UNIVERSITY FOR DEVELOPMENT STUDIES

STATISTICAL ANALYSIS OF SEX DIFFERENCE IN UNDERSTANDING, KNOWLEDGE AND PERCEPTION OF MATHEMATICS IN NALERIGU SENIOR HIGH SCHOOL.

BY

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Declaration

I hereby declare that this project work is the result of my own original work and that no part of it has been presented for another post graduate diploma in this university or elsewhere. Related works by others which served as a source of knowledge have been duly referenced.

ADAM ISSAHAKU …………………… **………………………**

(Candidate) Signature **Date**

Certification

I hereby declare that the preparation and presentation of the project work was supervised in accordance with the guidelines on supervision of the project work laid down by the University for Development Studies.

DR. ABUKARI ALHASSAN	**…………………..**	**……………………**
(Supervisor)	**Signature**	**Date**

Abstract

Themain purpose of the study was to examine the performance of students in mathematics based on their understanding, knowledge and perception, in Senior High Schools.

The study considered all second year students in Nalerigu Senior High School in the East Mamprusi District of the northern region. Well structured questions were administered to 30 males and 30 females through stratified random sampling.

Preliminary analysis reported high mean performance for males as compared to females.

Further analysis reveals that there was no significant difference in the performance of students across sex. However, the t-test results indicated significant difference ($p<0.05$) in the perception of mathematics across sex.

On the basis of the analysis, it is recommended that other variables such as, ethnicity, medical status and performance indicated variables should be considered.

Acknowledgement

There were many people who contributed towards achieving my goals during this project work which is one of the best educations that I have received in my life. All of these people guided me and encouraged me during various stages of this project work. However, some of them have special place in my heart.

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Time and space may not allow me to enumerate the numerous people who gave me a helping hand to make this research a successful one. Thanks to everyone who contributed to the success of this project work.

Dedication

I dedicate this work to God almighty for His protection and guidance. He is my source of strength and inspiration and His grace is always sufficient for me.

To my dearest wife Agyara Adam for her love, understanding and support.

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Chapter One

1.0 Introduction

Algebra is a broad concept in mathematics. It is a branch of mathematics concerning the study of rules of operations, relations, constructions and concept arising from these rules including terms, variables, equations and algebraic structures as well as algebraic properties (Mangorsi, 2013 cited by Solaiman*etal.*, 2014).

Many researchers have shown that many students experienced difficulties in algebra due to the poor understanding, poor knowledge and wrong perception they have. Wrong perception of students in algebra will be avoided from fully understanding the correct concept that somehow affect their performance not only in algebra but also in other mathematics subject as well (Belen; Ogena; Tan, 2008 cited by solaiman*etal.*, 2014). This study describes the perception, knowledge and understanding of senior high school students in (mathematics) algebraic properties such as properties of equality and field properties Nalerigu Senior High School in the East Mamprusi District, their possible causes, and ways how to overcome them.

1.1 Historical Background

A few years ago, when I was a primary School teacher, I Sobserved many students in my class battling to cope with learning mathematics(algebra).They had a good arithmetic background, and they could solve a problem using lengthy arithmetic procedures that they came up with themselves, but were hesitant to use algebraic methods. I always tried to use algebraic methods on my own to motivate them. However, my attempts were not very successful as students used their own lengthy arithmetic procedures or rather failed in using algebraic methods.

By observing the students, I found that they have some challenges in solving mathematics problem (algebra) that were persistent and could be as a result of the level of students knowledge in mathematics, understanding in mathematics and perception in mathematics.Sometimes, they repeatedly made the same conclusion. Also, through discussion with my fellow teachers, I realized that their explanations for these types of behaviors were surprisingly consistent with mine. However, one thing was clear to me. These level of students understanding, knowledge in mathematics and perception aboutmathematics were neither inborn nor were they instantaneous.

Some period later, I left my primary school teaching and joined a Junior High School where I had further opportunities to teacher and observe students in this area. However, to my surprise, as I observed, I realized that many J. H. S students also lack some basic understanding in mathematics, knowledge in mathematics and perception in mathematics. Most times, they commit the same mistakes by dint of their poor understanding in mathematics, poor knowledge in mathematics and wrong perception in mathematics as their primary School counterparts. I also observed that these students memorized only a few facts, formulas, and algorithms without understanding them conceptually, even though they could manipulate those limited number of facts in a correct or incorrect manner. Their lack of conceptual understanding prevented them from applying mathematical knowledge to new contexts in a flexible way .This will be one of my own explanation for the reasons of student inability of performing well in mathematics(algebra). As later I started to teach Nalerigu Senior High School, the problem resurfaced. During my teaching I observed that even S.H.S students commit the same mistakes as a result of their poor understanding in mathematics, poor knowledge in mathematics and wrong perception about mathematics as Junior High School students. By then, I realized that this problem is common to many education systems in the world. Up to this time, I had seen students' errors on paper due to their poor understanding in mathematics, poor knowledge in mathematics and wrong perception in mathematics when they did exercise in class or answered the tests. Thinking along this line, I formed my research question: What mathematical constructs will use to determine Senior High School students understanding in mathematics, knowledge in mathematics and perception in mathematics.

1.2 Statement of the Problem

Algebra is one of the mostabstract aspectsin mathematics. Algebra isthe integralpart ofthe mathematics syllabus at alllevels of education in Ghana. However, many attempts to better prepare students to improve on their understanding in mathematics (algebra), knowledge in mathematics(algebra) as well as good perception for mathematics(algebra) have not resulted in greater achievement in first –year algebra in the Senior High School .Students in form 1 and 2 are still struggling with mathematics (algebra) concepts and skills. Many are discontinuing their study of higher – level mathematics because of their lack of success in algebra as a result of poor understanding, poor knowledge and wrong perception about mathematics (Egodawatte 2011).

The demand for algebra at more levels of education is increasing. Wiki Answers, 2010, (cited by Egodawatte 2011), one of the world’s leading questions and answers websites, lists someof the uses of algebra in today‘s world. Algebra is used in companies to figure out their annual budget which involves their annual expenditure. Various storesuse algebra to predict the demandof a particular product and subsequently place their orders. Algebra also has individual applications in the form of calculationof annual taxable income, bank interest, and installment loans. Further, algebraic reasoning andsymbolic notations also serve as thebasis for the design and uses of compute spreadsheet models.

furthermoremathematical reasoning developed through algebra is necessary all through life, decisions wemake in many areas such as personal finance, travel, cooking and real estate, to name a few. Thus, it can be argued that a better understanding in mathematics(algebra), knowledge in mathematics (algebra) and perception in mathematics (algebra) improves decision making capabilities in society. More analysis is necessary in order to develop a clear understanding, knowledge and perception of what factors help students to be successful in mathematics(algebra) and how schools and other systems can assist in achieving this goal. We already know that even very basic mathematical concepts such as addition of whole numbers involve complicated cognitive processes. Since teachers are already very familiar with those basic concepts, this leads them to ignore or underestimate the complexity by taking a naïve approach to those concepts. Without adequate knowledge about students' learning of basic mathematics concepts or operations, teachers could underestimate the complexity of the individual learning process of mathematics.

Teachers or experts in the field often have differences of opinions about students' understanding, knowledge and perception in mathematics (algebra). This is not only because the amount of quantitative reasoning that experts use is greater than what novices use in a problem solving situation. It is also because of the qualitative nature of the reasoning that experts use in a situation. Frequently, experts do not realize that this quality is important to disseminate to their students. Students should be allowed to use this information that is sometimes not in the textbooks. For experts, this knowledge is structured in their heads as informal imagistic, metaphoric, and heuristics (Kaput, 1985, cited by Egodawatte, 2011). The problem is that this knowledge is not properly represented in the modern curricula. If this happens, students will be the beneficiaries.

Although there are many causes of student'sdifficulties inmathematics, the lack of support from research fields for teaching and learning is noticeable. If research could characterize students 'understanding, knowledge and perception in mathematics (algebra) it would be possible to design effective instructions to improve on students' understanding, knowledge and perception in mathematics (algebra). Research on students' performance by their understanding, knowledge and perception in mathematics (algebra) is a way to provide such support for both students and teachers. Problem of this nature are particularly worthy of investigation as there is still a lack of robust research in identifying students' performance for more than one conceptual area collectively. If researchers can identify students' difficulties collectively in more than one area, it will be easier to identify the systematic patterns of misperception, poor understanding and knowledge (i .e if there is any) that spread through the areas and make suggestions for remediation (Egodawatte, 2011).

In addition, there is a methodological change in modern research from classical studies in mathematics education, which are statistical statements about populations, to a close observation of cohort doing mathematical tasks. In this context, this study is significant because it addresses the poor performance made by form two(2) students and wrong perception in mathematics(algebra) solving tasks. I hope that addressing this issue will reduce the distance between real classroom and research leading to more practically applicable findings (Egodawatte, 2011).

1.3 Objectives to the Study

1.3.1 General objective to the study

- The main objective is to determine whether there is significant difference in students understanding, knowledge and perception of mathematics across sex.

1.3.2 Specific objectives to the study

The specific objectives to the study are:

- To determine the range of student's perception, knowledge and understanding towards mathematics (algebra) held by Nalerigu Senior High School students.
- To examine whether there is a relationship between the identified perception, knowledge, and understanding instudents' performance in mathematics.
- To examine whether there is significant difference in students understanding, knowledge and perception in mathematics across age.

1.4 Research Questions of the study

The research questions that guide the study are:

- Does knowledge, understanding and perception influencesstudents' performance in mathematics (algebra).
- What account for the differences in performance among students' in mathematics (algebra).
- What can be learned from students' performance by their understanding, knowledge and perception in mathematics (algebra).
- Male and female students' knowledge in mathematics, understanding in mathematics and perception about mathematics do not significantly differ in their performance.

1.5 Research Hypotheses:

H_0: There is no significant difference between male and female students' perception, knowledge, and understanding in mathematics (algebra).

H_1: There is a significant difference between male and female students' performances in mathematics (algebra).

1.6 Justification of the study

When students work out problems in mathematics they usually use a combination of conceptual and procedural knowledge, understanding and perception. Thus, the purpose of the study was to analyze how students used conceptual and/or procedural knowledge, understanding and their perceptionto work out problems in mathematics (algebra). These concepts are essential for understanding higher mathematics such as algebra as well as to understand daily tasks. By analyzing how students use their understanding, knowledge, either conceptual or procedural, or a combination of both, instruction can be improved to meet the needs of the students who create erroneous patterns in computation.

1.7Significance of the study.

Students are the most essential assets for any educational institution. The study of students' perception, knowledge and understanding in mathematics(algebra) wasessential as the results of the study could inform teachers, curriculum planners and other stakeholders to broaden their understanding of how students' perception, knowledge and understanding in mathematics(algebra) can be noticed and thoughtfully engaged. Also it will help teachers and researchers to design effective methods and approaches to improve students' understanding in mathematics(algebra), knowledge in mathematics (algebra) and perception about mathematics (algebra). Such comprehensive information about students' knowledge, understanding and perception in learning mathematics could contribute to teachers' classroom instruction. Therefore, if research focuses on identifying students' level of understanding, knowledge and perception of students when solving mathematical problems so that they can be improve upon through well-organized instructional methods.

1.8 Conceptual Framework

The Figure below shows the relationship and interplay between two sets of variables: independent variables (IV) and the dependent variable (DV). The students' demographic characteristics such as sex and age make up the independent variables in this study, while the performance of the students thus knowledge in mathematics, understanding in mathematics and perception in mathematics of respondents constitute the dependent variable. The latter was determined through a questionnaire in mathematics(algebra) for students to answer.

In the former set of variables the researcher searched for the likely factors/ causes of the failure in mathematics(algebra) from the students' point of view, based on their understanding, Knowledge and perception of Students' performance in mathematics(algebra), the dependent variable, thus knowledge, understanding and perception is the distinguishable evaluation on the performance in mathematics(algebra). According to Rappaport (2011), cited by Solaiman e tal., (2014) "expert problem solvers are thinking individuals who can observe, classify, measure, communicate, predict, interpret, analyze, synthesize, deduce and infer. They can see, organize, and make sense of the information given in a problem situation through reflective abstraction. They possess the process skills needed to systematically engage in any mathematical task.

Based on the findings, the researcher would attempt to generate theories, and offer recommendations for improving the teaching and learning of mathematics (algebraic).

Figure 1.1

Independent Variables **Dependent Variables**

Demographic` Characteristics of performance of students:

Students (sex and age) perception, knowledge and understanding

1.9 Organization of the project

Chapter one sets the preamble for the study, outlining the historical background, statement to the study, objectives to the study, justification of the study, the significance of the study and the conceptual framework. In chapter two some related works were reviewed to give focus and perspective to the study. Chapter three discussed the methodology employed in the study, whilst data analysis, results and discussions were presented in chapter four. The conclusion and recommendationforms the chapter five.

Chapter Two

Review of Related Literature

2.0 Introduction.

Mathematics education is one of the subjects recognized as a major factor in development, causing national agenda to focus in this area (Ogena, 2010 cited by Suan, 2014). The development of mathematical reasoning is the goal of K -12 Educations in US (National Research Council, 2001) and other countries for it is an important skill for employment (Ketterlin –Geller, Chard, Fien, 2008 cited by Suan, 2014). Performance of schools in all levels, the kind of teacher quality and its teaching output became a national priority in addressing the quality of education learners receive. Evaluation of educational attainment using standardized high-stakes testing was administered, and the poor result was unforgiving. Low achievements in many areas are now the concern for all academic and government institutions (Cave and Brown, 2010 cited by Suan, 2014). Therefore, revisiting how the way students learned and the way students' achievement was performed is an effort worthwhile to consider. However, failure to meet the standards of proficiency is a complex matter to pin point the blame even to the learners. There are many variables like teacher quality, financial resources of the school, quality of instruction, and many more are out of their control (McGuire, 2000 cited by Suan, 2014).

Even though there are numerous causes of students' difficulties in studying mathematics, the lack of adequate support from research fields for teaching and learning is an important one. If research could characterize students' learning difficulties, it would be possible to design effective instructions to help students learning. As Booth (1988, 20) pointed out, "one way of trying to find out what makes algebra difficult is to identify the students' level of understanding, whether the students' has knowledge about algebra in mathematics and the perception they have about mathematics. The research on students' understanding in mathematics (algebra), knowledge in mathematics (algebra) and perception about mathematics (algebra) is a way to provide such support for both students and teachers.

The researcher reviews literature on the following aspects: sex performance differences in mathematics, assessing knowledge, understanding and performance, prior knowledge and new experience, students" learning preferences, students' understanding in mathematics, students' perception about mathematics and students' knowledge in mathematics.

2.1 Sex Performance Differences in Mathematics (algebra)

There has been aenormous amount of research in the differences in performance among students ether by sex or age base on their understanding in mathematics, knowledge in mathematics and perception about mathematics. One of the many reasons why students' either sex or age differences in mathematical performance have been studied so greatly because there is a lot of contradicting evidence. Perhaps one of the most controversial articles on this topic was by Benbow and Stanley, 1980 (cited by Foy 2013). Benbow and Stanley, 1980 (cited by Foy 2013) found that boys had consistently better in understanding, knowledge acquisition and perception (scores) on the mathematical portion than girls, even when their course content was almost identical. Benbow and Stanley, 1980 (cited by Foy 2013) also found that girls excel in computational tasks, while boys excel on tasks that require mathematical reasoning skills (p. 1262). The reason this article was so controversial is due to their conclusion that states: "we favor the hypothesis that sex differences in achievement in mathematics and attitude towards mathematics result from superior male mathematical ability, which may in turn be related to greater male ability in special tasks" (Benbow& Stanley, 1980, p. 1262 cited by Foy 2013). This article triggered an extensive look to determine whether male mathematics performance (understanding, knowledge and perception in mathematics) are generally higher than female mathematics performance or no differences in performances, thus by students understanding, knowledge and perception in mathematics by sex.

There have been recent studies that show that "males continue to perform higher base on their knowledge in mathematics, understanding in mathematics and perception in mathematics than females on measures of mathematical performance, especially on more difficult items" (Ross, Scott, & Bruce, 2012, p. 278-279 (cited by Foy 2013). However, there is also evidence that the sex gap in performance is declining, and that gender patterns are different among different countries. One study found that the gender gap in mathematical achievement in the United States was smaller than previously, but the gap grows larger as the students get older (Ross, Scott, & Bruce, 2012, p. 279 cited by Foy 2013). Studies in other countries did not necessarily produce the same results. Regardless of the current research, there is no doubt that one of the general stereotypes in mathematics is that boys perform better than girls. However, there is now substantial evidence to contradict Benbow and Stanley's belief that this difference is caused by pure innate ability and aptitude. The focus of this paper is to shed light on the recent research on the students perception in mathematics, knowledge in mathematics and understanding in mathematics by sex.

Again, the general consensus in the related research is that males do outperform females in mathematics achievement, but this difference does not really emerge until adolescence. The difference is also more prevalent when it comes to problem solving (Hyde, Fennema, Ryan, Frost, &Hopp, 1990, p. 300 cited by Foy 2013). Interestingly, females tend to have higher grades on report cards than males do (Hyde, Fennema, Ryan, Frost, &Hopp, 1990, p. 300 cited by Foy 2013). This may be due to the fact that teachers reward females higher test grades than warranted because of the belief that girls put more effort in than boys and that girls tend to have less behavioral problems than boys (Ross, Scott, & Bruce, 2012, p. 279, cited by Foy 2013). So then, what is the driving force behind males outscoring females on standardized achievement tests? Eccles and Jacobs, 1986 (cited by Foy 2013) argue that standardized performance tests are not true measures of innate mathematical ability due to many factors that can affect performance such as test anxiety, risk-taking preferences, cognitive style, and confidence in one's abilities (p. 369). According to Eccles and Jacobs, 1986 (cited by Foy 2013), "sex differences in mathematical achievement and attitudes are largely due to sex differences in math-anxiety; the understanding in mathematics, knowledge in mathematics and perception in mathematics" (p.370). GanleyandVasilyeva, 2013 (cited by Foy 2013) found that females tend to be more anxious towards mathematics than males. It has been shown that anxiety may impact mathematical performance due to the relationship between anxiety and working memory. Prior research suggests that "individuals with high anxiety would perform less efficiently on tasks requiring working memory resources because their worrisome thoughts interfere with working memory, making them unable to fully utilize their working memory capacity for task performance" (Ganley&Vasilyeva, 2013, p. 2 ,cited by Foy 2013). Ganley and Vasilyeva looked at the two different types of working memory in their research study: visual spatialworking memory and verbal working memory. They found that visual spatial working memory was more strongly related to both mathematical performance and gender than verbal working memory (p. 10).Their study requires future research because they used a meditational analysis which does not allow for casual claims. It would be interesting to see if the strong correlation found in this study actually constitutes that changes in anxiety and working memory could cause changes in mathematical outcomes.

It is natural to believe that one's anxiety in mathematics could be affected by their attitude about mathematics. If one has a really good attitude in mathematics, they would probably experience less anxiety in the subject. Thus, attitudes may play an important role in mathematical performance. Generally, females tend to have more negative attitudes towards mathematics than males (Gunderson, Ramirez, Levine, &Beilock, 2012 cited by Foy 2013). Attitudes towards mathematics in adults can be traced back to childhood and tend to be more positive in younger age groups than in older age groups (Aiken, 1970, cited by Foy 2013). It is generally believed that people who have negative attitudes towards mathematics tend to avoid the subject all together and can be easily frustrated when doing mathematics. In contrast, people with positive attitudes towards mathematics are more likely to be motivated and enjoy doing mathematics more than people with highly negative attitudes. Thus it is natural to think that attitude influences mathematical performance. Aiken, 1970 (cited by Foy 2013) found that attitudes affect achievement and achievement in turn affects attitudes. Further research indicates that attitude only has an effect on performance at the extremities: that is either extremely negative attitudes or extremely positive attitudes (Aiken, 1970, cited by Foy 2013). Interestingly, one study showed that attitude is a predictor of mathematical performance among females more often than males (Aiken, 1970, cited by Foy 2013). This goes along with Eccles and Jacobs', 1986 (cited by Foy 2013) findings that social and attitudinal factors appear to have a much stronger direct effect on mathematical performance and belief in one's ability than aptitude, especially among girls (p. 375).

2.2 Assessing Knowledge, Understanding, Performance/Product

The skills that need to be assessed in the classrooms are presented in a nomenclature on knowledge, understanding, and performance/product. This nomenclature was proposed in order to develop the necessary skills of school children. At present, the Department of Education proposed that students need to be assessed on the domains of knowledge, understanding, and product/process (DepEd

Order No. 31, s. 2012 cited by Magno, 2014). This nomenclature were made in order for the students to reach the content and performance standards of the curriculum. The assessment system is described to be "holistic" where teachers use both formative assessment and summative assessment. Formative assessment involves students accomplishing a bank of items accompanied by a series of feedback; it is non-threatening and provides students a series of practice for the mastery of the lesson. It reinforces students understanding and interest in the subject matter (Black & William 2003; Gonzales & Birch, 2000 cited by Magno, 2014).

Kulik and Kulik, 1998 (cited by Magno, 2014) explained that the best assessment practice incorporates several assessment and feedback that enhances students' learning. The nature of formative assessment provides a more authentic nature of student learning because it is a combination of what the students know and monitoring their progress. On the other hand, summative assessment is given when students have mastered the lesson, to determine the learners' achievement on a unit or course. Formative assessment is emphasized in the new assessment system in order to help students reach the standards. Through a series and multiple assessments, the teacher is able to see the immediate evidence what students have learned and therefore be able to design and adjust the instruction based on their needs. According to Stiggins, 2001 (cited by Magno, 2014) that "when we assess for learning, teachers use the classroom assessment process and the continuous flow of information about student achievement that it provides in order to advance, not merely check on, student learning". This process requires teachers to become assessment literate where they should have the ability to transform their expectations into assessment activities and utilize the assessment results to further improve their instruction and eventually student learning. A more contemporary viewpoint of assessment is also introduced. Through formative assessment, the process of assessment becomes closely integrated with instruction and becomes instruction itself.

Teachers may provide activities through games, small groups, exercises that immediately provide information on how the teacher begins her instruction. The teacher after teaching some small bits of skills follow with immediate assessment to determine if the lesson will be repeated or who among the students need further help. The actual activities in the classroom such as games can provide information to the teacher about what the students can and cannot do.

Assessing Knowledge was defined by the Department of Education as facts and information that students need to acquire. The knowledge domain contains similar skills with Bloom's taxonomy that includes defining, describing, identifying, labeling, enumerating, matching, outlining, selecting, stating, naming, and reproducing. Assessing Process was defined by the Department of Education as cognitive operations that the student performs on facts and information for the purpose of constructing meanings and understanding. Cognitive operations are specific procedures, tasks, heuristics, strategies, techniques, and mental processes that learners use in order to arrive with an answer. It is concerned with what individuals will do, think about, and go through in order to derive an answer. Cognitive operations are manifested when students answer word problems in mathematics; they show the teacher the strategy they used to arrive with their answer. The cognitive operations involve the use of metacognition, self-regulation, and learning strategies. Metacognition is thinking about one's thinking.

According to Winn and Snyder(1998) citied by Magno(2014), metacognition as a mental process that involves monitoring the progress in learning and making changes and adapting one's strategies if one perceives he is not doing well. On the other hand, process skills are also manifested through self-regulation. Self-regulation is defined by Zimmerman(2002) cited by Magno(2014) as self-generated thoughts, feeling, and actions that are oriented to attaining goals. Learners who are academically self-regulated are independent in their studies, diligent in listening inside the classroom, focused on doing their task inside the classroom, gets high scores in tests, able to recall teacher's instruction and facts lectured in class, and submits quality work (Magno, 2009). The idea now is that teachers do not only teach the content but also teach and assess these processes among students.

Understanding was defined by the Department of Education as the enduring big ideas principles and generalizations inherent to the discipline which may be assessed using the facets of understanding. The perspective of understanding by Wiggins and McTighe(2005) cited byMagno(2014) is used. The big idea is "a concept, theme, or issue that gives meaning and connection to discrete facts and skills" Understanding is to make connections and bind together our knowledge into something that makes sense of things. Wiggins and McTighe(2005) cited by Magno(2014) further elaborated that understanding involves "doing" and not just a "mental act" and thus includes application. Understanding is classified into six facets: Explain, interpret, apply, have perspective, empathize, and have self-knowledge (cited by Magno, 2014).

2.3 Prior Knowledge and New Experience

Educators often focus on the ideas that they want their students' to have. But research has shown that a learner's prior knowledge often confounds an educator's best efforts to deliver ideas accurately. A large body of findings shows that learning proceeds primarily from prior knowledge, and only secondarily from the presented materials. Prior knowledge can be at odds with the presented material, and consequently, learners will distort presented material. Neglect of prior knowledge can result in the students learning something opposed to the educator's intentions, no matter how well those intentions are executed in an exhibit, book, or lecture Roschelle(1995).

The aspects of learning, prior knowledge and experience drawn out in these examples have a solid basis in research on learning. There is widespread agreement that prior knowledge influences learning, and that learners construct concepts from prior knowledge (Resnick, 1983; Glaserfeld, 1984 cited by Roschelle, 1995). But there is much debate about how to use this fact to improve learning.

Roschelle (1995) presents a set of research findings, theories, and empirical methods that can help the designer of interactive experiences work more effectively with the prior knowledge of their students. It focuses on the central tension that dominates the debate about prior knowledge. This tension is between celebrating learners' constructive capabilities and bemoaning the inadequacy of their understanding. On one hand, educators rally to the slogan of constructivism: "create experiences that engage students in actively making sense of concepts for themselves." On the other hand, research tends to characterize prior knowledge as conflicting with the learning process, and thus tries to suppress, eradicate, or overcome its influence

The juxtaposition of these points of view creates a paradox: how can students ideas be both "fundamentally flawed" and "a means for constructing knowledge?" The question cuts to the heart of constructivism: constructivism depends on continuity, because new knowledge is constructed from old. But how can students construct knowledge from their existing concepts if their existing concepts are flawed? Prior knowledge appears to be simultaneously necessary and problematic. This version of the learning paradox (Bereiter, 1985) is called the "paradox of continuity" (Roschelle, 1991). Smith, diSessa, and Roschelle (1993) argue that educational reforms must include strategies that might avoid, resolve, or overcome the paradox. This requires careful consideration of assumptions about knowledge, experience, and learning.

Piaget's theory (Inhelder& Piaget, 1958; Ginsburg &Opper 1979; Gruber &Voneche, 1979 cited by Roschelle, 1995) concerns the development of schemata in relation to new experience. Children, like adults, combine prior schemata with experience. However, children's notions of space and time qualitatively differ from adults' (Piaget, 1970 cited by Roschelle 1995). Piaget provides a theory of conceptual change that focuses on the development of schemata from childhood to maturity (Roschelle 1995).

Piaget provides a characterization of children's knowledge at four stages of maturity, termed sensi-motor, preoperational, concrete operational, and formal operational (Corsini, 1994 cited by Roschelle 1995). At each successive stage, more encompassing structures become available to children to make sense of experience. For example, Piaget demonstrates that children cannot perform controlled experiments with variables, or reason with ratios, before the formal operational stage. Prior knowledge, in the form of structural schemata, thus play a determining role in how children make sense of interactive experience (Roschelle, 1995).

In Piaget's account of conceptual change, knowledge grows by reformulation. Piaget identifies a set of invariant change functions, which are innate, universal, and age independent. These are assimilation, accommodation, and equilibration. Assimilation increases knowledge while preserving of structure, by integrating information into existing schemata. Accommodation increases knowledge by modifying structure to account for new experience. For Piaget, the critical episodes in learning occur when a tension arises between assimilation and accommodation, and neither mechanism can succeed on its own. Equilibration coordinates assimilation and accommodation, allowing the learner to craft a new, more coherent balance between schemata and sensory evidence. Reformulation does not replace prior knowledge, but rather differentiates and integrates prior knowledge into a more coherent whole (Roschelle, 1995).

Piaget influences educators not only by his theory, but also by his method. He spent long hours coming to know children's modes of thinking (using the clinical interview, discussed later). After Piaget, we must assume that children will make sense of experience using their own schemata. Yet, we also must carefully interview children, seeking an understanding of their form of coherence. Most followers of Piaget are constructivists who cultivate a deep appreciation of children's sense-making, and design interactive experiences accordingly (Roschelle, 1995).

Piaget generated many innovative task-settings in which children become involved in active manipulation of physical objects. Trying to achieve a goal in physical task can promote conflict between assimilation and accommodation in the accompanying psychological task. Moreover, alternative physical actions can suggest different conceptual operations, and thus opportunities that arise in physical activity can inspire mental restructuring. Using these insights, Kuhn et al., (1988) cited by Roschelle (1995) shows that children can learn to coordinate theory and evidence in a period of several weeks if provided with engaging, playful, thought-provoking tasks. Harel&Papert (1991) cited by Roschelle (1995) extend this point by suggesting that the best tasks for constructing ideas are those in which children have to build something that works. While "construction" and "constructivism" are not necessarily linked, they go well together. Dewey's theory, discussed in the next section, also identifies designing, making, and tinkering real things as critical to conceptual change.

In summary, Piaget suggests that learners overcome the paradox of continuity with the help of slow, maturational processes that operate when doing a task provokes conflict between accommodation and assimilation, and support for equilibration between these. He suggests that designers of interactive experiences invest the empirical effort needed to appreciate learner's perspective. From an understanding of this perspective, one can design tasks that are likely both to attract learners, to provoke disequilibration, and to support the necessary but difficult work of knowledge reformulation. Tasks should be simple and direct, with individual concrete operations mapping closely to the conceptual operations at stake. Experience in which learners construct a working physical arrangement are often powerful for constructing knowledge; for example, the best way to progress past your prior understanding of a painting might be to try to paint one like it (cited by Roschelle (1995) . S

2.4 Students' Learning Preferences

A good match between students' learning preferences and instructor's teaching style has been demonstrated to have positive effect on student's performance (Harb& El-Shaarawi, 2006 cited by Mlambo, 2011). According to Reid (1995) cited by Mlambo (2011), learning preference refers to a person's "natural, habitual and preferred way" of assimilating new information. This implies that individuals differ in regard to what mode of instruction or study is most effective for them.

Scholars, who promote the learning preferences approach to learning, agree that effective instruction can only be undertaken if the learner's learning preferences are diagnosed and the instruction is tailored accordingly (Pashler, McDaniel, Rohrer, & Bjork, 2008) cited by Mlambo (2011). "I hear and I forget. I see and I remember. I do and I understand." (Confucius 551-479 BC) cited by Mlambo (2011) a quote that provides evidence that, even in early times, there was a recognition of the existence of different learning preferences among people. Indeed, Omrod (2008) cited by Mlambo (2011) reports that some students seem to learn better when information is presented through words (verbal learners), whereas others seem to learn better when it is presented in the form of pictures (visual learners). Clearly in a class where only one instructional method is employed, there is a strong possibility that a number of students will find the learning environment less optimal and this could affect their academic performance.

Felder (1993) cited by Mlambo (2011) established that alignment between students' learning preferences and an instructor's teaching style leads to better recall and understanding. The learning preferences approach has gained significant mileage despite the lack of experimental evidence to support the utility of this approach. There are a number of methods used to assess the learning preferences/styles of students but they all typically ask students to evaluate the kind of informationpresentation they are most at ease with. One of these approaches being used widely is the Visual/Aural/Read and Write/Kin aesthetic (VARK) questionnaire, pioneered by Neil Fleming in 1987, which categorizes learners into at least four major learning preferences classes. Neil Flemming (2001-2011) cited by Mlambo (2011) described these four major learning preferences as follows: Visual learners: students who prefer information to be presented on the whiteboard, flip charts, walls, graphics, pictures, colour. Probably creative and may use different colours and diagrams in their notebooks, aural (or oral)/auditory learners: prefer to sit back and listen. Do not make a lot of notes. May find it useful to record lectures for later playbacks and reference, read/write learners: prefer to read the information for themselves and take a lot of notes. These learners benefit from given access to additional relevant information through handouts and guided readings and kinesthetic (or tactile) learners: these learners cannot sit still for long and like to fiddle with things. Prefer to be actively involved in their learning and thus would benefit from active learning strategies in class.

A number of learners are indeed, multimodal, with more than one preferred style of learning in addition to using different learning styles for different components of the same subject. There is a strong possibility that learning preferences would depend on the subject matter being taught. The question that arises is whether a particular learning preference is favored in certain subjects/courses. This study will attempt to answer this question with regard to an introductory biochemistry course taught in the Faculty of Science and Agriculture at the University of the West Indies, St. Augustine. Learning style in this study was measured by administering to students, the VARK questionnaire that provides users with a profile of their learning preferences. The category with the highest score was taken as the student's learning preference. Where categories had equal scores, all the categories were taken as the student's learning preferences (multimodal) (Mlambo (2011).

2.5 Students' understanding in mathematics (algebra).

Students' construction of knowledge in mathematical problem solving is base on understanding in their use of strategies as they attempt to solve mathematics problems. Various stages of the solving process will bring different sets of challenges to them. It is the construction of cognitive structures that are enabling, generative, and proven successful in problem solving (Confrey, 1991 cited by Egodawatte 2011). Confrey (cited by Egodawatte 2011) presented a simple model to describe the construction of cognitive structures in problem solving. As shown in figure 1, students can solve mathematics problem by first having knowledge about the problem,understanding the mathematical problem, and then developing a positive perception, and this can help students to solve problem in mathematics. This is followed by checks to determine whether those problems were resolved satisfactorily by perception on the problems again, thereby making the process cyclic. And below is the adopter model for Confrey (cited by Egodawatte 2011)

Figure 2.1

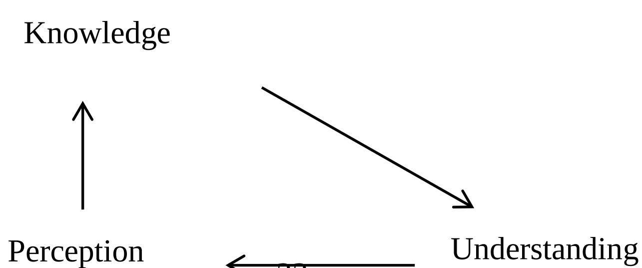

Figure 2.1: Stages of problem solving (Source: Confrey ,1991, p. 119 cited by Egodawatte 2011)

"If this process proven successful, it is repeated in other circumstances to create a scheme, a more automated response to a situation" (Confrey, 1991, p. 120 cited by Egodawatte 2011).

Over time, these schemes emerge from assimilations of experience to ways of knowing. They have duration and repetition, and they are more easily examinable than isolated actions (Confrey, 1994 cited by Egodawatte 2011). "Assimilating an object into a scheme simultaneously satisfies a need and confers on an action, a cognitive structure" (Thompson, 1994, p. 182 cited by Egodawatte 2011). By listening to student explanations, teachers can decode student understanding patterns thereby allowing teachers to identify not only the reasons behind their particular perception but also their poor understanding. Hence, analyzing student data can prompt re-examination of one's mathematical understanding and their mathematical meaning.

According to Polya(1957) cited by Egodawatte(2011), problem solving is a stage-wise procedure. Polya(1957) cited by Egodawatte(2011) presented a four-phase heuristic process of problem solving. The stages under this model are: understanding the problem, devising a plan, carrying out the plan, and looking back. Schoenfeld(1983) cited by Egodawatte(2011) devised a model for analyzing problem solving that was derived from Polya's model. This model describes mathematical problem solving in five levels: reading, analysis, exploration, planning/implementation, and verification. In applying this framework, Schoenfeld (cited by Egodawatte 201)1 discovered that expert mathematicians returned several times to different heuristic episodes. For example, in one case, an expert engaged in the following sequence of heuristics: read, analyze, plan/ implement, verify, analyze, explore, plan/implement, and verify. Therefore, according to Schoenfeld(1983) cited by Egodawatte(2011), the model is cyclic rather than linear.

English, (1996),cited by Egodawatte(2011), reviewed the steps on children's development of mathematical models. According to her empirical findings, children first examine the problem for cues or clues thatmight guide the retrieval from memory of a relevant mental model of a related problem or situation. After retrieving a model, they attempt to map the model onto the problem data. This mapping may involve rejecting, modifying, or extending the retrieved model or perhaps replacing it with another model. If there is a correspondence between the elements of the mental model and the data of the problem, the model is then used to commence the solution process.

However, retrieving an appropriate mental model may not be automatic or easy forchildren. English, (1996) cited by Egodawatte(2011), further said that, as children progress on the problem, they may recycle through the previous steps in an effort to construct a more powerful model of the problem situation and its solution process. This construction process is considered responsible for the development of new mathematical ideas. This model is very similar to Confrey's cyclic model. English's model also provides important clues about ongoing Metacognitive activity during or after each cycle.

Comparing and contrasting the above models, it is evident that, although the number of steps in the solving process is different for each model, almost all the models contain similar basic aspects. For example, Schoenfeld's (cited by Egodawatte 2011), categories of reading, analysis, and exploration taken together could be considered as "understanding" in Polya's model. Exploration was not specified in the Garofalo (cited by Egodawatte 2011) and Lester framework, although they indicated the distinctive metacognitive behaviors that may be associated with each category.

2.6 Student's perceptions about mathematics (algebra)

The study focuses on the part of students' performance in mathematics (Algebra) so I investigated students" insights about the mathematics (Algebra). In the response of the question about Algebra, a student shared that, "I like Mathematics but I do not like Algebra. Algebra is complex subject because we don't know the value of a or b" (In: January 29, 2008 cited by Mashooque, 2008). Another student said I also like Mathematics because I like to solve sums and getting answers. I enjoy solving the exercises given in Mathematics (algebra). But in Mathematics the part of Algebra is a difficult subject because usually in Algebra the values are not given and we have to find the answer so it is difficult to get answer without any given value. (In: January 29, 2008 cited by Mashooque, 2008) Students shared that: I do not like Algebra because of big and difficult formulae. I find it difficult to keep in mind these formulae and I could not understand where I should use these formulae. For example in Factors I feel complexity that which formula I suppose to use to solve it." (In: January 29, 2008 cited by Mashooque, 2008)

The above quote highlighted that very big formulas in mathematics (Algebra) make it difficult for students because they could not remember them. Students, who had previously learned mathematics (algebraic) formulae in one context, found difficulty in applying these formulas in other/unfamiliar contexts. Skemp(1986) cited by Mashooque(2008) attributed this difficulty of students" ability to use formula in different contexts as instrumental understanding rather than relational understanding of the formula. Relational understanding suggests that students become able to apply their knowledge in solving problems in different situations. The data also revealed that students had some strong rationales for their disliking. They highlighted the problem of interpreting letters and variables and use of letters in Algebra. Moreover, they also indicated that they had some concerns about the methods of solving the algebraic problems which they indicated by saying like, formulae are difficult and when and where to use them.

2.7 Students' Knowledge in mathematics (Algebraic)

A number of research studies have shown that Students‟ interpretation of symbols in algebra is not proper because some of the difficulties faced by the students are specific to mathematics (algebra) (Kuchemann, 1981& Clement 1982 cited by Mashooque, 2008). For instance, a difficulty in algebraicunderstanding was identified by Davis (1975). He called the "name-process" dilemma by which an expression such as 9a is interpreted in algebra as an indication of a process "What you get when you multiply 9 by a" and a "name for the answer". Sfard and Linchevski (1993) cited in Herscovics and Linchevski, (1994) cited by Mashooque, (2008) have suggested that the term "process-product dilemma" better describes this problem. Collis' theory of the student's Acceptance of the Lack of Closure (ALC) is a little bit different which describes the level of closure at which the pupil is able to work with operations (Collis, 1975) cited by Mashooque, (2008) . He observed that at the age of seven, children require that two elements connected by an operation (e.g. 5 + 3) be actually replaced by a third element; from the age of 10 onwards, they do not find it necessary to make the actual replacement and can also use two operations (e.g. 8+3 +1); fifteen year-olds can refrain from actual closure and are capable of working with formulas such as Volume = L x B x H; between the ages of 16 - 18, although students are not yet able to handle variables, they have no difficulty with symbolization as long as the concept symbolized is underpinned by a particular concrete generalization. Collis' ALC theory is particularly relevant to the teaching of mathematics (algebraic) since the operations performed on the pro-numerals cannot be closed as in arithmetic. For example in the response of a question in a research most of the students could not accept 5 x a as the area of an indicated square unless it was inserted in the formula "Area of square = 8 x a".

Chapter Three

Research Methodology

3.0Introduction

Statistical analysis of students' understanding in mathematics, knowledge in mathematics and perception about mathematics in Nalerigu senior High School was aimed at analyzing the pattern of performances in mathematics(algebra) and the factors that influence the performances of the students. Primary data on second year students inNalerigu Senior High School was obtained.

3.1 Study Area

East Mamprusi District is one of the twenty six (26) districts in the northern region of Ghana. It has Gambaga as its capital town. According to the 2010 population and housing census (2010 PHC) East MamprusiDistrict has a total population of 121,009 representing 4.9 percent of the total population in Ghana, males constitute 49 percent and females representing 51 percent. A large number of the population 81,850 resides in the rural parts of the District with the remaining 39,159 in the urban areas. However, a higher population of males (25.5%) compared to females 18.3 percent attended SSS/SHS/Secondary, and the district has a land mass of 1,706.8 square kilometers representing about 2.2 percent of the total land mass of the region. The district has two Senior High Schools, Nalerigu senior high and Gambaga Girls Senior High School, but the study was conducted at Nalerigu senior high school.

3.2 Data Collection

Data for this study was collected base on the questionnaires answered by students (respondents) at Nalerigu senior high school. This included data on students' performance in algebra and demographic features.

3.3 Population and Sample Size

All the second year students ofNalerigu senior high school was the target population. Only students provided response to the questionnaire was used: thus giving a proportionate stratified random sample size of male and female, that is **60** students. With the proportionate, the chance of inclusion in the sample is the same for all units (people) regardless of the strata they are in.

3.4 Variables

The variables considered in this study includes: age, gender,departments and students performances or understanding in mathematics, knowledge in mathematics and perceptions in mathematics (response variable).

3.5 Data Analysis

Descriptive exploratory analysis was conducted on the outcome variables. The multivariate analysis of variance (MANOVA) and T – test to compare means was used as the analytical tools.

3.6 MANOVA

Multivariate analysis of variance evaluates differences among centroids for a set of dependent variables when there are two or more levels of independent variables (groups). This technique provides a multivariate test to compare the mean vectors of k random samples for significant differences when the levels of the grouping variables are two or more: in this study it was used when the levels were more than two.

Consider k independent random samples of size n obtained from p – variate normal populations. The model for each observation is (Rencher, 2002):

y_{ij}= μ + α_i + ε_{ij}

y_{ij}= μ +ε_{ij}, I = 1, 2, . ..,k; j = 1, 2,, p **3.1**

In terms of the p variables iny_{ij}(3.1) becomes

$$\begin{pmatrix} y_{ij1} \\ \vdots \\ y_{ijp} \end{pmatrix} = \begin{pmatrix} \mu_{ij1} \\ \vdots \\ \mu_{ij1} \end{pmatrix} + \begin{pmatrix} \alpha_{i1} \\ \vdots \\ \alpha_{ip} \end{pmatrix} + \begin{pmatrix} \varepsilon_{ij1} \\ \vdots \\ \varepsilon_{ijp} \end{pmatrix} = \begin{pmatrix} \mu_{i1} \\ \vdots \\ \mu_{ip} \end{pmatrix} + \begin{pmatrix} \varepsilon_{ij1} \\ \vdots \\ \varepsilon_{ijp} \end{pmatrix} \quad \mathbf{3.2}$$

With respect to this study, our interest was to compare the mean vectors of k sample for significant difference. The multivariate model

Y' = Xβ + ε**3.3**

Leads to multivariate hypothesis of the form:

CβA' = 0 **3.4**

Where $\boldsymbol{\beta}$a matrix of parameters, C is specifies constraints on the design matrix Xfor a particular hypothesis, and **A** provides a transformation of **Y**. An estimate of β is provided by

$\hat{\boldsymbol{\beta}} = (\boldsymbol{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Y}$ **3.5**

The error sum of squares and cross products (SSCP) matrix is

$W = A\,(Y'\,Y - \hat{\beta}'X'\,X\,\hat{\beta}\,)A$

$W = \sum_{i=1}^{k}\sum_{j=0}^{n}(y_{ij} - \bar{y}_{i.})(y_{ij} - \bar{y}_{i.})'$

$W = \sum_{ij} y_{ij}\, y'_{ij} - \sum \frac{1}{n} y_{i.}\, y'_{i.}$ **3.6**

With $\sum_{i=1}^{k} n - k$ degree of freedom.

Where $y_{i.}$ **is** the total of the i^th^ sample with its transpose $y'_{i.}$ andthe SSCP matrix for the hypothesis is

$B = n\sum_{i=1}^{k}(\bar{y}_{i.} - \bar{y}_{..})(\bar{y}_{i.} - \bar{y}_{..})'$

$B = \sum \frac{1}{n} y_{i.}\, y'_{i.} \frac{1}{kn} y_{..}\, y'_{..}$ **3.7**

Where $y_{..}$ and $\bar{\mathbf{y}}_{..}$ are the overall totals and mean respectively.

Be the usual “within” and between sums of squares, respectively.

The hypothesis being tested by the MANOVA is:

$H_{0\,1}: \mu_1 = \mu_2 = \ldots = \mu_k$ (Testing for equality of k population means)

The wilks proposed a test of ratio of generalized variances to test the number of effects as

$\Lambda^{2/n} = \frac{|SS_w|}{|SS_w + SS_b|}$ **3.9**

$$\Lambda^{\forall} = \Lambda^{2/n} = \frac{\left|\left(\sum_{i=1}^{k}\sum_{j=0}^{n}(y_{ij}-\bar{y}_i)\right)(y_{ij}-\bar{y}_i)'\right|}{\left|\sum_{i=1}^{k}\sum_{j=0}^{n}(y_{ij}-\bar{y})(y_{ij}-\bar{y})'\right|} \quad \textbf{3.10}$$

Reject H_0 if $\Lambda^{\forall}$ is too small.

(a) Pillai's trace statistics, V, is defined as follows:

$$V = \sum_{i=1}^{p} \frac{\lambda_1}{1+\lambda_1} = tr\{(W + B)^{-1} B \quad \textbf{3.12}$$

An approximate F statistics for the pillai's trace with p(2m + p +1) and p(2n + p +1) degree of freedom is used to determine significance levels given by :

$F = \frac{2n+p+1)V}{2m+p+1)(s-V)}$, It is used to determine the significance levels.

(b) Lawley – Hotelling trace :

$$U = \sum_{i=1}^{p} \lambda_i = tr(W^{-1} B) \quad \textbf{3.13}$$

With an approximate F statistics given by

$F = \frac{2(pn+1)U}{P^2(2m+p+1)}$, the approximation F distribution is used to determine significance levels.

(c) Roy's Largest root

Roy's Largest root is also known as Hotelling's generalized T^2 statistics and it's taken as $\lambda_i andso$metimes as $\theta = \frac{\lambda_1}{1+\lambda_1}$ which is bounded between zero and one. This statistics provides a test based on the union-intersection approach to test construction. An upper bound F statistics (providing a lower bound on the p-value) for Roy's Largest root is

$F = \lambda_1 \frac{V_w - d + V_b}{d}$ with d and $V_W - d + V_h$ degree of freedom, where $d = \max(p, V_h)$.

3.7 Assumptions and Test of Hypothesis (Hotelling's T2)

This study considered various students segments: Sex, Age and Departments. It was assumed that the responses (performance) for the different groups were independent of one another; however, the case is not the same for repeated measures of the i[th] subject.

Suppose the two groups were P – dimensional populations with n_1 and n_2 observations respectively and suppose group one (Male) and group two (Female) were both characterized by a mean vector of $\mu^{(1)} = (\mu^{(1)}, \ldots, \mu_p^{(1)})'$ and $\mu^{(2)} = (\mu_1^{(2)}, \ldots, \mu_p^{(20)})'$ respectively.

Assuming the distribution of the two populations to be multivariate normal, that is, the distribution of the first population follows $N_k(\mu^{(1)}, \Sigma)\ \Sigma > 0$ and that of population two is $N_k(\mu^{(2)}, \Sigma)\ \Sigma > 0$ for a sample of size $n = n_1 + n_2$ where n_1 and n_2 are defined as before; the sample statistics for the two populations are computed using the following relations (Johnson &Wichern, 2007):

$$X^{(1)} = \frac{1}{n_1}\sum_{i=1}^{n_1} X_i^1 \qquad \textbf{3.14}$$

$$X^{(1)} \sim N_k(\mu^{(1)}, \frac{\Sigma}{n_1}) \qquad \textbf{3.15}$$

$$(n_1 - 1)S_1 = \sum_{i=1}^{n_1}\{(X_i^1 - \bar{X}^{(1)})(X_i^{(1)} - X^{(1)})'\} \qquad \textbf{3.16}$$

$$(n_1 - 1)S_1 \sim W_k(n_1 - 1, \Sigma) \qquad \textbf{3.17}$$

The two distributions (3.15) and (3.17) are independent because they are base on the random sample from the first population. Similarly, for the second group (Johnson&Wichern, 2007);

$$X^{(2)} = \frac{1}{n_2}\sum_{i=1}^{n_1} X_i^{(2)} \qquad \textbf{3.18}$$

$$X^{(2)} \sim N_k(\mu^{(2)}, \frac{\Sigma}{n_2}) \qquad \textbf{3.19}$$

$$(n_2 - 1)S_2 = \sum_{i=1}^{n_1}\{(X_i^{(2)} - \bar{X}^{(2)})(X_i^{(2)} - X^{(2)})'\} \quad \textbf{3.20}$$

$$(n_2 - 1)S_2 \sim W_k(n_2 - 1, \Sigma) \quad \textbf{3.21}$$

Furthermore, because we had the first set of statistics from the first population and the second set from the second population, by analogy, the statistics from both populations were independent. This implies that (Rencher, 2002; Johnson &Wichern, 2007);

$$(X^1 - X^{(2)}) \sim N_n[\mu^{(1)} - \mu^{(2)}, \frac{\Sigma}{n_1} + \frac{\Sigma}{n_2}] = N_n[\mu^{(1)} - \mu^{(2)}, \Sigma(\frac{n_1 + n_2}{n_1 n_2})] \quad \textbf{3.22}$$

In order to investigate the similarities or differences of statistics of performance which was one of the objectives of the study the following hypothesis was tested.

$$H_{O1}: \mu_j^{(1)} - \mu_j^{(2)} = \mu_{j-1}^{(1)} - \mu_{j-1}^{(2)}, \; j = 1, 2, 3, \ldots, p \quad \textbf{3.23}$$

Which can be written as

$$H_{o1}: A(\mu_j^{(1)} - \mu_j^{(2)}) = 0, \quad \textbf{3.24}$$

The distribution of the parameters is given by:

$$A(X^{(1)} - X^{(2)}) \sim N_{n-1}[A(\mu^{(1)} - \mu^{(1)}), \frac{n_1 + n_2}{n_{1n_2}} A\Sigma A'] \quad \textbf{3.25}$$

$$A(X^{(1)} - X^{(2)}) \sim N_{n-1}[\,, \frac{n_1 + n_2}{n_{1n_2}} A\Sigma A'] \quad \textbf{3.26}$$

$$(n_1 + n_2 - 2)ASA' \sim W_{n-1}(n_1 + n_2, A\Sigma A') \quad \textbf{3.27}$$

Using the above distribution of the sample parameters, the Hotlling's T^2 statistics derived as;

$$T^2 = (\frac{n_1 n_2}{n_1 + n_2})(n_1 + n_2 - 2)[\{A(X^{(1)} - X^{(2)})\}'\{(n_1 + n_2 - 2)ASA'\}^{-1}\{A(X^{(1)} - X^{(2)})\}]$$

At $(n_1 + n_2 - 2)$ d.f. **3.28**

Therefore, under the null hypothesis we have:

$$\left(\frac{T^2}{(n_1+n_2-2)}\right)\left[\frac{(n_1+n_2-2)-(m-1)+1}{m-1}\right]\sim F_{m-1,}(n_1+n_2-m) \qquad \textbf{3.29}$$

Hence the null hypothesis will be rejected if the value of the test statistics

$$T^2\left[\frac{n_1+n_2-m}{(m-1)(n_1+n_2-2)}\right] > F_{m-1,}(n_1+n_2-m)\ (\alpha) \qquad \textbf{3.30}$$

And accept otherwise.

If the test of similarities of statistics is in the affirmative, then the test for the equality of variances becomes necessary. The hypothesis for the test of variances of performance is given

$H_{O2}: \mu_j^{(1)} - \mu_j^{(2)} = 0$ $\qquad$ $j = 1, 2, \ldots, p$ $\qquad$ **3.31**

The null hypothesis under equation 3.25 could also be presented in the following form;

$H_{02}: 1'\mu^{(1)} = 1'\mu^{(2)}$

Or

$H_{02}: 1'(\mu^{(1)} - \mu^{(2)}) = \underline{0}$ $\qquad$ **3.32**

Taking A' = 1' as in the previous derivation of the test statistic of the Hotlling's T^2 and it's associated test, the Hotlling's T^2 statistic becomes;

$$T^2 = \left(\frac{n_1 n_2}{n_1+n_2}\right)[\{1'(X^{(1)} - X^{(2)})\}'\{1'S1\}^{-1}\{1'(X^{(1)} - X^{(2)})\}] \qquad \textbf{3.33}$$

Where the null hypothesis is:

$$\left(\frac{T^2}{n_1+n_{2-2}}\right)\left[\frac{n_{1+n_2-2)-1+1}}{1}\right]\sim F_{1,(n_{1+n_2-2})} \qquad \textbf{3.34}$$

Hence, the null hypothesis is rejected at level α if the observed value of T^2 is such that: $T^2 > F_{1,(n_{1+n_2-2})}(\alpha)$ and accept otherwise.

3.8T – Test

The t – test is used for testing differences between two means. In order to use a t – test, the same variable must be measured in different groups at different times or comparison to a known population mean. But for this case we are testing the difference between independent groupssuch as male and female or testing the difference between dependent groups. A test for independent groups is useful when the same variable has been measured in to independent groups and the researcher wants to know whether the difference between group (sex) means is statistically significant (Tannor, 2010).

3.9 Student's *t*-test

A *t*-test is any statistical hypothesis test in which the test statistic follows a Student's *t*-distribution under the null hypothesis. It can be used to determine if two sets of data are significantly different from each other, and is most commonly applied when the test statistic would follow a normal distribution if the value of a scaling term in the test statistic were known. When the scaling term is unknown and is replaced by an estimate based on the data, the test statistic (under certain conditions) follows a Student's *t* distribution (Wikipedia, 2016).

3.10. Hypotheses

The null hypothesis (H_0) and alternative hypothesis (H_1) of the independent samples T test can be expressed in two different but equivalent ways:

H_0: $\mu_1 = \mu_2$ ("the two population means are equal")

H_1: $\mu_1 \neq \mu_2$ ("the two population means are not equal")

OR

H_0: $\mu_1 - \mu_2 = 0$ ("the difference between the two population means is equal to 0")

H_1: $\mu_1 - \mu_2 \neq 0$ ("the difference between the two population means is not 0")**3.35**

Where μ_1 and μ_2 are the population means for male(group 1) and female(group 2), respectively. Notice that the second set of hypotheses can be derived from the first set by simply subtracting μ_2 from both sides of the equation(kent state university, 2016) .

3.11Independent two-sample *t*-test

3.11.1 Equal sample sizes, equal variance

This test is only used when both:

- The two sample sizes (that is, the number, *n*, of participants of each group) are equal;
- It can be assumed that the two distributions have the same variance.

Violations of these assumptions are discussed below.

The *t* statistic to test whether the means arSe different can be calculated as follows (Wikipedia,2016):

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_{X_1X_2} \cdot \sqrt{\frac{1}{n}}}$$

3.36

Where

$$s_{X_1X_2} = \sqrt{s_{X_1}^2 + s_{X_2}^2} \quad \textbf{3.37}$$

Here $S_{X_1}S_{X_2}$ is the grand standard deviation (or pooled standard deviation), 1 = group one (Male), 2 = group two (Female). $S_{X_1}^2$ and $S_{x_1}^2$ are the unbiased estimators of the variances of the two samples. The denominator of *t* is the standard error of the difference between two means.

For significance testing, the degrees of freedom for this test is $2n-2$ where *n* is the number of participants in each group.

3.11.2 Equal or unequal sample sizes, equal variance

This test is used only when it can be assumed that the two distributions have the same variance. (When this assumption is violated, see below.) The *t* statistic to test whether the means are different can be calculated as follows (Wikipedia, 2016):

$$t = \frac{\bar{X}_1 - \bar{X}_2}{s_{X_1X_2} \cdot \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \quad \textbf{3.38}$$

Where

$$s_{X_1X_2} = \sqrt{\frac{(n_1 - 1)s_{X_1}^2 + (n_2 - 1)s_{X_2}^2}{n_1 + n_2 - 2}}. \quad \textbf{3.39}$$

Note that the formulae above are generalizations of the case where both samples have equal sizes (substitute *n* for n_1 and n_2).

S_{X1X2} is an estimator of the common standard deviation of the two samples: it is defined in this way so that its square is anunbiasedestimator of the common variance whether or not the population means are the same.

In these formulae, *n* = number of participants, 1 = group one (Male), 2 = group two (Female).

$n - 1$ is the number of degrees of freedom for either group, and the total sample size minus two (that is, $n_1 + n_2 - 2$) is the total number of degrees of freedom, which is used in significance testing.

3.11.3 Equal or unequal sample sizes, unequal variances

This test, also known as Welch's *t*-test, is used only when the two population variances are not assumed to be equal (the two sample sizes may or may not be equal) and hence must be estimated separately. The *t* statistic to test whether the population means are different is calculated as (Wikipedia, 2016):

$$t = \frac{\overline{X}_1 - \overline{X}_2}{s_{\overline{X}_1 - \overline{X}_2}} \quad \textbf{3.40}$$

Where

$$s_{\overline{X}_1 - \overline{X}_2} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}. \quad \textbf{3.41}$$

Here s^2 is the unbiased estimator of the variance of the two samples, n_i = number of participants in group i, i=1 or 2. Note that in this case ${s_{\overline{X}_1 - \overline{X}_2}}^2$ is not a pooled variance. For use in significance testing, the distribution of the test statistic is approximated as an ordinary Student's t distribution with the degrees of freedom calculated using

$$\text{d.f.} = \frac{(s_1^2/n_1 + s_2^2/n_2)^2}{(s_1^2/n_1)^2/(n_1-1) + (s_2^2/n_2)^2/(n_2-1)}. \quad \textbf{3.42}$$

Chapter Four

Data Analysis and Discussion of Results

4.0 Introduction

This chapter presents the analysis of the data collected and discussion of results.

4.1Descriptive Statistics

The mean performance and standard deviations at each measurement point for a sample of 60 students, broken down by Sex, are presented in table 4.1 The results from the table indicate the means of the various measures, thus understanding in mathematics mean for male is 4.87, female is 4.47, Knowledge in mathematics mean for male is 5.70, female is 4.57, and Perception in mathematics mean for male is 5.73, female is 4.3. Note, however, that at this stage, the preliminary results from the study indicated a close disparity in the mean performance of males and female students across all the variables, thus understanding in mathematics, knowledge in mathematics and perception in mathematics by students. Amount the three variables measure for sex as shown in table 4.1, the deviations for both male and female students understanding in mathematics is minimal as compare to the other two variables.

Table 4.1: Descriptive Statistics

	SEX OF STUDENT	Mean	Std. Deviation	N
UNDERSTANDING IN MATHEMATICS	MALE	4.87	2.662	30
	FEMALE	4.47	2.609	30
	Total	4.67	2.621	60
KNOWLEDGE IN MATHEMATICS	MALE	5.70	2.961	30
	FEMALE	4.57	3.115	30
	Total	5.13	3.067	60
PERCEPTION IN MATHEMATICS	MALE	5.73	2.449	30
	FEMALE	4.30	2.842	30
	Total	5.02	2.728	60

4.2 Test of Equality of Covariance Matrices across Groups.

The Box's M test statistics is transformed to an F statistics with df1 and df2 degrees of freedom. From table 4.2the significance (p- value =0.833) is greater than 0.05, which means that the Box's M test is not significant, indicating that the data are consistent with the assumption of homogeneity of covariance matrices (base on the three measured variables) across the population subgroups (sex). Therefore it shows that the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups is accepted.

Table 4.2 Box's Test of Equality of Covariance Matrices[a]

Box's M	2.972
F	0.467
df1	6
df2	24373.132
Sig.	.833

The significance of the likelihood chi – square test statistics is 0.000 which is significant at the 5% significance level. Thus the null hypothesis of residual covariance matrix is proportional to an identity matrix for male and female is rejected at 5% significance level. The result in table 4.3 below indicates that, at 5% level of significance, the null hypothesis of residual covariance matrix is proportional to an identity matrix by sex cannot be accepted since p – value 0.000 is less than alpha value 0.05. Hence there is statistically significant difference in performance in mathematics by sex (male and female).

Table 4.3: Bartlett's Test of Sphericity[a]

Likelihood Ratio	0.000
Approx. Chi-Square	29.555
DF	5
Sig.	0 .000

4.3 Multivariate Tests[c] of sex and age

The four test statistics in the multivariate table below is used to test the significance of each model effect.

Table 4.4: Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent Parameter	Observed Power[b]
Intercept	Pillai's Trace	.179	4.004[a]	3.000	55.000	.012	.179	12.012	.811
	Wilks' Lambda	.821	4.004[a]	3.000	55.000	.012	.179	12.012	.811
	Hotelling's Trace	.218	4.004[a]	3.000	55.000	.012	.179	12.012	.811
	Roy's Largest Root	.218	4.004[a]	3.000	55.000	.012	.179	12.012	.811
AGE	Pillai's Trace	.090	1.818[a]	3.000	55.000	.155	.090	5.454	.447
	Wilks' Lambda	.910	1.818[a]	3.000	55.000	.155	.090	5.454	.447
	Hotelling's Trace	.099	1.818[a]	3.000	55.000	.155	.090	5.454	.447
	Roy's Largest Root	.099	1.818[a]	3.000	55.000	.155	.090	5.454	.447
SEX	Pillai's Trace	.057	1.103[a]	3.000	55.000	.356	.057	3.309	.282
	Wilks' Lambda	.943	1.103[a]	3.000	55.000	.356	.057	3.309	.282
	Hotelling's Trace	.060	1.103[a]	3.000	55.000	.356	.057	3.309	.282
	Roy's Largest Root	.060	1.103[a]	3.000	55.000	.356	.057	3.309	.282

The results of the multivariate tests of actual performance by sex and age are shown intable 4.4 above. Since the significance values are greater than 0.05 (sig. = 0.155 age and sig. = 0.356 sex in all cases), we can confidently conclude that there were no sex and age differences in the performances of students at 5% significance level, the Wilks' Lambda row for sex $F(3, 55) = 1.103$ Significance greater than 0.05 Wilks' Lambda = 0.943 partial eta squared is 0.057. Generally there is no statistically significant difference in overall academic performance between Male and Female in mathematics.

4.4 Test of equality of error variances by sex

The results of the Test of equality of Error variances by sex base on performance are shown in table **4.5**. A separate test is performed for each dependent measure, Understanding' in mathematics, knowledge in mathematics and Perception in mathematicsby sex of students. Levene's test is not significant for any of the dependent measure and therefore the homogeneity of variance assumption has not been violated. Since significance values are greater than 0.05 (Sig. = 0.533, 0.633 and 0.500 in all case), then the null hypothesis cannot be rejected. The assumption that variability by sex are equal, implies that there were no Sex difference in the performance of students per their 'Understanding' 'Knowledge' and 'Perception' in mathematics.

Table 4.5: Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
UNDERSTANDING IN MATHEMATICS	.393	1	58	.533
KNOWLEDGE IN MATHEMATICS	.231	1	58	.633
PERCEPTION IN MATHEMATICS	.461	1	58	.500

4.5 The Test of Between – Subjects Effects

To determine how the dependent variables differ for the independent variable, we need to look at the Tests of between – subject Effects. The various results outline in the table 4.6 shows the significant effects by sex and age, we can see from the table 4.6 that students performance has no statistically significance effect either sex or age at 5% significance level, since in all cases significance value is greater 0.05. Thus by sex (Male and Female), Students 'Understanding in mathematics' (F (1,57) = 0.006, Significance value 0.936 > 0.05 and Partial eta square is 0.000, 'Knowledge in mathematics' (F (1, 57) = 0.082, Significance value 0.374 > 0.05 and Partial eta square is 0.014 and Students 'Perception in mathematics' (F(1 , 57) = 3.348, Significance value 0.073> 0.05 and Partial Eta Square is 0.055.Therefore we fail to reject null hypothesis, and conclude that either sex or age has no statistically significant difference on students performance in mathematics.

Table 4.6: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Corrected Model	UNDERSTANDING IN MATHEMATICS	24.422[a]	2	12.211	1.827	.170	.060	3.654	.366
	KNOWLEDGE IN MATHEMATICS	51.976[c]	2	25.988	2.945	.061	.094	5.890	.552
	PERCEPTION IN MATHEMATICS	33.661[d]	2	16.830	2.367	.103	.077	4.734	.460
Intercept	UNDERSTANDING IN MATHEMATICS	24.221	1	24.221	3.624	.062	.060	3.624	.465
	KNOWLEDGE IN MATHEMATICS	23.773	1	23.773	2.694	.106	.045	2.694	.365
	PERCEPTION IN MATHEMATICS	72.795	1	72.795	10.237	.002	.152	10.237	.882

AGE	UNDERSTANDING IN MATHEMATICS	22.022	1	22.022	3.295	.075	.055	3.295	.431
	KNOWLEDGE IN MATHEMATICS	32.710	1	32.710	3.707	.059	.061	3.707	.473
	PERCEPTION IN MATHEMATICS	2.844	1	2.844	.400	.530	.007	.400	.095
SEX	UNDERSTANDING IN MATHEMATICS	.043	1	.043	.006	.936	.000	.006	.051
	KNOWLEDGE IN MATHEMATICS	7.076	1	7.076	.802	.374	.014	.802	.142
	PERCEPTION IN MATHEMATICS	23.809	1	23.809	3.348	.073	.055	3.348	.436
Error	UNDERSTANDING IN MATHEMATICS	380.912	57	6.683					
	KNOWLEDGE IN MATHEMATICS	502.957	57	8.824					
	PERCEPTION IN MATHEMATICS	405.323	57	7.111					
Total	UNDERSTANDING IN MATHEMATICS	1712.000	60						
	KNOWLEDGE IN MATHEMATICS	2136.000	60						
	PERCEPTION IN MATHEMATICS	1949.000	60						

Corrected Total	UNDERSTANDING IN MATHEMATICS	405.333	59
	KNOWLEDGE IN MATHEMATICS	554.933	59
	PERCEPTION IN MATHEMATICS	438.983	59

4.6 The Parameter estimate (Age and Sex)

The parameter estimates for the independent variables indicate the direction and the performance of students by sex and age as shown in the table 4.7 below.

Table 4.7: Parameter Estimates

Dependent Variable	Parameter	B	Std. Error	T	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound	Partial Eta Squared	Noncent. Parameter
UNDERSTANDING IN MATHEMATICS	Intercept	2.402	1.231	1.951	.056	-.064	4.868	.063	1.951
	AGE	1.032	.569	1.815	.075	-.106	2.171	.055	1.815
	[SEX=1]	.056	.694	.081	.936	-1.334	1.445	.000	.081
	[SEX=2]	0^b	.	.	.	.	.	.	.
KNOWLEDGE IN MATHEMATICS	Intercept	2.051	1.415	1.449	.153	-.783	4.884	.036	1.449
	AGE	1.258	.653	1.925	.059	-.050	2.567	.061	1.925
	[SEX=1]	.714	.797	.895	.374	-.883	2.311	.014	.895
	[SEX=2]	0^b	.	.	.	.	.	.	.
PERCEPTION IN	Intercept	3.558	1.270	2.801	.007	1.015	6.102	.121	2.801

MATHEMATICS	AGE	.371	.587	.632	.530	-.804	1.546	.007	.632
	[SEX=1]	1.310	.716	1.830	.073	-.124	2.743	.055	1.830
	[SEX=2]	0^b	.	.	.	.	.	.	.

From the table 4.7 above since there is an intercept term the third level sex = 2 (female) is redundant. The results of the various parameters estimate in the three categories of dependent variable are: for students' 'understanding' in mathematics age estimate value is 1.032, standard error is 0.569 and significance value 0.075, for sex=1 (Male) estimated value is 0.56, standard error is 0.694 and significance value is 0.936. For students' 'knowledge' in mathematics age estimated value is 1.258, standard error is 0.653 and significance value is 0.59, for sex = 1 (Male) estimated value is 0.714, standard error is 0.797 and significance value 0.374 ,finally perception of students in mathematics estimated value for age is 0.371, standard error 0.587 and significance value 0.530, for sex estimate value is 1.310, standard error 0.716 and significance value 0.073 , comparing this parameters by performance for the three categories of the dependent variables those with age categories perform more than the sex = 1(Male) at 5% significance level .We therefore fail to reject the hypothesis since the significance values are all greater than 0.05 in all cases and then conclude that there were no statistically significant difference in performance either by sex or age.

4.7 The Transformation Coefficients

T**he results** of table 4.8 form3*3 identity matrix of the dependent variables with zero covariance matrixes which means that the performance of the students was significantly independent across all groups (Male and Female).

Table 4.8: Transformation Coefficients (M Matrix)

	Transformed Variable		
Dependent Variable	UNDERSTANDING IN MATHEMATICS	KNOWLEDGE IN MATHEMATICS	PERCEPTION IN MATHEMATICS
UNDERSTANDING IN MATHEMATICS	1	0	0
KNOWLEDGE IN MATHEMATICS	0	1	0
PERCEPTION IN MATHEMATICS	0	0	1

4.8 SSCP Matrix

The results shown in table 4.9 is the sum–of–squares and cross-product matrix, variance-covariance matrix and the correlation matrix which will use to determine how students performance in mathematics by sex or age vary and covary. In the covariance matrix the main diagonal is the variances and the covariances appears in the off-diagonal elements as shown below.

Table 4.9: Residual SSCP Matrix

		UNDERSTANDING IN MATHEMATICS	KNOWLEDGE IN MATHEMATICS	PERCEPTION IN MATHEMATICS
Sum-of-Squares and Cross-Products	UNDERSTANDING IN MATHEMATICS	380.912	139.028	70.819

	KNOWLEDGE IN MATHEMATICS	139.028	502.957	259.855
	PERCEPTION IN MATHEMATICS	70.819	259.855	405.323
Covariance	UNDERSTANDING IN MATHEMATICS	6.683	2.439	1.242
	KNOWLEDGE IN MATHEMATICS	2.439	8.824	4.559
	PERCEPTION IN MATHEMATICS	1.242	4.559	7.111
Correlation	UNDERSTANDING IN MATHEMATICS	1.000	.318	.180
	KNOWLEDGE IN MATHEMATICS	.318	1.000	.576
	PERCEPTION IN MATHEMATICS	.180	.576	1.000

From the table 4.9 we are to interpret the variance and covariance statistics to understand how the various performances of students by sex or Age in mathematics vary and covary. From the matrix, the variance of performance by each test is as follows: the students 'knowledge' in mathematics has biggest variance (8.824), and the students 'understanding' in mathematics, the smallest (6.683), so we can conclude that there is more variability in performances of students in the variable knowledge in mathematics more than the other variables.

The covariance between understanding in mathematics by students and their knowledge in mathematics is positive (2.439), and the covariance between the variables 'understanding in mathematics' and 'perception in mathematics' by students in performance is positive (1.242). This means the performances tend to co-vary positively. As performances on students understanding in mathematics go up, knowledge in mathematics and perception in mathematics by sex or age tend to decrease up, and vice versa.

The correlation matrix of performances in table 4.9above indicated that the correlations are positive and generally increasing in performances across three variables. Thus the performance of students either by sex or age depended less on his/her understanding in mathematics, knowledge in mathematics and perception in mathematics.

4.9 Independent t – test

An independent sample t test was conducted to test whether there was a significant difference between male and females students' perception about mathematics, knowledge in mathematics and understanding in mathematics. It must be recalled that the study hypothesized that there is no significant difference by male and females students' performance in mathematics (algebra).

TABLE 4.10 Independent Samples Test

	Levene's Test for Equality of Variances	t-test for Equality of Means

		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
UNDERSTANDING IN MATHEMATICS	Equal variances assumed	.021	.886	.588	58	.559	.400	.681	-.962	1.762
	Equal variances not assumed			.588	57.977	.559	.400	.681	-.962	1.762
KNOWLEDGE IN MATHEMATICS	Equal variances assumed	.463	.499	1.444	58	.154	1.133	.785	-.437	2.704
	Equal variances not assumed			1.444	57.852	.154	1.133	.785	-.437	2.704
PERCEPTION IN MATHEMATICS	Equal variances assumed	.429	.515	2.093	58	.041	1.433	.685	.062	2.804
	Equal variances not assumed			2.093	56.756	.041	1.433	.685	.062	2.805

From table 4.10 above for "understanding in mathematics" a t - value of 0.588, a degree of freedom of 58 with corresponding significance value of 0.559 and for "knowledge in mathematics" a t - value of 1.444, a degree of freedom of 58 with corresponding significance value of 0.154, since the two dependent variables all has p – value greater than alpha value 0.05 (p > 0.05). We therefore do not reject the null hypothesis and conclude that there is no significant difference in understanding in mathematics and knowledge in mathematics among male and female students.

However, for the case of students' perception about mathematics (algebra) a t - value of 2.093, a degree of freedom of 58 with corresponding significance value of 0.041. Since the p – value 0.041 for perception about mathematics among male and female group is less than alpha value 0.05 ($p < 0.05$) we reject the null hypothesis at 5% significance level, and therefore conclude that there is significant differences in the way mathematics (algebra) is perceived by male and females students.

4.10 Discussion

Results of the descriptive statistics indicated that the mean performance (scores) of students in Nalerigu Senior High School in mathematics differed across Male and Female groups. The Male reported the highest average mean performance, as well as the highest variability.

The test of equality of covariance matrix indicated that the students performance by Male and Female groups was assumed to be equal across all Male and Female groups, it means that there were no significant difference in Male and Female groups by their performance in mathematics. And also in the Box's M test has no different results to the test of equality of covariance matrix, as the Box's M test is not significant since p – value is 0.833 greater than $\alpha = 0.05$,indicating that the covariance matrix across Male and Female groups are equal. But in Bartlett's test of sphericity since the p – value 0.000 is less than alpha value 0.05 the equality of covariance matrices for Male and Female groups cannot be accepted at 5% significance level, it assumed that there were significance difference in performance by sex.

The correlation and variance – covariance matrices of the performance of student over the dependent measures was examined across the groups of sex. It was statistically evident that the variance – covariance matrix of the mean performance across the group of sex and age were compound symmetric. The statistically test for equality of vector of means was rejected 5%

significance level, indicating that the vector of means for Male and Female are not equal and hence there were statistically significance difference in performance by sex.

The multivariate test, applied to the statistically means, showed that there are no significant sex differences in the pattern of change of student performance in mathematics at the 5% significance level. The evidence of no difference in performance by male and female students in terms of academic performance contradicted the findings of (Ross, Scott, & Bruce, 2012, p. 278-279 (cited by Foy 2013) "males continue to perform higher base on their knowledge in mathematics, understanding in mathematics and perception in mathematics than females on measures of mathematical performance, especially on more difficult items", but supported the view of Chinwuba&Osamuyimen (2011), that there was no difference in academic performance between male and female Senior High School students. Ding (2008) in a related study established that ethnicity, but not sex, distinguished two types of change statistics. Results supporting the female dominance in academic performance in the subject – based research were done in the developed countries whereas the findings in support of this study were done in the developing countries.

The test of between – subjects effects, applied to statistically examined how the dependent measures differ by the independent measures, and the statistics of the various measures showed that there was no statistically significant difference in performance by sex in mathematics

As part of the objectives of the study, the statistics across male and female groups were examined. The statistics showed that there was no statistically significant difference across sex. And also on the part of determining the range of students' perception about mathematics (algebra), knowledge in mathematics (algebra) and understanding in mathematics, in the covariance matrix the highest variability was on students' knowledge in mathematics and the smallest variability on understanding in mathematics by students.

The t test, also applied to the statistically means, showed that there are no statistically significant difference by sex for the two dependent variables thus, knowledge in mathematics, understanding in mathematics. The evidence of no difference in performance by sex contradicted the findings ofBenbow and Stanley, 1980 (cited by Foy 2013) found that boys had consistently better in understanding, knowledge acquisition and perception (scores) on the mathematical portion than girls, even when their course content was almost identical. But Benbow and Stanley, 1980 (cited by Foy 2013) findings that boys had consistently better in understanding, knowledge acquisition and perception (scores) on the mathematical portion than girls, even when theircontent was almost identical, supported the evidences that there is significant difference by sex perception about mathematics (algebra).

Chapter Five

Conclusions and Recommendations

5.0 Introduction

This chapter presents the conclusion based on the analysis of the sampled data. Recommendation(s) are made thereafter.

5.1 Conclusion

The analysis revealed that the mean performance (scores) of students in Nalerigu Senior High School in mathematics were significant the same across male and female groups.

The statistics of male and female students showed no gender differences in the performance of students. Thus, though there was some change in performance of students across the variables. The pattern and the level of this change in performance was the same for both sexes.

The overall average performance of student can significantly be predicted by the sex of students and age of students.

5.2 Recommendations

Further research is recommended to include other variables such as ethnicity, medical status, and other performance indicator variables: dependent factors using probability sampling design to examined more on the response statistics of student' performance in the Senior High Schools.

It is also recommended that further research is done to investigate into the poor performance of students in mathematics in the Senior High Schools to help address this problem.

As a way to improved students performances of the subject mathematics, a careful examination and possible review of the course structure and content mathematics is recommended.

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