly agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. Angela Reilly Harden's internet games was interactive. | | | | |
| 2. Students can determine their marks they have scored by the use of the internet games. | | | | |
| 3. I enjoy learning algebra using the internet games. | | | | |
| 4. Solving algebra problems through the use of the internet games is much difficult. | | | | |
| 5. Students practise much in their leisure time when they use the Angela Reilly Harden's internet games. | | | | |
| 6. I am able to solve problems faster when I use the Angela Reilly Harden's internet games. | | | | |
| 7. I have a few problems understanding the concepts using the game. | | | | |
| 8. The computer program tells me when I go wrong in | | | | |

| | | | | |
|---|---|---|---|---|
| solving problems in linear algebra. | | | | |
| 9. The Angela Reilly Harden's internet games help me to follow the right procedure when solving problems. | | | | |
| 10. The use of the Angela Reilly Harden's internet games enables me to determine the time I have used in solving the question. | | | | |

# APPENDIX G

## QUESTIONNAIRE FOR STUDENTS
## CONTROL GROUP

This questionnaire is supposed to provide data to be used in a research. Please kindly answer the questions as frankly as possible. Your confidentiality is assured.

**SCHOOL: …………………………………………………………**

Tick ( $\checkmark$) the appropriate option.

i.     Sex:     Female           Male

ii.     Age:   ………………………………………………….

iii.     Form:   …………………………………………

Tick ( $\checkmark$) one option for each statement to indicate your degree of agreement to each statement.

| Statement | Strongly agree | Agree | Disagree | Strongly disagree |
|---|---|---|---|---|
| 1. The traditional method of solving algebra problems was quite interactive. | | | | |
| 2. Students can determine their marks they have scored by the use of the traditional method. | | | | |
| 3. I enjoy learning algebra using the traditional method. | | | | |
| 4. Solving algebra problems through the use of the traditional method. is much difficult. | | | | |
| 5. Students practise much in their leisure time when they use the traditional method. | | | | |
| 6. I am able to solve problems faster when I use the traditional method. | | | | |
| 7. I have a few problems understanding the concepts when I use the traditional method. | | | | |
| 8. The traditional method tells me when I go wrong in solving problems in linear algebra. | | | | |

| | | | | |
|---|---|---|---|---|
| 9. The traditional method helps me to follow the right procedure when solving problems. | | | | |
| 10. The use of the traditional method enables me to determine the time I have used in solving the question. | | | | |

**TEST FOR EFFECT SIZE**
**PRETEST**

For p< 0.001 which is less than the alpha value (0.05), the difference in the means was significant. To test for how large their difference was eta squared test by Cohen 1988 was use to calculate the effect size.

According to Cohen 1988, 0.01 represent a small effect, 0.14 represent moderate effect and 0.18 represent a large effect.

$$\text{Eta squared (d)} = \frac{t^2}{t^2 + (N_1 + N_2 - 2)}$$

where 
$$t = 4.477$$
$$N_1 = 60$$
$$N_2 = 60$$

$$\text{Eta squared} = \frac{4.477^2}{4.477^2 + (60 + 60 - 2)}$$

$$= \frac{20.044}{20.044 + 118}$$

$$= \frac{20.044}{138.044}$$

$$\text{Eta squared (d)} = 0.145 \quad \text{(small effect)}$$

## APPENDIX I

## TEST FOR EFFECT SIZE
## POSTTEST

For p< 0.108 which is greater than the alpha value (0.05), the difference in the means was not significant. To test for how large their difference was, eta squared test by Cohen 1988 was use to calculate the effect size.

According to Cohen 1988, 0.01 represent a small effect, 0.14 represent moderate effect and 0.18 represent a large effect.

Eta squared (d) = $\dfrac{t^2}{t^2 + (N_1 + N_2 - 2)}$

where    t  =  1.622

$N_1$  =  60

$N_2$  =  60

Eta squared  =  $\dfrac{(1.622)^2}{(1.622)^2 + (60 + 60 - 2)}$

=  $\dfrac{2.6244}{2.6244 + 118}$

=  $\dfrac{20.044}{120.6244}$

Eta squared (d)  =  0.022    (small effect)