CHAPTER ONE

INTRODUCTION

Background to the Study

Mathematics in English-speaking Cameroon has come a long way. In the traditional society, before the introduction of formal education, mathematics was used mainly in stocktaking of daily farming, keeping record of livestock and other properties, and trading activities. According to Aguele and Kolawole (2007), most traditional societies had their number systems which were either base five or twenty. These could be seen in their market days and counting systems. This, however, is not still the case in Cameroon.

Since the introduction of formal education in English-speaking Cameroon, mathematics has gone through several developments; from the era of formal Arithmetic, Algebra, Geometry etc, through the period of traditional mathematics and the modern mathematics controversy to the present everyday general mathematics. These changes similar to those taking place in neighbouring Nigeria have always been necessitated by the realization of the role mathematics should play in the nation's scientific and technological development as well as responses to societal needs and demands (Aguele, 2004). Today, mathematics remains very important to all disciplines and fields of human work and study (Odili, 2006). It is generally seen as an intellectually challenging subject affecting almost every aspect of life. Its role is such that there is hardly any discipline of study in which mathematics is not involved.

Academics and educators have emphasized the important role of mathematics in several ways. As Baiyelo (2007) observed, mathematics is widely regarded as the language of science and technology. Ebude (2016) equally stated that, while technology is an engine of growth with endless potentials, mathematics is the key to accessing all these potentials. Abakpa and Iji (2011) on their part, viewed mathematics as an intellectually stimulating subject which affects every talent of human activities such as politics, economics, science and technology. To them, it is

the model by which scientific concepts are understood and bedrock for understanding and applying technologies. Some authors like Tukur and Abimbola (2013), have in a similar manner stressed the dependence of other disciplines and modern society on the knowledge of mathematics. To Tukur and Abimbola, mathematics is the queen of all sciences and servant to all disciplines. This view is in line with that of Ukeje as cited by Orji and Uche (2010), that mathematics contributes enormously to the modern culture of science and technology, hence, without mathematics there is no science, without science there is no modern technology and without modern technology there is no modern society. Drawing from the aforementioned authors, one can say that the state of science and technology and the state of modernity of any nation is a function of the development and application of mathematics.

Mathematics is a compulsory subject from the primary through the five years of secondary education in the English-speaking subsystem of education in Cameroon. This important position occupied by the subject in the school curricula is borne out of the role of mathematics in daily life and in scientific and technological development, a sine qua non in nation building. Another role of mathematics is its use as a basic entry requirement into many prestigious courses such as medicine, accountancy, architecture and engineering among other degree programmes.

Despite the importance and benefits of mathematics in our day-to-day activities, its use as a basic entry requirement into other higher level fields, and its role as an agent of national development and wealth creation, students' interest and achievement in the learning of mathematics in English-speaking secondary schools in Cameroon have been pitiable. There has been consistent poor performance and failure of students in mathematics at secondary school level (Akoko, 2010; Babila, 2003; Olaleye as cited in Umoru & Ubom, 2013). Achievement in mathematics at the General Certificate of Education Ordinary Level (GCE O/L) in Cameroon has not exceeded 25% in the past 12 years (See Appendix A, p. 124).

Academic achievement on the one hand is the measure of the extent of successes recorded by learners in an academic setting. Martins-Umeh (2012) noted that academic achievement refers to students' progress in school as measured by their scores. Academic achievement can thus be measured using scores from tests, examinations, assignments, etc. Fisher, Dobbs-Oates, Doctoroff and Arnold (2012) asserted that the academic achievement of a student in any discipline can be greatly affected by his/her interest in that discipline. This implies that students interested in mathematics are more likely to seek out opportunities that allow their engagement with the subject and consequently, perform well in the subject.

On the other hand, students' interest can be said to be the feeling experienced by students whose attention, curiosity or concern is engaged by something or someone. Boekaerts and Boscolo (2002) conceptualized interest as the effect that relates one's self to the activities that provide the type of novelty, challenge, or aesthetic appeal that one desires. From experience, the mathematics classroom is very often not an interesting place for most secondary school students. Okereke (2006) also asserted that mathematics is feared and hated by most students, resulting in a decline in their achievements in this subject. It is of course absurd for one to develop interest in what one hates and fears.

Most have tried to explain why interest and achievement rates in this very important subject are consistently low. Imoko and Agwagah (2006), Iyekekpolor (2007), and Anyagh and Ok'wu (2010) did identify many variables as responsible for students' low interest and poor performance in mathematics. They include: curriculum, mathematics pedagogy, examination bodies, teachers, students, environment and textbooks. Also, Obioma (2005) and Okereke (2006) identified poor primary school background, incompetent teachers in primary schools, students not being interested in mathematics, perception that mathematics is difficult, large class syndrome, psychological fear of the subject, poor methods of teaching, and lack of qualified mathematics teachers as some of the main causes of poor achievement in secondary school mathematics. Akoko (2010) on his part pointed out that poor

achievement of Cameroonian students in mathematics could be largely attributed to poor instructional practices, mathematics anxiety and students' learning styles.

Visibly, most writers seem to find fault in the way mathematics is being taught and learnt. Abakpa and Iji (2011) reported that the methods and strategies of teaching and learning mathematics have consistently generated interest among scholars over the years. The chalk and talk method of teaching, which is a teacher-centered teaching method, is still very popular with mathematics teachers of English-speaking secondary schools in Cameroon. Johnson, Johnson and Holubec (2002) asserted that more than 85% of teaching that goes on within schools is carried out through the lecture method. In the traditional or conventional teacher-centered method, the teacher is the main source of information; the teacher is the "sage on the stage" (King, 2001). That is, the teacher is the sole content expert who provides information to students, generally via direct instruction or lecture, with little or no student interaction. The students are required to complete independent practice (assignment) at home where they may have limited resources to help them accomplish such task.

The commonly used teacher-centered methods for the teaching-learning of mathematics are still popular for the reason that they were once incredibly successful. Tanksi (2016) noted that the traditional teaching-learning methods may have been successful in the past, but the minds of the current generation vary from those of the previous generation. To Tanksi, this teaching method appears to be straight forward but its efficiency is reduced due to the short attention span of the present day students. Since most teachers do not sufficiently interact with their students or allow students to interact among themselves, most students lose their focus and their minds turn to wander.

There is an outcry by researchers, parents and other stakeholders in education, that teacher-centered methods which are currently the predominantly used instructional methods in Cameroon are not yielding the so much needed achievements in mathematics at the GCE O/L. Best and Khan (2003) also tried to explain why the teacher-centered methods are not yielding required achievements.

According to them, the lecture method is through verbal supply of information by teachers, while students just receive passively whatever is delivered to them. Some students even display passive presence during mathematics lessons. This is buttressed by Ursula and Eluwa (2013) who opined that many students are often bored and restless during mathematics lessons, sometimes hanging their heads down and wondering when the teacher would just shut up and leave the class. Thus, the teaching method used in the class is one of the factors that make students become passive and have less interaction with each other in doing tasks. This passivity has caused much concern among educators in Cameroon because knowledge of mathematics, as earlier mentioned, plays a significant role in enhancing the country's technological and socio-economic development. Thus passive reception of mathematical facts, usually resulting to low achievement scores for learners, will certainly not be able to greatly enhance such development.

The foregoing suggests that to enhance the understanding of mathematics, students must be more active in the classroom and must creatively acquire knowledge, especially in understanding and solving mathematical problems. Students should be given the opportunities to develop, to interact, and to share with friends through interactive and active teaching-learning activities. In this technological age, both teachers and students should also be given the opportunity to integrate technology into the teaching-learning process in a bid to improve on their critical and creative thinking abilities. Thus, through such activities, the cognitive (achievement) and affective (interest) development of students in mathematics can possibly be improved. Among the alternative teaching-learning methods for the delivery of mathematics lessons which can possibly keep learners active and allow them to interact creatively with technology and with each other are the Flipped and Cooperative learning methods.

Cooperative learning is an active team-based teaching-learning method where learners work in manageable subgroups to solve problems. Zakaria and Iksan (2007) asserted that in cooperative learning, students work face-to-face to complete a given

task collectively. According to Enfield (2015), cooperative learning refers to a set of instructional methods in which students work in small-mixed-ability learning groups where they are encouraged to discuss, examine, contend, and disagree, with the ultimate goal of teaching each other during the learning process. Small groups provide accountability for the students not only to learn the material being taught but also to assist those in their groups to ensure that they also understand the material. Success of one member translates to success for all.

One defining feature of a cooperative learning environment is that of the group goal. The commonality in goals places a higher value on academic work and increases students' motivations in their learning. Enfield (2015) accentuated that when the group has the task of ensuring that every group member learns something, then every group member has the duty to spend time explaining concepts to his or her group mates. This suggests that a cooperative learning environment does not just happen in a classroom because students are placed in groups. Nor does it exist merely because students collaborate on a project. Thus, because cooperative learning seeks end goals that promote the well-being of all group members and not just individuals, students have a higher possibility of mastering material/content more effectively when they work in cooperative groups rather than as individuals. Furthermore, according to Enfield (2015), the structure of the traditional classroom is highly inconsistent with adolescent development and peer norms. In such classrooms, students are expected to work independently and to compete for good grades, teachers' approval and recognition. Here, students are expected to succeed in isolation from others, which indeed deviate from adolescent development and peer norms.

Cooperative learning encourages students to be active participants in the construction of their own knowledge and also to interact and to communicate with peers in harmony (Effandi, Titi, Yusoff & Zulkarnain, 2013). One can therefore arguably insinuate from the authors that cooperative learning promotes values such as honesty, cooperation, mutual respect, responsibility, tolerance, and a willingness to sacrifice a consensus. Furthermore, execution of duties in cooperative learning can

develop self-confidence in learners, which is an indispensable tool required for any good performance in mathematics. Zakaria, Chin and Daud (2010), found that cooperative learning improves students' achievement in mathematics. This is further buttressed by Shimazoe and Aldrich (2010) who ascertained that cooperative learning is an effective method which mathematics teachers need to incorporate into their teaching because it promotes deep learning of materials. Melihan and Sirri (2011) concluded that the cooperative learning method is more effective than the traditional or conventional teaching-learning method, in the academic success of students.

It would appear from literature that there is much research evidence carried out in many countries supporting the use of the cooperative learning method. According to Robert et al. (2013), cooperative learning is one of the most widely researched methods to pedagogy in mathematics. Despite the strong and widely replicated experimental evidence supporting the use of cooperative learning in mathematics, little of this research has taken place in Cameroon. Most have been carried out in the US, Israel and other research oriented nations (Slavin & Lake, 2008; Slavin, Lake & Groff, 2013).

On the other hand, a relatively new and less widely researched teaching-learning method which is an embodiment of technology and active learning is the Flipped learning method (Robert et al., 2013). As technology develops, the students' learning culture appears to also change. It is therefore necessary to develop and try out improved methods of teaching and learning that complement and enhance students' learning styles. This is in accordance with Blank, Alas and Smith (2007) who affirmed that "the success of standard-based reforms in education requires teachers to have deep knowledge of their subject and the pedagogy that is most effective for teaching and learning the subject" (p. 3).

The flipped learning method, a contrary teaching-learning method to the traditional teacher-centered method, is suggested by the Flipped Learning Network (FLN, 2014). According to the FLN, flipped learning is a pedagogical method in which teachers shift direct learning/instruction out of the large group learning space

or classroom and move it into the individual learning space, with the help of one of several technologies. Teachers create instructional videos of class lessons. Students watch these videos at home. Provision is made in schools for students who do not have internet access (or other facilities) at home to watch these videos in schools. After or while watching the videos, the students write down any questions they have. They can ask these questions during online or class discussions with the teacher or their peers. In most cases students' questions are reviewed in class by the teacher who also guides these students in reviewing and practicing the material. So in a flipped classroom, lecture and homework elements are reversed in the sense that students watch lectures at home through online videos supported by online discussions between students and teacher and in the class these students are engaged by their teacher in concept mastery exercises. Consequently the two key components of this teaching-learning method are educational technology and activity learning. However, flipped learning is not achieved only through the use of video lessons (technology) as the foregoing may suggest.

Flipped learning refers to a teaching-learning method in which students gain first exposure to new material outside of class, usually via lecture videos and/or reading of other assigned material, and then the class time is used to do the harder work of assimilating that knowledge, perhaps through problem-solving, discussions, or debates (Brame, 2013). Thus capitalizing on the students' preparedness before the lesson, teachers can devote more time to opportunities for integrating and applying acquired concepts from the video watched and/or material read, via a variety of student-centered, active learning approaches such as solving problems independently or collectively, engaging creatively in the subject matter with the assistance of the teacher or working on projects with classmates. This method therefore increases active learning opportunities both in and out of the classroom (Butt, 2014; Findlay-Thompson & Mombourquette, 2014). There is thus an interchange between what happens in class and what happens at home. That is, lectures (which can be in the

form of reading materials and/or watching video lessons) move out of class while assignments move into class.

In the flipped learning method, teachers record and/or create videos of themselves or other experts teaching, or download video lessons from internet sites such as those of TED-Ed and Khan Academy. The videos are available on VCDs, DVDs, internet or other storage devices, for students to access whenever and wherever it is convenient; at home, in study halls, on the bus, even in the hospital as many times as they like, enabling them to come to class better prepared (Musallam, 2010). Such videos include ready-made video lessons made available to the learning community in Cameroon by Global Science Vision Services, a non-gorvenmental organisation (NGO). These videos cover key areas of most subjects written at the GCE O/L, including mathematics and are used by many Cameroonian students as study aids.

A significant body of research on active learning according to Prince (2004) supports the effectiveness of the flipped learning method in increasing students' learning and achievement. This is in consonance with Kellogg (2009), Marcey (2011), Novak (2011) and Strayer (2012), who all established that the flipped learning method yields better achievement scores than the teacher-centered method to teaching-learning. Accordingly, Borg and Shapiro as cited by Lage, Platt and Treglia (2000) reported that students learn best when the teacher's instructional methods match the student's learning style. Cameroonian students' learning styles seem to have changed. The present day learners in Cameroon are digital natives who seem to relate better with technological tools. Thus, by allowing students to watch videos at home and complete work (assignment) in class, not only are students given greater resources, but they also develop a culture of using resources to solve problems. Completing work in class provides students with a greater number of resources and rather than skipping problems that are too difficult at home, students would work with their peers and teachers to solve the problem in class. Therefore, even the so

called ‘weak students’ have greater possibilities of also mastering the concepts of lessons.

It has long been argued that boys are more likely to have mathematical talents than girls, leading boys to do better in mathematics than girls, to develop high mathematical abilities, self-concepts, and to be more likely to enter mathematics related technical fields (Guimond & Roussel, 2001; Skaalvik & Skaalvik, 2004). This is buttressed by the Organization for Economic Cooperation and Development (OECD, 2010) report which shows that females, on average, performed worse than males in mathematics in many countries. Notwithstanding, one cannot state with certainty that mathematics per se is stereotyped as male. This is because in the early eighties, studies in the USA, found that mathematics was one of the least gender-stereotyped subject areas (Huston, 1983). Later studies suggest that most children, particularly girls, indicated that neither boys nor girls were more likely to excel in mathematics (Ruble, Martin, & Berenbaum, 2006). This debate is however put to rest by a recent study by Stoet and Geary (2013). Using 1.5 million children from 75 countries (Cameroon not included), they established that on the whole, boys scored higher than girls in mathematics. However, they did not find a sex difference in mathematics among below average performing students. They further found that there were many countries without a sex difference in mathematics performance and in some countries girls scored higher than boys. Going by the findings of Stoet and Geary, it can be argued that countries in which the performance of students in mathematics is generally low, may not experience any gender difference.

However, statistics from the Cameroon General Certificate of Education Board (CGCEB) indicate that up to 2010, males still performed better than females in English-speaking secondary schools in Cameroon (See Appendix B, p.125). It is therefore necessary to establish the current state of gender inequality in the achievement and interest of students in mathematics in English-speaking secondary schools in Cameroon, using student-centered teaching-learning methods. It is against this background that this study sought to compare the effectiveness of the flipped

learning and the cooperative learning methods in enhancing students' interests and achievements in mathematics in Cameroon.

Statement of the Problem

Mathematics is not only an intellectually stimulating subject which affects every aspect of human activities, but it also plays an indispensable role in the development, emergence and modernity of any nation. Unfortunately, students' achievements in mathematics at the GCE O/L examinations in Cameroon have not exceeded 25% in the past 12 years. This is definitely a perturbing issue. Worse still, up to 90.6% of the 86,724 GCE O/L candidates and 91.1% of the 102,857 GCE O/L candidates who wrote the examination in the June 2014 and June 2016 sessions respectively, could not obtain a pass in mathematics. This is a pointer to the fact that students lack understanding of concepts, functionality and application of mathematics ideas.

Evidence points to the fact that students' lack of understanding and application of mathematical concepts, leading to such persistent poor performance, could be blamed on teaching methods. The conventional method, which is a teacher-centered lecture teaching method, is still very common in mathematics classrooms in Cameroon. Although this method has helped many learners to succeed in mathematics over the years, it would appear the learning culture of students has changed. This probably accounts for the constant unsatisfactory performances. Thus the teaching and learning of mathematics in English speaking secondary schools in Cameroon need to be handled using methods that align with students' learning styles.

Though Global Science Vision Services has provided mathematics video lessons to the learning community in Cameroon in a bid to curb such catastrophic performances, the situation appears to be far from getting better as the years go by. This revelation of persistent poor performances in mathematics is not good for Cameroon as it aspires to become an emerging nation in 2035. Based on the foregoing, different and innovative teaching-learning methods need to be restructured

and applied in order to reverse the current poor achievements and lack of interests in mathematics, common in English-speaking secondary schools in Cameroon. Among these are the flipped learning method and the cooperative learning method. Which of them could improve students' interests and achievements better than the other, the much researched cooperative learning or the relatively new flipped learning? To what extent can each of these methods minimize gender inequality in the study of mathematics reported by some researchers? These are the problems which form the focus of this study.

Purpose of the Study

The purpose of this study was to compare the effectiveness of flipped learning and cooperative learning methods in enhancing students' interests and achievements in mathematics in Mezam Division of North West Region, Cameroon.

Specifically, this study was designed to

1. Compare the effectiveness of the flipped learning method in enhancing students' achievements in mathematics, with that of the cooperative learning method.
2. Compare the effectiveness of the flipped learning method in enhancing students' interests in mathematics, with that of the cooperative learning method.
3. Determine the influence of gender on students' achievement in mathematics in the flipped and cooperative learning methods.
4. Determine the influence of gender on students' interest in mathematics in the flipped and cooperative learning methods.
5. Determine the interaction effect of learning methods and gender on students' achievements in mathematics.
6. Determine the interaction effect of learning methods and gender on students' interest in mathematics.

Significance of the Study

The findings of this study, it is hoped, will go a long way to greatly improve the poor performance of mathematics learners in Cameroon. The findings will therefore be beneficial to mathematics teachers, learners, curriculum planners, educational administrators, teacher trainers and other researchers.

It is very likely that any mathematics teacher who is grounded with diverse instructional methods would produce higher achievement scores in mathematics for their students. This study provides a forum for investigating alternative workable teaching-learning methods. Mathematics teachers can always detect when their teaching-learning methods are working or failing during class lessons. They may have to venture into other workable alternative teaching-learning methods when they experience failures in their classrooms. If these methods prove to be effective, then mathematics teachers will be able to structure learning environments to enhance students' interest and achievement in mathematics. Thus the findings of this study would assist mathematics teachers to determine which pedagogic techniques they could confidently resort to when they experience failures in their classes.

If the findings of this study reveal flipped learning as a better learning method, teachers will be encouraged to adopt this instructional method in the teaching of mathematics. This pedagogical shift will enable students to divert some of the time they put in, and the interest they have in watching films and movies to watching mathematical video lessons which is hoped will greatly increase their interest and involvement in the study of mathematics. Thus the findings of this study, it is hoped, will help secondary school students to do away with some of the social apathy towards mathematics. They will also be able to understand that their achievement in mathematics depends on their active participation and not only on their teachers. Thus students will be able to appreciate the need for their involvement either as individuals or as group members in mathematics activities in and out of the classroom. This will enable them to develop the required interest towards mathematics, and acquire mathematical skills and mathematical knowledge which are

all necessary for the desired achievement that is expected in English-speaking secondary schools in Cameroon. This will subsequently lead to an improvement in achievement and an increase in the number of students offering allied courses such as Physics, Engineering and Pharmacy. Going further, it is hoped that if the findings of this study reveal flipped learning as an effective learning method, then each learner will have the opportunity to access lessons as many times as possible, whenever and wherever, through VCDs, DVDs, websites and other forms, thereby helping to enhance their retention.

The findings it is hoped, will act as eye-openers to curriculum planners, administrators and teacher trainers. They will be spurred to take appropriate decisions towards the re-assessment, re-evaluation and even in the discarding of the current mathematics teaching methods in the Cameroon English-speaking subsystem of education; teaching methods which have clearly, not yielded the required results. Consequently, it is hoped that, after this study on flipped and cooperative learning methods, whichever proves to be more effective, more emphasis will be laid on its use as a means of producing the much needed good performances in mathematics examinations especially in primary and secondary schools. Thus the findings of this study may suggest a better pedagogical method in the training and retraining of teachers in teacher training institutions in Cameroon.

The findings will greatly contribute to the body of knowledge in the area of flipped and cooperative learning, and other related areas of research in and out of Cameroon. Specifically, researchers concerned with information on cooperative learning and more especially in the area of flipped learning, which is a relatively new instructional method, and their effect on students' academic performance and interest, will find this work a useful source of literature.

Scope of the Study

Students' achievement in mathematics in this study was delimited to their achievements in Indices, Inequalities, Algebraic expressions, Transposition of

formulae and Triangles. These are key topics in the Form Three scheme of work whose effect, from experience, is felt in most other topics even in later classes. With regard to students' interests in mathematics, the study focused on situational interests, since personal interest is developed over a long time.

There are many methods of cooperative learning. However, this study was delimited to the Student Team-Achievement Divisions (STAD) method of cooperative learning. With regard to flipped learning, the study focused on the use of recorded mathematics video lessons available on electronic storage devices such as DVDs, VCDs and flash drives, rather than on the use of the internet. This is because most homes in Cameroon have at least a television set, laptop or desktop on which such electronic devices could be used, unlike internet facilities, which very few homes can boast of.

The study was delimited to all Form Three students in English-speaking public secondary schools in Mezam Division in Cameroon. Statistics from the GCE Board indicate that this division sends in the highest number of GCE candidates yearly.

The study focused on comparing the effectiveness of the flipped learning method and the cooperative learning method in enhancing students' interests and achievements in mathematics, with gender being the only moderating variable.

Research Questions

1. How effective is the flipped learning method in enhancing students' achievements in mathematics when compared with the cooperative learning method?
2. How effective is the flipped learning method in enhancing students' interests in mathematics when compared with the cooperative learning method?
3. What are the mean achievement scores of male and female students taught mathematics using the flipped learning method?
4. What are the mean achievement scores of male and female students taught mathematics using the cooperative learning method?

5. What are the mean interest scores of male and female students taught mathematics using the flipped learning method?
6. What are the mean interest scores of male and female students taught mathematics using the cooperative learning method?

Hypotheses

The following null hypotheses guided the study and were tested at 0.05 level of significance:

1 There is no significant difference between the effectiveness of the flipped learning method and that of the cooperative learning method in enhancing students' achievements in mathematics.
2 There is no significant difference between the effectiveness of the flipped learning method and that of the cooperative learning method in enhancing students' interests in mathematics.
3 There is no significant difference in the mean mathematics achievement scores of male and female students taught mathematics using the flipped learning method.
4 There is no significant difference in the mean mathematics achievement scores of male and female students taught mathematics using the cooperative learning method.
5 There is no significant difference in the mean mathematics interest scores of male and female students taught mathematics using the flipped learning method.
6 There is no significant difference in the mean mathematics interest scores of male and female students taught mathematics using the cooperative learning method.
7 There is no significant interaction effect between learning methods used and gender on students' achievement scores in mathematics.
8 There is no significant interaction effect between learning methods used and gender on students' interest scores in mathematics.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Literature was reviewed in this chapter under the following subheadings:

Conceptual Framework

- Academic achievement
- Interest
- Flipped learning
- Cooperative learning

Theoretical Framework

- Bloom's Taxonomy

Theoretical Studies

- Nature of mathematics
- Interest and academic achievement
- Studies on flipped learning
- Studies on cooperative learning

Empirical Studies

- Effect of cooperative learning method on students' achievement and interest
- Effect of flipped learning method on students' achievement and interest
- Effect of gender, interest and other active teaching-learning methods

Summary of Review of Related Literature

Conceptual Framework

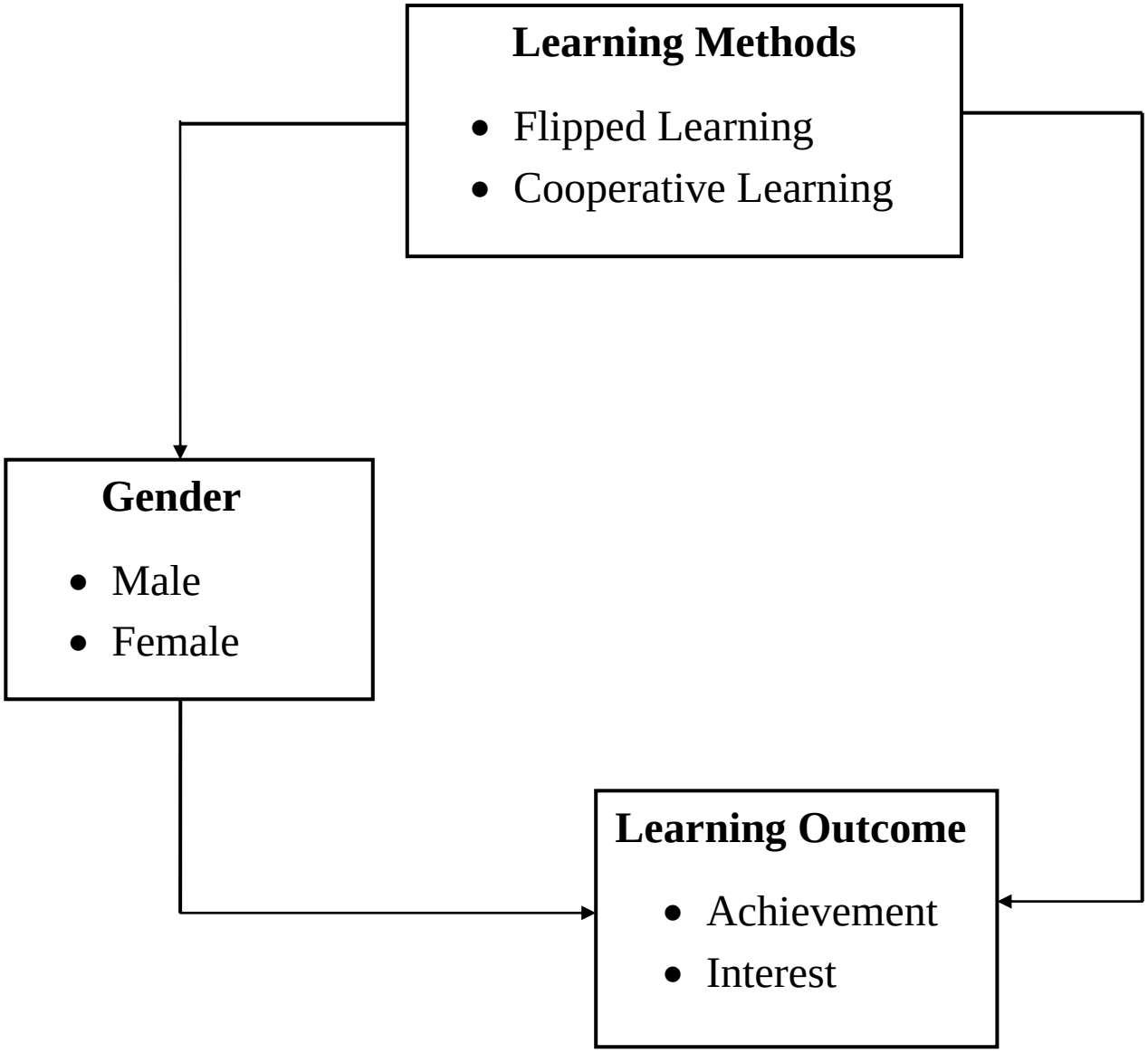

Figure 1: Schematic Representation of the Study Concepts

Figure 1 suggests that the flipped learning method and the cooperative learning method all have the potentials of helping the mathematics learner to achieve academically. Furthermore, the use of these methods could possibly trigger situational interest in secondary school learners as they use technology and interact actively in the teaching-learning process in mathematics. Considering the activities embedded in each method, it could be said that their outcomes on the mathematics learners with

regard to enhancing their achievements and their interests could possibly differ. Going further, the figure also indicates that, the achievements and the interests of male and female mathematics learners could also differ under each method. Lastly, the figure shows that there is the possibility of interaction effects between learning methods and gender on the mathematics learners' interests and also on their achievements. To better comprehend the conceptual diagram in figure 1, it is necessary to examine some of the concepts on the diagram.

Academic Achievement.

Academic achievement is the outcome of education; it is the extent to which either an institution, a teacher or a student meets set academic goals. With regard to students, academic achievement could be represented by their scores in a test or examination. Thus academic achievement depicts students' performance on a standard of measurement such as skills test, performance test and analytical test. It is therefore a result oriented construct indicating the extent of performance in a desired task which could be measured using tests, examinations, projects and assignments. However, there is no general agreement on how it is best tested or which aspects are most important; procedural knowledge such as skills or declarative knowledge such as facts (Bossaert, Doumen, Buyse & Verschueren, 2011). Different authors have defined and described academic achievement in different ways.

Apiase (2015) described academic achievement as the gain in knowledge of students as a result of taking part in a learning programme. He further asserted that academic achievement is a result oriented construct that epitomizes the extent of performance in a given task. This is in line with Ganai and Muhammad (2013) who affirmed that academic achievement is defined as excellence in all academic disciplines, in class as well as co-curricular activities. It includes excellence in sporting behaviour, confidence, communication skills, punctuality, arts, culture and the like which can be achieved only when an individual is well adjusted. Mehta (2009) also defined academic achievement in terms of curricula and non curricular activities.

To him, academic achievement includes both curricular and co-curricular performance of the students, which indicates their learning outcome. He further stated that in classrooms, learning takes place as a result of students utilizing their potentials efficiently. The learning outcome therefore changes the behaviour pattern of the students through different subjects. Other authors have focused their definition of academic achievement to school tasks as well as method of measurement. One such is Trom (2011), who defined academic achievement as knowledge attaining ability or degree of competence in school tasks usually measured by standardized tests and expressed in a grade or unit, based on pupils' performance. This is in consonance with Peterson (2012), who referred to academic achievement as, the knowledge obtained or skills developed in school subjects, usually measured by test scores or marks assigned by the teacher.

Ricarda, Anja, Anne and Wirthwein (2015) noted that academic achievement represents performance outcomes that indicate the extent to which a person has accomplished specific goals that were the focus of activities in instructional environments, specifically in school, college, and university. School systems mostly define cognitive goals that either apply across multiple subject areas (e.g., critical thinking) or include the acquisition of knowledge and understanding in a specific intellectual domain (e.g., numeracy, literacy, science, history). Thus, academic achievement could be considered to be a multifaceted construct that comprises different domains of learning. Therefore, in this study, academic achievement will refer to the measure of the cognitive abilities of learners on some specific task, using an achievement test.

Interest.

Interest is a very important variable in the teaching-learning process. This is because although a student may have a very high Intelligence Quotient (IQ) and is physically apt, he/she may not be able to learn if his/her interest is not stimulated, no

matter how well a teacher teaches. This can be understood from the views of Imoko and Agwagah (2006), who defined interest as a subjective feeling of concentration or persisting tendency to pay attention and enjoy some activity or content. Thus if this persisting tendency to pay attention and enjoy some activity is absent in the classroom, then no effective teaching and learning is likely to take place. This view is held by Okigbo (2010) who reported that interest is a mother of attention and once there is direct interest, attention is guaranteed and learning is assured.

Many authors have also put forward varying definitions of interest. Delbridge, Bernard, Blair and Ramson (2007), defined interest as "the feeling of one whose attention or curiosity is particularly engaged by something" (p. 910). Furthermore, it is a positive affect that is directed towards some object, termed the interest object. Interest is regarded as having both trait and state characteristics (Schiefele, 2011).

At the trait level, interest is described as a "person's relatively enduring predisposition to reengage particular content over time" (Hidi & Renninger, 2006, p. 113). It is a close personal attachment to, or a valuing of an interest object. On the other hand, interest at the state level is more transitory and is associated with higher levels of emotion. This state can be induced by aspects of the environment and in such instances is termed situational interest. According to Csikszentmihalyi (2002), such interest is very similar to the concept of flow; a state where learners become so absorbed in the teaching-learning process that they lose all sense of time. Other authors have had similar but modified views about the concept of interest.

To Boekaerts and Boscolo (2002), interest is conceptualized as the effect that relates one's self to the activities that provide the type of novelty, challenge, or aesthetic appeal that one desires. This probably explains why Okigbo (2010) asserted that interest can be expressed through simple statements made by individuals of their likes and dislikes and one is likely to do well in a discipline of interest. Hidi and Harackiewicz (2000) on their part, described interest as an interactive relation between an individual and certain aspects of his or her environment (e.g. objects, events, ideas). To them, it can be viewed both as a state and as an outlook of a person, and it

has a cognitive as well as an affective component. Indeed, many researchers went as far as arguing that interest is a basic emotion (Silvia, 2001). Hidi (2006) considered interest to be a unique motivational variable, as well as a psychological condition that occurs during interactions between persons and their objects of interest, and is characterized by increased attention, concentration, engagement and affect. Students' engagement, attention and concentration with learning tasks are therefore likely to be higher when they are interested in that task. The views of the aforementioned authors suggest the existence of different types of interest. Hidi (2006) identified two main types of interest; situational interest and individual interest.

Interest, on the one hand, can be situational in which case it is triggered and involves an affective reaction and focused attention (Hidi, 2006). Boekaerts and Boscolo (2002) acknowledged that it is dependent on favourable environmental conditions, and can therefore be transient in nature. However, Del Favero, Boscolo, Vidotto and Vicentini (2007) noted that it can influence learning by inducing stronger attention to learning materials and by increasing persistence in the task. Hidi and Harackiewicz (2000) further asserted that situational interest should play an important role in learning, especially when students do not have pre-existing individual interests in academic activities, content areas, or topics. These authors seem to suggest that situational interest could make a significant contribution to the motivation of academically unmotivated learners. Evidently, most Cameroonian learners seem to get into secondary school without any pre-existing individual interests in mathematics. This could be the reason why many do not study this subject at the high school level. Thus the use of flipped and cooperative teaching-learning methods could possibly trigger situational interest in secondary school learners as they use technology and interact actively in the teaching-learning process.

On the other hand, interest could also be seen as individual or personal. Boekaerts and Boscolo (2002) defined individual or personal interest as interest built on stored knowledge about a class of objects or ideas, which leads to a desire to be involved in activities related to such knowledge. Going further, those experiencing

this type of interest possess an inner drive to seek out opportunities to learn more about a specific topic. Hidi and Harackiewicz (2000) ascertained that it is a relatively enduring predisposition that develops over time and is associated with increased knowledge, value, and positive feelings. This type of interest according to Alexander (2007), energizes and motivates learners' thoughts and actions in a very goal-directed way. An interested person can therefore formulate curious questions, and attenuate negative feelings, such as frustration and anxiety (Hidi & Renninger, 2006). The foregoing suggest that learners who have individual interest in mathematics are likely to be interested in the subject, persist for longer periods of time without being distracted, learn more and enjoy their involvement to a greater degree than individuals without such interest. Thus this study considers interest to be the persistent attitude of a learner to keep desiring to engage in his/her studies freely and joyfully. Whatever the case, interest and academic achievement in mathematics seem to be greatly influenced by the teaching method employed by the teacher.

Flipped Learning.

Educators have been working to break the lecture-centered instructional method by shifting the focus from the curriculum pacing guide to student learning needs as the driver of instruction. This is probably because according to Ferriman (2014), something is different with the students of these days. To him, students in this age of super saturation of technology are good at decoding information via media. Videos and pictures are to them what textbooks were to the learners of the yore. As such, educators are, increasingly, turning to an alternative method of instruction called Flipped Learning in which technologies are used, alongside other material, to shift direct instruction outside of the group learning space to the individual learning space. Offloading direct instruction in this way allows teachers to reconsider how to maximize individual face-to-face time with students. Time becomes available for students to collaborate with peers on projects, engage more deeply with content, practice skills, and receive feedback on their progress. Teachers can devote more time

to coaching their students, helping them develop procedural fluency if needed, and inspiring and assisting them with challenging projects that give them greater control over their own learning. To better comprehend what flipped learning is all about, more precise definitions are required.

According to Chipps (2014), a flipped classroom is a specific type of blended learning design which uses technology to move lectures outside the classroom and uses learning activities to move practice with concepts inside the classroom. Richer, open-ended problem solving experiences can be conducted within the classroom environment to allow for more engaged pedagogies (Kellogg, 2009; Strayer, 2012). Similarly, the Flipped Learning Network (FLN) (2014) defined Flipped Learning as a teaching-learning method in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter. Thus class lectures take the place of assignments and assignments take the place of class lectures. The FLN (2014) leaders distinguished between a 'Flipped Classroom' and 'Flipped Learning'; to them, these terms are not always interchangeable and should thus be used with caution. They argued that flipping a class can, but does not necessarily, lead to flipped learning. However, they made no objection to the fact that flipped learning takes place in a flipped classroom. Consequently, these terms are used interchangeably in this study since the study is focused on flipped learning, which takes place in a flipped classroom. Some writers have further identified some misconceptions with regard to flipped learning.

Some of the misconceptions are that it is a teaching-learning process in which: students spend the entire time in front of a computer or television screen, students work without structure, videos replace the teacher, students work in isolation, or that a flipped classroom is an online course or a synonym for online videos (Bergmann, Overmyer, & Wilie, 2013; Szparagowski, 2014). These authors have not only pointed

out the misconceptions about flipped learning but have also tried to better clarify the concept.

To Szparagowski (2014), an effective flipped classroom is one in which, lectures in the form of reading tasks or video lessons take the place of assignments which students can play, pause or rewind as many times as possible for better comprehension. Moreover, the time normally spent lecturing, is used for in-class activities, discussions, problem solving, and group projects. This is in line with Tucker (2012) who asserted that the most meaningful learning in a flipped classroom occurs as a result of efficient use of the extra class time. Thus this extra class time which should have been spent lecturing is now used to help students better master the concepts of the lesson by focusing on the higher cognitive aspects of learning through discussions, problem solving, and group work, among others. Furthermore, to Bergmann et al. (2013), flipped classroom is a means to increase interaction and personalized contact time between students and teachers; an environment where students take responsibility for their own learning; a classroom where the teacher is not the "sage on the stage", but the " guide on the side"; a blending of direct instruction with constructivist learning; a classroom where students who are absent due to illness or extra-curricular activities such as athletics or field-trips, don't get left behind; a class where content is permanently archived for review or remediation; a class where all students are engaged in their learning; a place where all students can get a personalized education.

Flipped learning is not synonymous to multimedia learning. According to the University of Delaware (2017), multimedia is the use of a computer to present and combine text, graphics, audio and video, with links and tools that let the user navigate, interact, create and communicate. To them, in multimedia, there must be a way to gather, process and communicate ones own ideas and information. Thus, the flipped learning method can use multimedia at a particular stage of its implementation, only as a means to an end. Flipped learning can therefore be considered as a teaching-learning method in which students gain first exposure to new material out of class

through video lessons and/or other assigned task, while the class period is spent on assimilating the concepts of the lesson through some concept mastery exercises.

Cooperative Learning.

One of the greatest and inevitable challenges educators face is determining the most effective teaching-learning methods for their students. Understanding and assessing student involvement in learning can help teachers design the most effective curriculum and determine how students learn best. In addition, instructors must consider which skills will be most practical for students entering a workforce where building relationships and productivity go hand-in-hand. To meet the demand, many educators are using active learning pedagogies, such as cooperative or team-based learning. Active learning in the context of secondary education is often a social and formal process where ideas are casually exchanged through student involvement and intellectual and interpersonal activities (Melitus & Morgan, 2015). Bonwell and Eison (2011) conceptualized active learning as a process involving students not only "doing" things, but analyzing what they are doing. The aforementioned definitions of active learning constitute a right step to understanding cooperative learning.

Cooperative learning is an active team-based teaching-learning method in which students of varying abilities work in subgroups to solve problems. This definition is similar to that of Slam (2013), who defined cooperative learning as a teaching method in which students work together in small groups to help one another learn academic content. Nwagu and Nzewi (2008) further defined cooperative learning as group learning activity organized so that learning is dependent on socially structured exchange of information between learners in groups in which each learner is held accountable for their own learning and is motivated to increase the learning of others. This form of active pedagogy is therefore centered on the notion of teamwork and group orientation, interdependence, and success.

Cooperative learning, due to its ancient pedigree and positive outcomes, has been a focus of research in the past century and continues to be one in this present

century. Most 21st century researchers on cooperative learning appear to have anchored on the definitions of 20th century researchers. Some of these definitions which have a strong bearing on this present study are more goal-oriented. Roger, Olsen and Kagan (1992) proposed that cooperative learning is group learning activity organized in such a way that learning is based on the socially structured change of information between learners in groups. Each learner is held accountable for his or her own learning and is motivated to increase the learning of others so that group goals could be attained. Similarly, Parker (1994) defined the small group cooperative learning as classroom environment where students interact with one another in small groups while working together on academic task to attain the common goal. This is in consonance with Aryn and Socrates (2010) who defined cooperative learning as small groups of learners working together as a team to solve a problem, complete a task, or accomplish a common goal.

While some writers are more goal oriented in defining cooperative learning, others see it as a multidimensional concept. To Davidson (2012), cooperative learning is a word as well as a term. He claimed that cooperative learning is a long standing concept in human affairs and, indeed, is known to be essential to the functioning of human groups, organizations and societies. This is in line with Apiase (2015) who affirmed that cooperation involves joint operation or action and it also has social, economic and biological interpretation. To him, the social meaning of cooperation is an activity shared for mutual benefits; the economic cooperation is a joint effort for the purposes of production, purchase and distribution and the biological / ecological meaning of cooperation is the conscious or unconscious behavior of organisms living together for survival. This suggests that learning or classroom activities must not always be cooperative in nature.

Melitus and Morgan (2015) provided a brief definition of cooperation and cooperative learning which differentiated it from competitive and individualistic learning. Cooperation means working together to accomplish shared goals. Within

cooperative situations, individuals seek outcomes that are beneficial to all other group members. To Melitus and Morgan, cooperative learning is instructional use of small groups so that students work together to maximize their own and each other's learning. It may be contrasted with competitive (students work against each other to achieve an academic goal such as grade 'A' that only one or a few students can attain) and individualistic (students work by themselves to accomplish learning goals unrelated to those of other students) learning.

However, being in a group does not necessarily mean that learners are involved in the learning process. Johnson, Johnson and Smith (2007) identified five criteria that define true cooperative learning groups. According to them, cooperative learning is instruction that involves students working in teams to accomplish a common goal, under some conditions. Thus, cooperative learning is not simply a synonym for students working in groups. A learning exercise only qualifies as cooperative learning when some elements are present. When these elements are present in a cooperative learning environment, it is expected that learners will achieve better. Therefore cooperative learning is a teaching-learning method in which students of varying abilities work in teams to achieve a common goal under some conditions such as positive interdependence, individual accountability, face-to-face promotive interaction, appropriate use of collaborative skills and group processing.

Theoretical Framework

This study hinges on the Bloom's Taxonomy.

Bloom's Taxonomy.

In 1956 Benjamin Bloom and his colleagues classified learning into three domains: Cognitive (intellectual skills and acquisition of knowledge), Affective (feelings, values, attitudes and preferences, and Psychomotor (physical skills). From these, Bloom created a taxonomy for categorizing levels of abstract thinking and questioning. The taxonomy ranges from basic thinking skills (knowledge, comprehension, application) through to more higher order thinking skills (analysis,

synthesis, evaluation). Thus, the taxonomy is divided into six levels: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. Bloom's Taxonomy is hierarchical. That is, learning at the higher levels is dependent on having attained prerequisite knowledge and skills at the lower levels.

Lorin Anderson, a former student of Bloom, revisited the cognitive domain in the learning taxonomy in the mid nineties and made some changes; he changed the names in the six categories from noun to verb forms and slightly rearranged them (See Figure 2). Thus the new taxonomy reflects a more active form of thinking. It provides an important framework for teachers to use to focus on higher order thinking. By providing a hierarchy of levels, this taxonomy can assist teachers in designing performance tasks, designing lesson plans, crafting questions for conferring with students, and providing feedback on student work. This study adopted Anderson's revised form of Bloom's taxonomy.

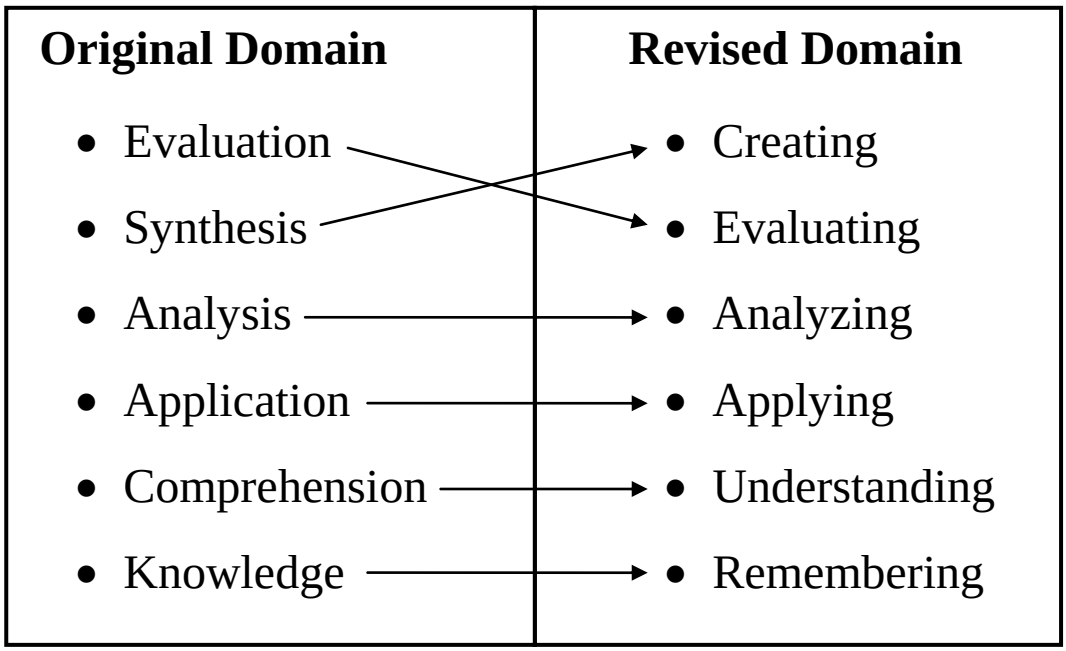

Figure 2: Bloom's Original and Revised Cognitive Domains Compared.

The activities within the flipped learning method are designed such that the lower levels of Bloom's taxonomy such as remembering, understanding and to some extent, applying, are handled by the students at home as they watch video lessons or

work on assigned task. During class lessons, the teacher starts by helping to clarify students' doubts on the lower level concepts handled at home. This is then followed by class work on concepts from the higher levels of Bloom's taxonomy (applying, analyzing, creating and evaluating). This is coordinated by the class teacher with the intention of helping students to assimilate the concepts of the lesson. Thus in flipped learning the lower levels of the Bloom's taxonomy are handled out of class sorely by students while the higher levels are handled by both teachers and students during class time.

On the other hand, the cooperative learning method is structured such that students work in teams on concepts at all the levels of the Bloom's taxonomy with the teacher offering regular interventions especially on concepts at higher levels of the taxonomy. At the end of the lesson, the teacher gives some concept mastery exercises, mostly at the higher level of the Bloom's taxonomy. Students are expected to solve these exercises at home.

The handling of different levels of Bloom's taxonomy at different points during the same lessons in the flipped and cooperative learning methods could possibly enhance mathematics learners' interests and achievements differently within these methods. Thus this study set out to compare the effectiveness of the two methods in enhancing Cameroonian students' interest and achievement in mathematics.

Theoretical Studies

Nature of Mathematics.

It seems impossible to comprehend how one could live a normal life in this 21st century without making use of some kind of mathematics in one way or the other; a century in which mathematics seems to contribute immensely to every aspect of human life. Varying descriptions and definitions of mathematics have been put forward by a number of authors.

To Ojerinde cited in Ebude (2016), mathematics is simply the communication system of those concepts of shape, size, quantity and order used to describe diverse

phenomena. Ojerinde's definition is not so different from that of Obodo (2001) who opined that mathematics is a language of size, order and symbol used in estimating, calculating and decoding information. Madu and Hogan (2010) further asserted that mathematics is made up of a set of concepts, facts, principles, and operations that are fundamental to the existence of every individual. Drawing from the ideas of the abovementioned authors, one could postulate that mathematics is a language consisting of concepts, facts, principles and operations which enable us to decode information and carry out calculations that are fundamental to human existence.

Other authors have described and defined mathematics by including elements of its usefulness. One of such writers is Stephen (2009) who viewed mathematics as a precise and logical language, which not only leads to interesting activities in their own right but can also be applied to everyday life and is further used as descriptions or models in science and other areas. Others such as Aminu and Marut as cited in Tukur and Abimbola (2013) have followed suit, asserting that mathematics is not only the mother and language of the sciences, but it is the essential nutrient for thought, logic, reasoning and therefore progress. While Olosunde and Olaleye (2010) on their part claimed that mathematics is a fundamental science that is necessary for the understanding of most fields, Ajayi, Lawani and Adeyanju (2011) were more field-oriented, as according to them, mathematics is the queen of all sciences and servant to all disciplines. This goes to support the fact that one can hardly live a normal life without making use of some kind of mathematics. To enable one to better comprehend what mathematics is, Bassey, Joshua and Asim (2007) used an analogy to describe the subject. They opined that mathematics is to a nation what protein is to a young human organism.

Unfortunately, learners have often complained about the abstract nature of such a foundational subject. Effandi, Titi, Yusoff and Zulkarnain (2013) said that mathematics is still a subject that is considered difficult and boring to many students. This could possibly be why many students develop a phobic attitude and anxiety

towards mathematics; anxiety which from experience, affects their academic achievement in mathematics.

Interests and Academic Achievements.

Semaya (2013) reported that high levels of student interest were positively associated with academic achievement, deeper levels of cognitive processing, the use of self-regulatory learning methods and students' ratings on the quality of their learning experiences in mathematics. This agrees with many authors who have established that subject-specific interest is an important determinant for successful learning and advanced achievement (Fisher, Dobbs-Oates, Doctoroff & Arnold, 2012; Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008; Hidi & Renninger, 2006). This implies that students interested in mathematics are more likely to seek out opportunities that allow their engagement with the subject and consequently, perform well in the subject. As a result of this, student interest is known to be a predictor of subject choice. McPhan, Morony, Pegg, Cooksey and Lynch (2008) reported that interest was one of five factors that explained students' choice of senior mathematics course in an Australian context; the others being their mathematics self-concept, their previous achievement in mathematics, and their perceptions regarding the usefulness and difficulty of mathematics. The interest, however, is formed through the years preceding senior secondary school, where interest towards mathematics appears to reach a minimum (Dotterer, McHale, & Crouter, 2009; Watt, 2004). Such low levels of interest for mathematics during adolescence are very often as a result of the teacher factor and arguably contribute to a decline in the number of students studying higher mathematics during their high school years (Forgasz, 2006; McPhan et al., 2008). This, in turn, contributes to the reported shortage of skilled mathematicians in most countries (Australian Academy of Science, 2006). Given this great importance of students' interest for their learning processes, it is highly problematic that this interest substantially declines during secondary school (Gottfried, Fleming & Gottfried, 2001). This decline occurs particularly in mathematics (Frenzel, Goetz, Pekrun, &

Watt, 2010; Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Nagy et al., 2010; Watt, 2004).

Some researchers have gone further to find out how interest relates to gender. Many studies indicate that girls portray lower interests levels compared to boys in mathematics (Fredricks & Eccles, 2002; Watt, 2006) and science (Gardner, 1998; Miller, Slawinski & Schwartz, 2006). Thus going by Fisher et al. (2012), alongside other researchers mentioned previously who say that subject-specific interest is an important determinant for successful learning and advanced achievement, one could insinuate that boys are expected to perform better than girls in mathematics. This gender gap may not speak well for mathematics instruction at a time when gender is one of the global contemporary issues in this 21st century.

One way to check the decline of interest and to narrow the gender gap is to identify and use appropriate methods in teaching-learning; methods that will identify and encourage aspects of students' beliefs and behaviors that are important for both girls' and boys' mathematics learning (Hidi & Renninger, 2006). Most writers assert that keeping students interested in mathematics is paramount. Without interest, students incline to surface level learning in mathematics (Chin & Brown 2000; Entwistle, 2008). With interest they are likely to engage in deep level learning. Chin and Brown (2000) further posited that the purposes for stimulating students' interest are: to attract students, to keep students active, to increase students' enthusiasm for and during lessons, and very importantly, if their study is interesting, and not always boring, then the students will be keen and happy to study.

Bolarin (2009) demonstrated that with the ability held constant through statistical techniques, students with higher educational interest have higher Grade Point Averages in mathematics and mathematics related courses than those with low interest scores. This is in agreement with the submission of Lavis (2010), that there is a reciprocal relationship between interest and learning achievements as each reinforces the other. This then indicates that interest can serve as a motivating factor of attention and thus enhance good memory in the learners. Therefore, the level of

learning difficulty of students is minimized for those with high levels of educational interest in a particular subject, leading to improved achievement in their academics.

Academic achievement is defined by different indicators of educational success and hence can be measured in different ways. Single studies and meta-analyses have demonstrated that the associations between academic achievement and its predictors such as intelligence, motivation, and personality differ depending on how academic achievement is measured (Ricarda et al., 2015). Literature suggests that Grade point average (GPA) and standardized achievement test are the most widely used indicators of academic achievement. According to Geisinger and Kurt (2013), GPA is one of the most frequently investigated variables in educational psychology and education. Even though it is a good indicator of academic achievement and can also be a valid predictor of subsequent academic success, Kuncel, Nathan, Marcus and Lisa (2005) demonstrated that one has to be cautious with self-reported GPA. Grades measure students' performance in the classroom as rated by teachers and are thus influenced by the frame-of-reference effect. On the other hand, standardized achievement tests are also important indicators of academic achievement because they provide more objective ratings of academic achievement than grades and can be viewed as more of a 'pure' indicator of academic knowledge (Camara, Wayne, Sheryl & Wiley, 2013). Thus, they are used in Cameroon and many countries as college entrance tests which are good predictors of success in tertiary education.

Individual differences in academic performance have been linked to differences in intelligence and personality (Stumm, Hell & Chamorro-Premuzic, 2011). Students with higher mental ability as demonstrated by IQ tests and those who are higher in conscientiousness; linked to effort and achievement motivation, tend to achieve highly in academic settings. Stumm et al. further suggested that mental curiosity, as measured by typical intellectual engagement has an important influence on academic achievement in addition to interest, intelligence, personality and conscientiousness. Children's semi-structured home learning environment transitions into a more structured learning environment when children start basic education. Judging from the

suggestion of Stumm et al., it seems obvious that many learners achieve academically later on in life because they were intellectually engaged at the basic level of their education which enhanced the development of their mental curiosity. This is in line with the conclusion of Bossaert et al. (2011) that early mental curiosity and academic achievement enhance later mental curiosity and academic achievement. Another very important enhancer of academic achievement is the presence of physical activities. Studies have shown that physical activities can increase neural activity in the brain. In one of such studies, Tomporowski, Catherin, Miller and Naglieri (2008) showed that physical involvement and exercises specifically increase executive brain functions such as attention span and working memory. Learners are therefore expected to be more attentive when they are actively involved in the teaching learning process. This calls for teaching-learning methods that will enable them to be 'masters' and not 'servants' in the learning process. Academic achievement has also been linked to gender differences.

A number of authors have argued on the relevance of gender in predicting academic achievement. Girls outperform boys with regard to school grades, whereas boys perform better with regard to standardized achievement tests or college placement exams in scientific and mathematical competence (Meece, Judith, Karyl & Askew, 2012). This is in line with Duckworth and Seligman (2006) who argued that although girls earn higher grades than boys, the performance of girls on standardized achievement tests is lower than the performance of boys. They further justified that girls earn higher grades because of their higher self-discipline. On the other hand Steinmayr and Spinath (2008) indicated that interest, motivation and personality are relevant for explaining the fact that boys perform better than girls in mathematics and other related science disciplines. However, Hyde (2005) concluded that there are more similarities than differences between males and females and argues that researchers should be aware of "overinflated claims of gender differences" (p. 590). This study among other things seeks to establish the validity of Hyde's statement in this second

decade of the 21st century using two student-centered active teaching/learning methods.

Parents, teachers, administrators and other stakeholders in education should strive at helping students to achieve academically. Cox (2003) commended the validity of the use of achievement tests in establishing academic success because many research studies are designed to compare the effectiveness of two or more methods, approaches or strategies of instruction. In this case, effectiveness is usually defined in terms of students' achievement at the end of a study. Thus achievement tests are the appropriate measuring instruments in such studies. A major advantage of achievement tests as posited by House (2007) is that apart from estimating the comparative effectiveness of instructional methods, they also identify areas of weaknesses in such methods. Therefore, this research employs a mathematics achievement test in studying the comparative effectiveness of flipped learning and cooperative learning in improving students' interest and achievement in mathematics in English speaking secondary schools in Cameroon. Consequently, the main concern is how to stimulate and cultivate the interest of students in mathematics lessons in English-speaking secondary schools in Cameroon. This study, among other things, attempted to find out if the cooperative learning and the flipped learning methods could be used to improve and equate interest and achievement between male and female secondary school students in mathematics. No known study (to the researcher) has attempted to compare interest and achievement of male and female secondary students in mathematics using the flipped and cooperative learning methods.

Flipped Learning.

The flipped classroom describes a reversal of traditional teaching, where students gain first exposure to new material outside of class, usually via reading or lecture videos, and then class time is used to do the harder work of assimilating that knowledge through methods such as problem-solving, discussion or debates.

(Vanderbilt University, Center for Teaching, n.d.). However, flipping may or may not always include technology.

Many teachers may have been flipping their classes by having students read text outside of class, watch supplemental videos, or solve additional problems, but according to Flipped Learning Network (2014), for flipped learning to effectively occur, "four pillars" (p. 1) must be applied in practice. These four pillars of good practice include: (1) *flexible environments* where the learning environment is physically rearranged to accommodate different types of learning and where there is flexibility in timelines for learning and assessment; (2) *learning culture* where a learner-centered approach that features student construction of personally-relevant knowledge is used. In the Flipped Learning method, there is a deliberate shift from a teacher-centered classroom to a student-centered approach, where in-class time is meant for exploring topics in greater depth and creating richer learning opportunities. Students move from being the product of teaching to the center of learning, where they are actively involved in knowledge formation through opportunities to participate in and evaluate their learning in a manner that is personally meaningful; (3) *intentional content* where content is intentionally designed to promote critical and higher-order thinking (e.g., as when one designs according to the levels of Bloom's taxonomy of the cognitive domain) in student-centered activities in and outside the classroom; and (4) *professional educator* where the instructor is an active observer who offers timely and relevant feedback and assessment, connectedness, reflection, revision, and demonstrates a tolerance for "controlled chaos" (p. 2) during live instruction.

Since 2007, the flipped learning concept was coined as "The Flipped Classroom" and began filtering down from the graduate and undergraduate levels into secondary and even elementary levels (Siegle, 2014). Siegle further reported that two science teachers in Woodland Park High School in Colorado were a driving force of the flipped concept; Jonathan Bergmann and Aaron Sams. These two decided to use

screen-capturing software to record introductory lessons and had students watch these lessons as homework. The students and their teachers would then use class time for more constructive activities. Although the flipped concept was used in education before 2007, its main purpose was to teach online courses via the internet. However, in 2012, Bergmann and Sams in their book, 'Flip Your Classroom', noted that their flipping initiative was slightly different. They began creating videos of themselves so they could increase the human or face-to-face contact with each student during class. This according to them allowed for more formative assessment, guidance on instruction, and differentiated learning.

Later on in 2008, Sal Kahn officially started his Kahn Academy, delivering step-by-step videos on mathematics and science concepts. The idea to create these videos came from the online tutoring sessions he had with his niece. He soon discovered that by recording his videos, his niece could pause, rewind, or watch the videos more than once if necessary. Khan began to reconsider what formal education could look and be like in the 21st century. With the financial support of several benefactors including Bill Gates, Khan began to create and provide more lessons for a much larger "classroom" than what had been traditionally known (Khan Academy, 2011).

In recent years, however, the concept has taken a more educationally friendly title of "Flipped Learning," where emphasis is put on the learning process that students go through in order to master content (Thoms, 2013). A greater focus has been put on the use of Bloom's Taxonomy rather than the production and distribution of videos. In the 21st century where a cry for a pedagogical shift is strongly being sounded to permit students acquire 21st century skills, teachers especially in developed nations have begun looking at the flipped learning concept as that possible shift from the traditional format to one that more closely resembles an environment in which the 'students also exist outside the classroom'.

Both the traditional (conventional) and the flipped environments design classroom learning based on Benjamin Bloom's Taxonomy for Learning model (1956); a taxonomy which has been revised by Anderson and Krathwohl (2001). According to Bergmann and Sams (2012), the traditional learning environment has not changed much over the course of the last 200 years. For the most part, students are still required to demonstrate understanding through rote memory. Typically, the lower levels of Bloom's Revised Taxonomy (Anderson & Krathwohl, 2001); Remembering, Understanding, and sometimes even Applying, are addressed within the classroom. This can include lectures, group work, or simply reading from the textbook or other material. The top levels of Bloom's Taxonomy; Analyzing, Evaluating and Creating, are then left for the student to do on their own with no other assistance other than parents and occasional classmates. This conventional learning method seeks to make students to 'master' work in the lower stages even through rote learning, which will then permit them to achieve the top stages on their own back at home. To Bergmann and Sams (2012), "the weakness of the traditional or conventional approach is that not all students come to class prepared to learn" (p. 31). Students, especially those mentioned by Bergmann and Sams, find it difficult to commit basic mathematical concepts to their memories. Consequently, higher order mathematical concepts appear to them as nightmares.

However, as the decades crept closer and into the turn of the 21st century, work environments began to change. The internet and mobile computers became more ubiquitous and access to information abundant. Presently, information no longer has to be memorized in order to be accessible. By comparison therefore, in terms of what makes a truly flipped learning environment, the lower levels of Bloom's Revised Taxonomy must be delivered and consumed outside of the regular class time. In most cases, this involves watching pre-recorded videos of lessons or reading some assigned material prior to attending class. This offers an opportunity for the class time to be focused on higher levels of cognitive work (Applying, Analyzing, Evaluating and

Creating) where students are supported by their peers and the teacher. Flipped learning does not occur haphazardly; it follows well planned stages.

Not all educators do succeed in flipping their classrooms for the purpose of learning. According to Sams and Bergmann (2013), some educators who attempt to flip their class may find it a little difficult at times. Sams and Bergmann put forward three main reasons to justify this assertion:

- The class environment may not be properly designed with the flipped learning pedagogy in mind.
- Original content that once took place during class (i.e. lectures, reading, etc.) is now pushed to outside of class time, and teachers may be finding it difficult to fully use that scheduled class time for more meaningful learning.
- Teachers' and students' inabilities to access and /or operate technology involved in the process.

New York University (NYU) (2015) outlined 6 steps which will guide and ensure the success of any flipped learning activity. Each step is accompanied by one or more questions which should be carefully considered by the instructors.

Step 1: Define content scope, learning objectives and instructional methods. The success of a flipped class depends on the alignment of what the instructors want their students to accomplish before, during, and after the class.

What is the scope of the topic? Defining scope is important so that students will not have difficulty building a mental model and connecting content. One of the biggest challenge is to determine how much of the subject matter can be taught within the time frame. The teacher should think in terms of the amount of time needed to cover the material and time needed for the students to really learn it through application. Concept maps are useful exercises to help define scope as well as demarcate clusters of sub-topics that can be turned into digestible lessons. Each lesson should logically build or connect to the next within the sequence of the learning experience.

How will students use or apply the material? The learning objectives and outcomes that align with the activities students will do before, during, and after the class should be clearly defined. It is not enough for students to just read, listen, watch videos and take notes. They need to make use of what they learn in order to really learn it. NYU (2015) recommended the use of the Revised Bloom's Taxonomy for selecting higher order action verbs to help write the learning objectives, with the following questions further guiding the formulation of worthwhile flipped learning objectives: What are students expected to know and be able to do? And how can what they know and are able to do be assessed? How will students meet the learning objectives? Which instructional approach will best fit the learning activity? How can the topic be contextualized?

Step 2: Students gain familiarity with new material before class. What instructional materials and resources will be used for students to familiarize themselves with the content prior to class? The teacher should carefully plan and prepare the new instructional materials that students will engage with prior to class. The best way to communicate and present the new instructional material prior to class (e.g., video, text, animation, simulation, online multimedia module, etc) should be sorted while ensuring that students are able to process the content in the chosen format effectively.

Step 3: Activities that motivate students to prepare before class. What kinds of activities will motivate students and prepare them for class? In selecting such activities, the teacher should bear in mind the learning objectives and tasks outlined in step 1. They should be able to determine the incentive or motivation that can enable students to better prepare for class and how they will be able to determine whether or not students have adequately prepared for the in-class activity. Below are some examples of ways to motivate students to do the pre-class work as outlined by Ferriman (2014).

Ask students to:

- respond to open-ended questions online about the instructional material before class
- prepare questions about the instructional materials viewed or read
- prepare a presentation about the topic
- attempt to solve some problems
- prepare to write a short quiz on materials read or videos watched at home.

These examples should also provide clues to the teacher on the extent to which students are prepared for the in-class part of the lesson.

Step 4: In-class activities that provide students opportunities to deepen understanding. What kind of in-class activities will focus students on attaining higher-level cognitive abilities? While referring to the learning objectives and tasks outlined in step 1, the teacher should plan, prepare, and develop in-class activities that focus on higher level cognitive activities such as Applying, Analyzing, Evaluating and Creating. Another key element in this step involves determining if students will be working individually in the classroom as the teacher walks around and provides help, or in groups to solve outlined problems, or if the teacher and students will solve problems together as a group. However, the activity chosen will depend on the learning goals and objectives as some activities lend themselves best to certain types of content. Whatever the case, Brame (2013) insisted that getting students in the right frame of mind by introducing and explaining what will be expected of them in the flipped learning processes is one crucial function of the teacher. This is because many students may not have any previous experience with a flipped classroom and/or active learning.

Going further, Ferriman (2014) and NYU (2015) strongly recommended that the first 10 minutes of each flip lesson should be spent on the following:

- Reviewing pre-class activities to determine the extent of students' readiness for the lesson, and to identify common questions or gaps

- A question/answer session with students, influenced by the pre-class activity results
- Providing a quick three-question review quiz (based on the basic learning objectives) that can be graded or ungraded. This can serve to review and focus the students so that the information is fresh in their minds.

The remaining class time can be spent engaging in what is commonly referred to as active learning methods which can help students further process what they learned in the pre-class content. Some of the active learning methods as put forward by Prince (2004) require students to: collaborate with peers to solve problems, work on assignments, present student created content, discuss examples or case studies, debate on a topic, share and exchange knowledge between peers.

Step 5: Post-class activities that extend student learning. How will students continue the learning experience from the in-class activities to outside of class? In determining this, the instructor should again refer to the learning objectives and tasks which they outlined in step 1, in order to plan, prepare and develop the continuation of the learning experience from the in-class activity to outside-of-class individual or collaborative practices. According to Ferriman (2014), human beings hardly learn something very effectively in one instance but through practicing in many ways over an extended period of time. The teacher should therefore determine what students should do after the in-class activity to continue learning or bridge to the next topic.

Step 6: Ongoing evaluation and assessment. The flip instructor should plan for ongoing formative and summative ways to assess students' understanding and mastery. This plan should enable the teacher and their students to verify if the learning objectives are being or have been attained as the case may be.

At the end of each flipped learning experience, the teacher should also be able to evaluate the effectiveness of the implementation. Did it work? How do I know? Where the ideas communicated effectively? Were there enough opportunities for

students to practice? Was it challenging enough? The teacher should be able to freely ask for feedbacks from students on what worked well and what didn't in order to update their practices accordingly.

Ferriman (2014) and NYU (2015) suggested that if the six steps are adhered to very closely, then, teachers can obviate the possibility of obtaining negative results in their flipping experiences. This is in line with the FLN (2014) who reported that most teachers who followed the due procedure in flipping their classrooms reported higher student achievement, increased student interest and engagement, and better attitudes toward learning and school. Furthermore, many flipped teachers reported improvement in job satisfaction and felt re-energized by their heightened interaction with students.

Many teachers and some skeptics believe Flipped Learning undervalues the power of good, engaging, face-to-face Socratic teaching (FLN, 2014). Critics argue that teachers won't have the opportunity to do that kind of teaching because class time is devoted to students collaborating, student-generated and led activities, and other interactive exercises. Reacting to this, Marshall (2013) pointed out that teachers are more important than ever in Flipped Learning. However, instead of the teacher lecturing to students, their role is to "lead from behind." In other words, the teacher has the tasks of observing, providing feedback, and assessing and guiding the learners' thinking, in the best spirit of the Socratic Method. The difference, and perhaps a major benefit, according to Marshall (2013) is that this form of instruction is partly spontaneous, cannot be planned out, and is relevant for the learners at that moment. Furthermore, the learners themselves can fill these same three roles as they observe and provide feedback to each other during class and as they assess their own learning.

An instructional method is but a framework and whether it succeeds or not, depends almost entirely on the implementation (Strayer, 2012). Boring lectures can be delivered digitally almost as easily as they can be presented in class and class

time in a Flipped Learning method could be taken up with filling out worksheets and doing computerized drills. But that is not the intent nor is it inevitable. Indeed, teaching successfully in a flipped classroom is even more demanding than is traditional teaching (Marshall, 2013). Consequently, if Flipped Learning is to succeed, teachers will need to be trained and supported on how to engage students more deeply in content.

One recommendation for implementing a flipped classroom in a mathematics lesson is to provide step-by-step instructions for classroom activities to create more structure for the students (Strayer, 2009). To create more structure, a teacher could also scaffold the activities. Scaffolding in this case refers to instructions given when learning a new task where different levels of support are given, with student eventually having most or all such support removed as the activity progresses (Hogan & Pressley, 2009). According to Strayer, one effect of the flipped classroom is that students will become more aware of their own learning processes. Because of this increased awareness, students will need more time to reflect upon their activities to make connections to the course materials. Critics have however pointed out some short comings with regard to flipped learning relating to students.

Critics argue the flipped classroom method has some drawbacks for students most especially. There exists a ‘digital divide.’ According to Nielsen (2012), not all families are from the same socio-economic background and thus access to computers or video-viewing technology outside of the school environment is not possible for all students. Nielsen claimed that this method of instruction may put undue pressure on some families as they attempt to gain access to videos outside of school hours. However, this study takes into consideration such pertinent drawbacks. Additionally, flipped classrooms that rely on videos to deliver instruction suffer some of the same challenges as traditional classrooms. Students may not learn best by listening to a lecture and watching instructional videos at

home is still representative of a more traditional form of teaching. Critics argue that other approaches would be more beneficial to all students (Nielsen, 2012). Reacting to Nielsen's statement, perhaps cooperative learning may be beneficiary to many more students than is flipped learning.

Cooperative Learning.

Distinctive characteristics which make cooperative learning different from other forms of active learning according to Nnaka and Anaekwe (2007) include the facts that learners: work in mixed ability groups of four to six members; share a clear group goal that bids them together in a sink and swim together motivation; work together as a team; make decisions by consensus; contribute ideas and suggestions together; complete assignments and class work together; seek for assistance primarily from group members; are rewarded as a team by the teacher who monitors them, and evaluates how well they are working. In addition to making cooperative learning distinct, the characteristics can further enhance learning especially in the mathematics classroom, since they provide a structure for supporting one another, especially weaker members of the group, thus enabling each group to attain the set objectives. The ultimate goal of cooperative learning is therefore to allow students to get away from lecture and move towards active learning (Felder & Brent, 2007).

Teachers have the options of structuring their lessons competitively, individualistically, or cooperatively. The decisions teachers make in structuring lessons can influence students' interest, interactions with others, knowledge and achievement, and attitudes (Carson, 2000; Melitus & Morgan, 2015). In a competitively structured classroom, students engage in a win-lose struggle in an effort to determine who is best (Johnson & Johnson, 1991). In competitive classrooms students perceive that they can obtain their goals only if the other students in the class fail to obtain their own goals. Thus the mentality of 'I swim, you sink or I sink, you swim' applies in a competitive classroom. Students in independently structured classrooms work by themselves to accomplish goals unrelated to those of the other

students (Johnson & Johnson, 1991). Such classrooms display the mentality of 'we are each in this alone'. In a cooperative learning classroom, students work together to attain group goals that cannot be obtained by working alone or competitively. In this classroom structure, students discuss subject matter, help each other learn, and provide encouragement for members of the group (Melitus & Morgan, 2015). Here students develop the feeling of 'we sink or swim together'. Cooperative learning, as an instructional methodology thus provides opportunities for learners to develop 21st century skills which will enable them to be fully involved in group interactions and in harmoniously working with others from varying backgrounds. In cooperative and individualistic learning, students' efforts can be evaluated on a criteria referenced basis while in competitive learning you grade students on a norm-referenced basis (Johnson, Johnson & Smith, 2007). Going further, while there are limitations as to when and where one may use competitive and individualistic appropriately, one may structure any learning task in any subject area with any curriculum cooperatively.

According to Melitus and Morgan (2015), cooperative learning experiences promote more positive attitudes toward the instructional experience than competitive or individualistic methodologies. In addition, cooperative learning should result in positive effects on student achievement and retention of information (Uyoata, 2002; Zakaria, Chin, Daud, 2010). According to Uyoata (2002), students are more likely to acquire critical thinking skills and metacognitive learning strategies, such as learning how to learn, in small group cooperative settings as opposed to listening to lectures. In summary, Macpherson (2007) outlined the following characteristics of cooperative learning group: Lessons are structured so that learners work together to maximize their own and each other's learning; Learners work together to achieve shared goals; all members of the group strive for all group members' success; learners work in small heterogeneous groups and joint success which is evaluated by matching performance with clear criteria set in advance, is celebrated. However, cooperative learning is more than simply working or putting learners in groups.

Cooperative learning is not all about working in groups. The following five key elements according to Johnson, Johnson and Smith (2007), differentiate cooperative learning from simply putting students into groups to learn:

1) Positive interdependence where team members are reliant on one another to achieve a common goal, and the entire group suffers the consequences if one member fails to do their work. Thus teachers can only succeed in structuring positive interdependence when students begin to perceive that they 'sink or swim together'. This can be achieved through mutual goals, division of labor, dividing materials, roles, and by making part of each student's grade dependent on the performance of the rest of the group. Group members must believe that each person's efforts benefit not only themselves, but all group members as well.

2) Individual accountability where each member of the group is held accountable for doing their share of the work. The essence of individual accountability in cooperative learning is that 'students learn together, but perform alone'. This ensures that no one can 'hitch-hike' on the work of others. A lesson's goals must therefore be clear enough such that students are able to measure whether (a) the group is successful in achieving them, and (b) individual members are successful in achieving them as well.

3) Face-to-face promotive interaction where, although some of the group work may be done on an individual basis, most of the tasks are performed through an interactive process in which each group member provides feedback, challenges one another, and teaches and encourages their group mates. Important cognitive activities and interpersonal dynamics only occur when students promote each other's learning. This includes oral explanations of how to solve problems, discussing the nature of the concepts being learned, and connecting present learning with past knowledge. Thus through face-to-face promotive interaction, members become personally committed to each other as well as to their mutual goals.

4) Appropriate use of collaborative skills where students are provided with the opportunity to develop and implement trust-building, leadership, decision-making,

communication, and conflict management skills. In cooperative learning groups, students learn academic subject matter (taskwork) and also interpersonal and small group skills (teamwork). Thus, a group must know how to provide effective leadership, decision-making, trust-building, communication, and conflict management. Given the complexity of these skills, teachers can encourage much higher performance by teaching cooperative skill components within cooperative lessons. As students develop these skills, later group projects are expected to run more smoothly and efficiently than early ones.

5) Group processing in which team members establish group goals, assess their performance as a team, periodically, and identify changes that need to be made in order for the group to function more effectively. After completing their task, students must be given time and procedures for analyzing how well their learning groups are functioning and how well social skills are being employed. Group processing involves both taskwork and teamwork, with the aim of improving it on the next project.

Johnson et al. (2007), group dynamics play an important role in effective collaboration. Furthermore, positive interdependence and cooperation are key to a group's ability to accomplish a common goal, while "competitively structured groups" can be a hindrance. "Positive interdependence exists when individuals perceive that they can reach their goals if and only if the other individuals with whom they are cooperatively linked also reach their goals and, therefore, promote each other's efforts to achieve the goals" (Johnson et al., 2007, p. 16). However, as Onwuegbuzie, Collins, and Jiao (2009) pointed out, individual accountability is key to the success of the overall group and helps to prevent "social loafing", that is, reduced individual effort resulting from too much dependence on other group members. There exist different types of cooperative learning groups.

There are three commonly recognized types of cooperative learning groups. According to Johnson, Johnson & Smith (2006), each type of group has its own purpose and application.

Informal cooperative learning groups. Informal cooperative learning groups are ad-hoc groups that last from a few minutes to one class period. They are used during direct teaching (lectures, demonstrations, films, videos) to focus student attention on the material they are to learn, set a mood conducive to learning, help set expectations as to what the class will cover, ensure that students cognitively process the material being taught, and provide closure to an instructional session. While this method leads to less time for lecture, it will increase the amount of material retained by students as well as their comfort working with each other. (Johnson et al., 2006).

Formal cooperative learning groups. This type of group forms the basis for most routine uses of cooperative learning. Groups are assembled for at least one class period and may stay together for several weeks working on extended projects. According to Johnson et al. (2006), within these groups, students learn and become comfortable applying the different techniques of working together cooperatively. To Johnson et al., formal cooperative learning groups ensure that students are actively involved in the intellectual work of organizing material, explaining it, summarizing it, and integrating it into existing conceptual structures. Furthermore, they are the heart of using cooperative learning.

Cooperative base groups. Cooperative base groups are long-term (lasting for at least a year), heterogeneous groups with stable membership whose primary purpose is for members to give each other the support, help, encouragement, and assistance each needs to progress academically as well as in other aspects of their lives. Cooperative base groups provide students with long-term, committed relationships. Implementing cooperative learning tasks in such a way that students meet regularly for the duration of a course can provide the permanent support and caring that students need to make academic progress and develop cognitively and socially in healthy ways (Johnson et al., 2006).

This study makes use of Formal Cooperative Learning Groups. However, no matter what the setting is, a properly designed cooperative classroom evolves in stages. Following well designed steps is critical to ensuring that the five key elements that differentiate cooperative learning from simply putting students into groups are met. Nwagu and Nzewi (2008) put forward the following five steps to be followed in the application of any cooperative learning method:

- Brief the students on the topic, objectives, contents and learning activities.
- Group students into small intellectually heterogeneous groups. The groups should have an equal mix of brilliant, mediocre and dull students.
- Challenge the group members to help motivate and guide each other since individual performance will be aggregated and averaged to obtain group performance which will be shared by all members of a particular group.
- Provide frequent feedback through formative evaluation, to enable students process their progress towards the set goal.
- At the end of the exercise, conduct final assessment and determine the group means scores which are shared by the members of the respective groups.

How these steps are implemented is another major concern in the cooperative learning classroom.

Researchers all over the world have been studying practical applications of cooperative learning principles and as a result many cooperative learning methods are in practice today. Slam (2015) has discussed some of the most researched and widely used cooperative learning methods with all the cooperative learning methods sharing the idea that students work together to learn and are responsible for their teammates' learning as well as their own. He divides these methods into the following categories:

1. *Student Team Learning Methods* which include: Student Team-Achievement Divisions (STAD), Teams-Games-Tournaments (TGT) and Jigsaw II.
2. *Other Cooperative Learning Methods*, encompassing: Circles of Learning,

Jigsaw, Jigsaw III, Group Investigation, Complex Instruction, Team Accelerated Instruction (TAl), Cooperative Integrated Reading and Composition (CIRC) and Structured Dyadic Methods.

3. *Informal Methods* include: Spontaneous Group Discussion, Numbered Heads Together, Team Product, Cooperative Review and Think-Pair-Share.
4. *Group Discussion and Group Projects* which include, Discussion Groups and Group Projects.

Due to the fact that the focus of this study is not only on cooperative learning, only the STAD which is within the scope of this study has been elaborated upon.

Implementation of the Student Team-Achievement Divisions (STAD) in the classroom. According to Slam (2015), STAD has been used in every imaginable subject, from mathematics to language arts to social studies and science, and has been used from the primary school through college. Thus it is most appropriate for teaching subjects with well-defined objectives. STAD is a general method of organizing the classroom rather than a comprehensive method of teaching any particular subject. Teachers are expected to use their own lessons and other materials within the STAD classroom. STAD is one of the simplest of all cooperative learning methods, and is a good method to begin with for teachers who are new to the cooperative approach. Slam described the implementation of STAD in the following five steps namely: class presentations, teams, quizzes, individual improvement scores and team recognition.

Class presentations: Material in STAD is initially introduced in a class presentation. This is most often done by direct instruction or a lecture- discussion conducted by the teacher, and could also include audiovisual presentations. Class presentations in STAD differ from usual teaching only in that they must be clearly focused on the STAD unit. In this way, students realize they must pay careful attention during the class presentation, because doing so will help them do well on the quizzes, and their quiz scores determine their team scores.

Teams: Teams are composed of four to six students who represent a cross-section of the class in terms of academic performance, sex, and race or ethnicity. The major function of the team is to make sure that all team members are learning, and more specifically, to prepare its members to do well on the quizzes. After the teacher presents the material, the team meets to study worksheets or other material. Most often, the study involves students discussing problems together, comparing answers, and correcting any misconceptions if teammates make mistakes. The team is the most important feature of STAD. At every point, emphasis is placed on team members doing their best for the team, and on the team doing its best to help its members. The team provides the peer support for academic performance that is important for learning and it provides the mutual concern and respect which are important for such outcomes as inter group relations, self-esteem, and acceptance of main streamed students.

Quizzes: After approximately one to two periods of teacher's presentation and one to two periods of team practice, the students take individual quizzes. Students are not permitted to help one another during the quizzes. Thus, every student is individually responsible for knowing the material. The quiz scores of each student contribute to their individual group scores.

Individual improvement scores: The idea behind the individual improvement scores is to give each student a performance goal that can be attained if they work harder and perform better than in the past. Any student can contribute maximum points to his or her team in this scoring system, but no student can do so without doing his or her best work. Each student is given a 'base' score, derived from the student's average past performance on similar quizzes. Students then earn points for their teams based on the degree to which their quiz scores exceed their base scores.

Team recognition: Teams may earn certificates or other rewards if their average scores exceed a certain criterion. Students' team scores may also be used to

determine up to 20 percent of their grades. Although cooperative learning has the potential of improving students' achievement (Johnson et al., 2007) its drawbacks also abound.

Slavin cited in Slam (2015) identified the following pitfalls related to cooperative learning:

Free rider: If not properly constructed, cooperative learning methods can allow for the "free rider" effect, in which some group members do all or most of the work (and learning) while others go along for the ride. The free-rider effect is most likely to occur when the group has a single task, as when they are asked to hand in a single report, complete a single worksheet, or produce one project.

Diffusion of responsibility: Diffusion of responsibility is a situation in which students who are perceived to be less skillful are ignored by other group members. For example, if a group's assignment is to solve a complex mathematics problem, the ideas or contributions of students believed to be poor in mathematics could be ignored or brushed off, and there is little incentive for the more active participants in the problem-solving activity to take time to explain what they are doing to the less active group members.

Learning a part of task specialization: When each group member is made responsible for a unique part of the group's task, as in Jigsaw, Group Investigation and related methods, there is danger that students may learn a great deal about the portion of the task they worked on themselves but not about the rest of the content. However, according to Slaven, these dangers are automatically controlled within the Student Team-Achievement Divisions (STAD) method of cooperative learning.

Empirical Studies

Effect of Cooperative Learning Method on Students' Achievement and Interest.

The effects of cooperative learning on academic achievement have been well documented and research suggests that cooperative learning produces greater student achievement than the conventional learning methodologies. Researchers have analyzed the effectiveness of cooperative learning with regard to academic achievement, interest, social adjustment and psychological health. There is excessive empirical support in favour of cooperative learning as an important contributor for higher academic achievement, interest, positive social relations and healthy psychological norms. Indeed, Seymour (2006) reported that a review completed by Slavin in 1984 indicated that 63% of all cooperative learning studies analyzed showed increases in academic achievement. This section reviews studies carried out in cooperative learning in relation to academic achievement, interest, gender and other variables.

Kolawole (2008) carried out a study on the effects of cooperative and competitive learning approaches on academic performances of Nigerian students in mathematics. The main purpose of the study was to investigate which of these methods produced better results in the teaching-learning of mathematics. The study further investigated the extent to which gender affected learning outcomes in these approaches. The sample of the study constituted of 400 senior secondary three (SS III) mathematics students, 240 boys and 160 girls randomly, selected from four out of five states in South West Nigeria. The study adopted a quasi experimental design where Pre-Test Achievement Test (PTAT) and Post-Test Achievement Test (PAT) were used in collecting data. The data collected was subjected to z-test analysis at $\alpha=0.05$ level of significance. The analysis revealed that mathematics students taught with cooperative learning method performed significantly better than those taught with competitive learning method. The results further revealed that boys performed

significantly better than girls in competitive learning method while girls were significantly better than boys in the cooperative learning method.

Another study on cooperative learning was carried out by Zakaria, Chin and Daud (2010). The purpose of the study was to determine the effect of cooperative learning on mathematics achievement and interest towards mathematics. This quasi experimental study was carried out on two form one classes in Miri, Sarawak. One class (n = 44) was assigned to an experimental group and the other (n = 38) was assigned to a control group. The two groups were pre-tested prior to the implementation. No initial differences in achievement were established between the two groups. During the experimental process, daily quizzes were used as a tool for formative testing. At the end of the study, which lasted for two weeks, a post test was given and the data was analyzed using the t-test. Performance was determined by comparing the mean of the post test for treatment and control groups. The results of the study showed that cooperative learning methods improve students' achievement in mathematics. It also showed higher interest levels towards mathematics for students in the experimental group.

Nawaz, Hussain, Abbas and Muhammad (2014) have further demonstrated how cooperative learning can influence performance in relation to gender at the basic level of education. The main purpose of the study was to find out the effect of cooperative learning on the academic achievement and academic self-concept of the students at the elementary school level. The study also investigated these effects across gender. In this study, all the 5^{th} class students comprised the population of the study. The sample of the study consisted of 40-pupils of class 5 selected randomly and equated on the basis of pre-test from Nayab English medium School Dera Ismail Khan. Two instruments were used for data collection. One was a self-made academic achievement test which was made valid and reliable through experts' views. This test was to check academic achievement after the experiment. The second instrument was a Self-description Questionnaire prepared by the researcher. This was used to check the academic self-concept of the students. The results showed that the Cooperative

learning method was better than the lecture method in the development of academic achievement and academic self- concepts of the students. With regard to gender, the self-concept of females was significantly better than that of males, while there was no significant difference on academic achievement across gender.

Effandi et al. (2013), using a quasi experiment, studied the effects of cooperative learning on students' mathematics achievement in secondary schools in Pekanbaru, Indonesia. In addition, this study also determined students' perception concerning cooperative learning. The sample of this study consisted of 61 Form Three students. In order to control initial differences of the dependent variables in the groups, a pre-test was given before treatment. After treatment, a post-test was administered to both groups. Two types of instruments were used to collect the data: the mathematics achievement test and open-ended questions on cooperative learning. The pre-test and the post-test data were analyzed using t-test while content analysis was used for the open-ended questions on cooperative learning. The results showed that there was a significant difference in the means of students' mathematics achievement for the cooperative group and the traditional group, with the cooperative group having a higher mean. Content analysis data revealed that students in the cooperative group were able to increase their understanding and to develop self-confidence in mathematics.

On his part, Opara (2002) sought to investigate the efficacy of self-regulation process on students' interest in quantitative chemical analysis. A quasi experimental pretest-posttest control group design was used for the study. The sample consisted of two hundred and eighty four (284) SS III students drawn from four secondary schools in Orlu education zone of Imo state. The data collected were subjected to ANCOVA. It was found that teaching method had a significant bearing on the interest of students in quantitative chemical analysis. Furthermore, self-regulation enhanced the interest of students in the experimental group more than the students in the traditional group. The reason for this observation could be due to the fact that the stages used in the process

of self-regulation were meant to actively involve the learner, as well as create an environment in which equilibration can occur in the minds of learners. Furthermore, this result could also be due to the local materials used, which were intended to enable students link them with classroom activities.

Another empirical study reviewed is that of Uchendu (2005), carried out in Anambra state, Nigeria. The study was titled "effects of two types of learner-learner interaction on students' achievement and interest in physics in a problem-based learning context". It was a non-equivalent control group design with two experimental groups and one control group. A total of 458 SSII physics students constituted the sample of the study. Data was collected using a Physics achievement test and a physics interest inventory. Ten hypotheses were formulated and the analytical techniques employed in testing them at a 0.05 level of significance were 2-ways and 1-way MANCOVA. A Scheffe test was further used to determine the level of significance between the group means. The findings of the study revealed that learner-learner interaction patterns vis-a-vis cooperation interaction and peer interaction have significant effects on the students' achievement and interest in physics. Furthermore, cooperative interaction appeared to have better outstanding effects. The researcher therefore recommended its inclusion in the science curriculum and for science teachers to popularize its use.

Using interest and attitude as independent variables in their study, Adodo and Gbore (2012) measured and predicted the effects of attitude and interest of students on academic performance in mathematics. Their study specifically investigated which of these two variables predicted students' performance in mathematics. Three instruments were used to collect data for the study: Science Oriented Attitude Scale (SOAS), Science Vocational Interest Inventory (SVII) and Achievement Test in Integrated Science (ATIS). The study adopted a quasi-experimental design using a sample of 30 JS I Students. Multiple regression was used to analyze the data and the outcome showed that Interest in mathematics possessed the stronger strength for predicting performance than attitude among the students in their different ability level

groups. The researchers therefore recommended that, teachers should use good innovative methods that will stimulate students' interest in an attempt to make learning of mathematics more meaningful to the learners and thereby generating improved learning outcomes that will lead to a change of students' attitude towards mathematics. Their recommendation is a bearing for the use of flipped learning and cooperative learning methods in this present study.

In the past 90 years, over 1000 studies have been conducted on cooperative learning methods (Robert et al., 2013). Unfortunately, most of the research findings in cooperative learning that appear on the research horizon of education according to Groff (2009) belong to USA, Israel, German, Japan, UK, Australia and some other developing countries of Africa and Asia. No such studies in mathematics have been located in Cameroon, even though the review suggests that cooperative learning is an effective teaching-learning method.

Effect of Flipped Learning Method on Students' Achievement and Interest.

Strayer (2009) conducted a study to see in what ways he could reach more students. In his mixed-method study involving 49 students at the undergraduate level, Strayer used extensive qualitative surveys in two separate classes. One classroom was taught a course using the traditional method while another classroom was taught the same course using the flipped method. The same content was covered in both classes and the same assessments were used. However, in the flipped method, Strayer offloaded his lectures by recording them and providing them online. The quantitative data from the study revealed that students' personal learning styles were being met. This was evident in the personalization section of the scale used for the study. Personalization for students in the traditional classroom scored a mean of 3.74/5 while the flipped section scored a mean of 4.17. Students remarked similarly in the qualitative discussions that took place at the end of the course with the majority of students strongly in favour of the flipped environment. However, Strayer noted that

one limitation may have been that students were not completely honest with their comments due to the fact that the researcher was also the instructor for the course.

Pearson Education Inc. (2013) reported on Clintondale High School and the results the school had from their flipped initiative. Clintondale was a school with unsatisfactory pass rates in the core content areas of math (56%), English (48%), science (59%), and social studies (72%). Using the pass rate as an indicator of achievement, Clintondale initially tested the flipped concept in a social studies classroom. The exact number of students involved was not reported. At the end of the course, there was a 100% pass rate reported. Given the results, the high school then quickly expanded the flipped concept to all freshmen classes and witnessed similar results. The following school year, all 553 students were learning in flipped environments. The school reported an increase of between 9%-19% subject pass rates from the previous year. The teachers in this case study followed the same flipped format of providing lecture videos or reading task outside of class and creating more collaborative and constructive activities within the class. Through the use of questionnaires, teachers and students also noted a significant increase in face-to-face time, which they perceived to contribute to the increase in pass rates.

Byron High School in rural Minnesota also flipped their secondary level environments for academic purposes. Fulton (2013) and Pearson Education Inc. (2013) reported that the flip was due to budget cuts which spurred the need for change. With only 30% of the 525 students proficient in mathematics, the school decided to shift the content delivery away from textbooks and use more frugal means to create an impact on achievement. During the course of a summer, five math teachers met daily to create videos and organize the lessons using Moodle, a free online Learning Management System (LMS). One year of using the flipped concept in all five math courses resulted in a 12% increase in proficiency in Algebra 2, an 11% increase in Pre-Calculus, and a 9% increase in Calculus 1. Surveys sent to all parents and students involved in the flipped courses also reported a 95% favour for the flipped

environment over the traditional one. Thus a mixed-method of data collection was employed and judging from the data, Fulton and Pearson Education Inc. established that the flipped learning environment was more effective than the traditional one.

In a study of 75 students in an undergraduate psychology course, Talley and Scherer (2013) found that by flipping the environment, they were actually able to provide more of the student-paced self-assessments in conjunction with the videos. By using an online resource called Quizlet, students could receive real-time formative feedback on their understanding of the content. In the qualitative survey, students noted the quizzes were an integral part in being more prepared for the in-class activities. As a result, Talley and Scherer (2013) reported a 9% increase in final exam scores. However, these scores were collected from one year to the next with a different sample set of students in each. Providing quizzes in conjunction with the video lectures boosted student motivation to complete the out of class materials (Talley & Scherer, 2013; McLaughlin et al., 2013; Strayer, 2009). Furthermore, proper preparation for in-class activities was also essential for increased student achievement.

Tune, Sturek and Basile (2013) used a similar method in their mixed-method study of 27 graduate students in a medical course. The 27 students were split into two sections: traditional method (n=14) and flipped method (n=13). In the flipped method, students were expected to watch recorded video lessons and/or read assigned materials. Quizzes took place every day and were calculated as 25% of their overall grade. These quizzes would then determine the necessary steps for further instruction during the remainder of class time. At the end of the course, when both sections took the exact same final exam, students in the flipped method scored significantly higher ($p < 0.05$) than those in the traditional method. However, these results could have also been attributed to the fact that class attendance was emphasized in the flipped method and factored into the final course grade.

How class time is used in flipped learning depends on what learning standards the instructor wants to achieve. An in-class activity that was developed to increase student achievement was the use of problem-based learning. Wilson (2013) incorporated such activities in her undergraduate statistics course. Students were expected to come to class after having reviewed the online materials. Wilson then provided the students with several real-world examples and problems to solve where they had the option to work in small groups. With the extra in-class time, Wilson also required students to present their findings to the entire class. At the end of the semester, students scored an average of 6.73 points higher than the previous year on the final exam. Wilson's findings of improved achievement and perceived engagement match those of other studies that used similar problem-based learning methods within the allotted class time (Davies, Dean & Ball, 2013; Gaughan, 2014; Rowe, Frantz, & Bozalek, 2013; Willey & Gardner, 2013).

DesLauriers, Schelew and Wieman (2011) have also published evidence that flipping the classroom can produce significant learning gains. They compared two sections of a large-enrollment physics class. The classes were both taught via interactive lecture methods for the majority of the semester and showed no significant differences prior to the experiment. During the twelfth week of the semester, one section was flipped, with first exposure to new material occurring prior to class via reading assignments and quizzes, and class time devoted to small group discussion of clicker questions and questions that required written responses. Although class discussion was supported by targeted instructor feedback, no formal lecture was included in the experimental group. The control section was encouraged to read the same assignments prior to class and answered most of the same clicker questions for summative assessment but were not intentionally engaged in active learning exercises during class. During the experiment, student interest increased in the experimental section (from 45 ± 5% to 85 ± 5% as assessed by four trained observers) but did not change in the control section. At the end of the experimental weeks, students completed a multiple choice test, resulting in an average score of 41 ± 1% in the

control classroom and 74 ± 1% in the flipped classroom. Although the authors did not address retention of the gains over time, this dramatic increase in students' achievement and interest supports the use of the flipped classroom method.

Another study on the flipped classroom was conducted by Toto and Nguyen (2009). In this flipped classroom, students watched a 30-minute video lecture in an engineering course prior to in-class activities. As a result, there was additional free time in class, which was spent using real-world tools and engaging in practical applications. This classroom was found to have increased student engagement. Furthermore, students had more opportunities to gain a sense of how the tools and ideas they were learning are used in the real world. Consequently, the success rate in that course improved as compared to that of the previous year. Toto and Nguyen attribute these positive results of their flipped experience to the effective use of class time.

The studies reviewed in this section suggest that the flipped learning method, when effectively implemented, also has the potential of improving students' interest and achievement in mathematics. Unfortunately, no such study is known to have been carried out in Cameroon. Thus the researcher was interested in comparing the effectiveness of this technologically friendly and less researched method with the much researched cooperative learning method, in enhancing students' interests and achievements.

Effect of Gender, Interest and other Active Teaching-learning Methods.

Gender has been an important moderating variable in many educational studies especially those related to instructional methods. This, according to Guthrie (2003), is because being aware of the differences in learning styles between males and females, makes it imperative for teachers to learn more about how these two sexes learn and disseminate information. Teachers further learn how to reach out to them on personal and academic levels, in order to help them utilize their potentials appropriately.

Information, feelings and emotions are processed differently by males and females. Wylde as cited by Martins-Umeh (2012) suggested that an emotion quickly moves into women's limbic system and expeditiously reaches the upper level of the woman's brain where the thinking process takes place. On the other hand, when men receive information, it is immediately conveyed to the lower part of the limbic system, in the area of the brain stem. Consequently, females have a tendency of handling anxieties better than males. They do so by merely discussing the issues at stake either with their fellow students, family members or friends. Martins-Umeh further reported that studies on talented youths from Johns Hopkins University indicate that students differ on the basis of achievement, endurance and affiliation. These dissimilarities are linked to gender differences.

Martins-Umeh (2012) cited Anaekwe as reporting that men have achieved more than women and that not even the most dedicated feminist can deny this fact. He further supported his position by indicating that men have achieved more than women not only in sciences, arts, business, engineering, but they have excelled even in traditional feminist fields such as cooking, dress making, hair dressing and interior decoration.

Contrary to the above findings, Lloyd, Walsh and Yallah (2005) found that girls' achievement in mathematics met or exceeded that of boys. With regard to performance attribution, they found that incidences of failure to achieve as expected in mathematics was as a result of inappropriate teaching methods employed by mathematics teachers. They recommended the use of teaching approaches which should facilitate the learning process for both males and females, asserting that teachers should be mindful that every student may not be able to comprehend new information unless their teaching methods, styles and approaches match the different learning styles that are dominant among each gender.

Again, Laidra, Pullman and Allik (2007) investigated the predictors of academic achievement using a sample of 3618 students (1872 girls and 1746 boys) in Estonia. The outcome of the study revealed that gender was not a significant predictor

of academic achievement. Rather, intelligence as measured by the Raven's standard progressive matrices was found to be the best predictor of academic achievement of students in relation to their GPA.

A similar study was carried out by Naderi, Abdullah, Hamid and Sharir (2008) on the effects of gender, intelligence and learning methods on the academic achievement of undergraduate students in Iran. With a sample of 153 students constituting 105 males and 48 females, the findings showed that gender was not a predictor of academic achievement.

Martins-Umeh (2012) carried out a study to investigate the relative effectiveness of Vygotsky's collaborative and conventional approaches on junior secondary school students' achievement in social studies and the acquisition of social skills. The study also sought to find out the effects of gender on students' achievements and the interaction effect of teaching methods and gender on students' achievement. It was carried out in Anambra state and adopted the non equivalent control group design. The study used a sample size of 126 students with 71 males and 55 females. Two instruments; the Social Studies Achievement Test (SSAT) and the Social Skills Inventory (SSI) were used for data collection. Means, standard deviations and ANCOVA were used to analyze the data collected. The results showed that students in the collaborative approach group had higher means in both social studies and the acquisition of social skills. Gender did not significantly affect students' achievement in the use of collaborative approach in social studies. Furthermore, teaching methods and gender had no significant interaction effect on students' achievements in social studies. The study recommended the adoption of the Vygotsky's collaborative approach in the teaching of social sciences.

Another empirical study reviewed on active methods of teaching is that of Okigbo (2010), carried out in Awka and Ogidi education zones of Anambra state, Nigeria. The study was titled "comparative effectiveness of mathematical games and instructional analogy as advanced organizers on students' achievement and interest in mathematics". It was a quasi experimental design with two experimental groups and

one control group. A total of 246 students constituted the sample of the study. Data was collected using a mathematics achievement test and a mathematics interest inventory. Data was analyzed using means, standard deviations and MANCOVA. The findings of the study revealed that: game and bridging analogy teaching enhanced both the achievement and interest of students in mathematics more than the lecture method; no significant difference exists in the achievement and interest of male and female mathematics students taught with either game or analogy; no significant interactions exist between teaching methods and gender on both students' achievement and their interest. The researcher recommended that mathematics teachers should use games and analogy teaching before, during and after mathematics lessons, in order to relate mathematics to real life.

Some researchers therefore report gender differences in academic achievement in favour of boys, others in favour of girls while others do not find any gender differences in academic achievement. This therefore suggests that sex related differences in mathematics may be complex and multivariate, and thus requiring an investigation within Cameroonian secondary schools especially with the use of active learning methods such as cooperative and flipped learning methods, which deviate from the conventional learning method.

Summary of Review of Related Literature

Literature was reviewed under four major sections namely: Conceptual Framework, Theoretical Framework, Theoretical Studies and Empirical Studies.

Key concepts of the study were reviewed. These included: academic achievement, interest, flipped learning and cooperative learning. The review showed that mathematics is a language consisting of concepts, facts, principles and operations which enable us to decode information and carry out calculations that are fundamental to human existence. It further showed that students' interests and academic achievements in mathematics are greatly influenced by the teaching and learning methods employed.

With regard to theoretical framework, this study hinged on Bloom's Taxonomy. The review suggested that in flipped learning, the lower levels of the Bloom's taxonomy are handled out of class sorely by students while the higher levels are handled by both teachers and students during class time. On the other hand, the cooperative learning method is structured such that students work in teams on concepts at all the levels of the Bloom's taxonomy, with the teacher offering regular interventions especially on concepts at higher levels of the taxonomy. The handling of different levels of Bloom's taxonomy at different points during the same lessons in the flipped and cooperative learning methods could possibly enhance mathematics learners' interests and achievements differently within these methods.

Empirical studies reviewed indicated that the flipped learning and the cooperative learning methods, when effectively implemented, have the potential of improving students' interests and achievements in mathematics. Furthermore, sex related differences in mathematics appear to be complex and multivariate as some researchers reported gender differences in academic achievement in favour of boys, others in favour of girls while others did not find any gender differences in academic achievement. This study therefore embarked on comparing the effectiveness of the flipped and coorperative learning methods in enhancing students' interest and achievement within Cameroonian secondary schools with gender as a moderating variable.

The literature reviewed indicated that no experimental study (known to the researcher), either on flipped learning or on cooperative learning in mathematics has been carried out in Cameroon. Furthermore, no single study comparing the effectiveness of these two teaching-learning methods in enhancing students' interest and achievement in mathematics was located. Lastly, according to FLN (2014), quantitative research on flipped learning is limited. These are gaps the present study intends to fill.

CHAPTER THREE

METHOD

The detailed description of the procedure used in the study is presented in this chapter under the following sub-headings: research design, area of the study, population of the study, sample and sampling techniques, instruments for data collection, validation of the instruments, reliability of the instruments, control of extraneous variables, experimental procedure, administration and scoring of the instruments, and method of data analysis.

Research Design

This study adopted a quasi experimental design. Specifically, the design used was a 2×2 factorial pretest-posttest non-equivalent group design. This is because the administrative set up of the schools is such that the classroom groupings and the rigid time tables could not be disorganized for the purpose of the study. Thus intact classes were randomly assigned to experimental and control groups. The design could be represented symbolically as in Figure 3.

Group	Pre-test	Treatment	Gender	Post-test
Flipped Learning Method (E_f)	O_1	X_1	M	O_2
	O_1	X_1	F	O_2
Cooperative Learning Method (E_c)	O_1	X_2	M	O_2
	O_1	X_2	F	O_2

Figure 3: Design of the Study

Where O_1 is the Pre-test administration

O_2 is the Post-test administration

X_1 is the Treatment of Experimental Group on Flipped Learning (E_f)

X_2 is the Treatment of Experimental Group on Cooperative Learning (E_c)

M = male

F = female

Area of the Study

This study was carried out in Cameroon. Cameroon is located in Central Africa and is bounded by Nigeria, Chad, Central African Republic, Congo, Gabon, and Equatorial Guinea (See Appendix C, p. 126). The country has ten regions, two of which are English-speaking (North West and South West Regions). The other eight regions are French-speaking. Consequently, two subsystems of education exist in Cameroon; the English subsystem of education used mostly in the two English-speaking Regions, and the French subsystem of education, used mostly in the other eight French-speaking Regions. Each Region is further partitioned into Divisions, giving a total of 58 Divisions for the entire country. This study was conducted in Mezam Division, found in the North West Region of Cameroon. The capital of Mezam Division which coincidentally is also the capital of the North West Region of Cameroon is Bamenda (See Appendix C, p. 126). While Mezam Division is essentially an English-speaking division, it is a business, academic and socio-cultural melting pot in Anglophone Cameroon, attracting French-speaking Cameroonians as well as foreigners.

Mezam Division is made up of seven subdivisions namely: Bamenda I, Bamenda II, Bamenda III, Bafut, Bali, Santa and Tubah subdivisions. Each of these subdivisions is dominated by schools with English as the primary language of instruction (English-speaking schools) alongside a few French-speaking schools. The public English-speaking secondary schools are either a Government Secondary School (GSS) (having only forms 1 to 5 – first cycle), a Government High School (GHS) (having lower and upper sixth classes- second cycle, in addition to the first cycle), a Government Bilingual Secondary School (GBSS) (first cycles of the English-speaking

and French-speaking sections coexisting) or a Government Bilingual High School (GBHS) (first and second cycles of the English-speaking and French-speaking sections coexisting). These schools are all co-educational. The distribution of English-speaking secondary schools in Mezam Division by subdivision and school type are shown in Appendix D (p. 127). The choice of Mezam Division was considered appropriate because according to the Director of the GCE Board Regional office in Bamenda and from available statistics (See Appendix E, p. 128), Mezam Division provides the majority of candidates for the GCE Examinations yearly, compared to the other 57 divisions in Cameroon.

Population of the Study

The population of the study was made up of all the Form Three students in the 46 English-speaking public secondary schools in Mezam Division. The population size was 5348 students with 2684 females and 2664 males (Source: Divisional Delegation for Secondary Education in Mezam Division- 2016).

The choice of Form 3 was because this is the class in which the actual General Certificate of Education Ordinary Level (GCE O/L) mathematics examination programme begins. The interest of students in mathematics at this level could also be cultivated and sustained before they get deep into the GCE programme. Furthermore, most students at this level can successfully operate (Play, Pause, Replay, Rewind, etc) a Video CD or flash drive either on a desktop, laptop or TV player. They are also able to organize themselves for small group activities better than those of the junior classes. All these were required during this study.

Sample and Sampling Techniques

The sample of the study consisted of 87 Form Three students. Using the multistage sampling procedure, in three stages, the sample was arrived at through a combination of simple random and purposive sampling techniques.

Stage one. Through simple random sampling technique, two subdivisions were selected from the seven subdivisions that make up Mezam Division. The two subdivisions include Santa and Bamenda II. Through simple random sampling technique again, each of the two groups (flipped, cooperative and control groups) were allocated to one of the two subdivisions above as follows: Cooperative learning group (E_c) to Santa and Flipped learning group (E_f) to Bamenda II.

Stage two. Due to the fact that the flipped learning method required electricity and computers or televisions, a school (GBHS Mankon), judged by the researcher to be able to meet the above requirements, was purposively selected from Bamenda II subdivision to host the experimental group on flipped learning (E_f). Through simple random sampling, a school was then obtained from the other subdivision (GHS Akum from Santa). This school was to host the experimental group on Cooperative Learning (E_c) (See details on Appendix F, p. 129).

Stage three. The entire exercise in stages one and two gave rise to two schools. The simple random sampling technique was then used in each of these schools to select a Form Three class to be used for the study, since each of the schools has more than one intact class in Form Three. Thus the 87 students who constituted the sample of this study are as distributed on Appendix F (p. 129).

Instruments for Data Collection

Two instruments were developed and used to collect relevant data required to answer the research questions as well as to test the hypotheses for this study. They are: Mathematics Interest Inventory (MINTIV) and Mathematics Achievement Test (MAT).

Mathematics Interest Inventory (MINTIV). The items of the MINTIV were adapted from Okigbo's (2010) Mathematics Interest Inventory (Mintiv). The final MINTIV had 20 items (See Appendix G, p. 130), selected from the originally modified and constructed 32 itemized MINTIV (See Appendix H, p. 132), alongside

an introductory letter (See Appendix I, p. 141). A major modification of Okigbo's Mathematics Interest Inventory was in the personalization and change of the scale from a five point to a four point response type scale as follows:

- I Like Very Much (**LVM**), if the student likes very much to engage in the activity.
- I Like (**L**), if the student likes to engage in the activity.
- I Dislike (**D**), if the student dislikes engaging in the activity.
- I Dislike Very Much (**DVM**), if the student dislikes very much to engage in the activity.

The options for the MINTIV, that is, LVM, L, D and DVM were weighted 4, 3, 2 and 1 respectively for positive items. An individual's interest score was obtained by summing the scores for all the twenty MINTIV items.

Mathematics Achievement Test (MAT). The items of the MAT (Multiple Choice Questions) were drawn from past GCE O/L mathematics examination, mock GCE examination and Form Three common mock examination question papers. Each item has four options among which are three distracters and one correct answer. There are 20 items based on the topics and content which the students covered during the period of the experiment which lasted for six weeks. The items cover the topics on Indices, Inequalities, Algebraic expressions, Transposition of formulae and Triangles in the Form Three scheme of work.

The 20 objective test items were used for both the pretest and posttest. However, the pretest items (See Appendix J, p. 142) were reshuffled and the paper colour changed from white to green before being administered as a posttest (See Appendix K, p. 145). The 20 test items also covered different mental skills as indicated on the Table of specifications (See Appendix L, p. 148). While lesson plans and a DVD containing mathematics lessons were used in teaching, the MAT was used to determine students' achievement levels before and after treatment of the

experimental groups. The pretest was also used to verify the existence or non existence of initial group differences in achievement.

Validation of the Instruments

This is concerned with the extent to which the research instruments (MAT and MINTIV) measured what they were expected to measure. The validation also took into consideration the content of the Lesson Notes and the Video lessons to be used in this study since they determined the content of the MAT. The validation of the instruments was done as follows:

Lesson notes and video lessons. Sixteen lesson notes (eight for each group) were prepared by the researcher. The contents of the lesson notes were drawn from the content of a DVD (obtainable from Global Science Vision Services) on secondary school mathematics lessons on the topics covered in this study (See scheme on Appendix M, p. 149). The 16 lesson plans, the DVD, alongside the title and purposes of the study, were presented to three mathematics teacher trainers at the Higher Teachers Training College (HTTC) Bambili, who had each taught for more than twenty years. They were requested to validate the lesson plans, paying keen attention to teacher's and students' activities in the two experimental groups, and also to comment on the content of the video lessons, in relation to meeting the objectives of the study. Their comments and recommendations were taken into consideration in writing out the final lesson plans (See Appendices N and O, pp. 150-201) for the study.

Mathematics Achievement Test (MAT). The initial draft of the MAT which had 30 items was presented to the three mathematics teacher trainers alongside the lesson notes and the DVD. The validators were requested to scrutinize and comment on the clarity of the test items, appropriateness of language used, the content coverage, as well as the adequacy of the questions, in measuring achievement with regard to the level of the students. They were further requested to suggest either to retain, modify or

drop any particular items. (See Request for Validation of Instruments on Appendix P, p. 202, and the suggestions and comments of validators on Appendix Q, p. 203).

Determination of psychometric indices. A trial test was carried out to ascertain the difficulty and discrimination indices of the 30 MAT items. Thirty Form Three students from a secondary school in Bali Subdivision (GBHS Bawock) who were not involved in the study sample, were randomly selected to participate in the exercise (See Appendix R, pp. 209-212 for data). Results from the item analyses revealed that 24 (80%) of the 30 items had a difficulty index within the acceptable range of 0.30 to 0.70. Five (16.67%) of the items were too difficult as their difficulty indices ranged between 0.00 to 0.29. One (3.33%) item was too easy as its difficulty index was within the range of 0.71 and 1.00 (See Appendix R, p. 209 for details).

The discrimination indices further revealed that 27 (90%) of the MAT items discriminated highly, two (6.67%) of the items discriminated moderately, while one (3.33%) item had a low discrimination index. No item discriminated negatively (See Appendix R, p. 209 for details).

Thus the table of specifications, the comments and suggestions of validators, alongside the psychometric indices of the items were considered, based on which the final Mathematics Achievement Test of 20 items (See Appendix J, p. 142) was obtained and submitted to the project supervisor for approval.

Mathematics Interest Inventory (MINTIV). The Mathematics Interest Inventory (MINTIV) which originally had 32 items in its draft was equally given to four lecturers to scrutinize. Two experts in psychology, from the University of Bamenda (UBa) and University of Buea (UB), one expert in measurement and evaluation from University of Bamenda (UBa) and one expert in adult education from Nnamdi Azikiwe University, Awka, were each presented with the Mathematics Interest Inventory (MINTIV) alongside the title and the purpose of the study to serve as guide. These four experts were requested to vet and comment on the items of the

MINTIV in relation to their language, clarity, length, content coverage and appropriateness for assessing the elements in the construct. They were further requested to suggest either to retain, modify or drop particular items. (See Request for Validation of Instrument, MINTIV, in Appendix S, p. 213, and the ratings, suggestions and comments of validators in Appendix H, pp. 132-140). Thus the validators' comments and suggestions were considered in arriving at the final Mathematics Interest Inventory of 20 items (See Appendix G, p. 147) which was submitted to the project supervisor for approval.

Reliability of the Instruments

After validating and refining the instruments (MAT and MINTIV), the final copies were administered on 40 Form Three students in a secondary school in Bamenda III Subdivision (GBHS Atiela), who were not part of the study sample (See data on Appendices T, p. 214, and U, p. 216).

The reliability of the MAT was established using Kudder-Richardson 20 (K-R 20) method. This measure is appropriate because the items of the MAT are dichotomously scored. Thus this method yielded a reliability index of 0.73 (See Appendix U, p. 216).

On the other hand, the reliability of the MINTIV was established using Cronbach's alpha method. This method is deemed appropriate because the items of the MINTIV are polytomously scored. Thus the application of the Cronbach's alpha yielded a reliability index of 0.84 for the MINTIV (See printout on Appendix T, p. 214). The above reliability indices required just a single administration of the instruments.

The estimates of temporal stability for the MAT and the MINTIV were further determined. After two weeks, the instruments were again administered to the same 40 Form 3 students (See data on Appendices V, p. 218, and W, p. 220). The MAT posttest items were used in place of the pretest items. The two sets of scores for each

instrument were correlated using the Pearson product moment correlation coefficient (See printouts on Appendices V, p. 219, and W, p. 221). Thus two-week test-retest reliability indices were established for the instruments of this study; 0.78 for the MAT and 0.95 for the MINTIV. According to Gad (2015), if an instrument is to be administered as a pretest and also as a posttest in an experimental study, then it is very necessary to establish its stability or consistency over time.

Experimental Procedure

The study was conducted according to the normal time table of the sampled intact classes. Before starting the teaching, the MAT and MINTIV were administered by the respective class teachers (with the researcher closely monitoring the process) on their students to answer and respond to, respectively. However, no feedback on the pretest achievement was given to the students. This measure also helped in creating acquaintance between the researcher and his subjects which further helped in reducing Hawthorne effect. The class teachers for the two experimental groups were trained by the researcher before the start of the experiment. The procedure used by the researcher in carrying out this study is therefore presented in three stages.

Stage one: Training of teachers. Training of the teachers for the cooperative learning and the flipped learning groups lasted for three days each. The cooperative and the flipped lesson plans alongside other materials were used in training the respective teachers. The training sessions took place in the various schools after the regular class periods and lasted for at least two hours each day.

Experimental group on cooperative learning.

Day 1.

- Introduction and purpose of the training.

Overview and discussions on

- Cooperative learning and methods.
- Student Team-Achievement Divisions (STAD) method of cooperative learning

- Effective organization, implementation and management of students in the Student Team-Achievement Divisions (STAD) classroom.
    - pre-sensitization
    - formation of cooperative learning groups
    - face-to-face positioning of students
    - group leadership.
    - role of the students and teachers in a STAD classroom.

Day 2.

Discussions on

- The objectives and content of the cooperative learning lesson plans.
- Teacher's and students' activities in the cooperative learning classroom.
- Key elements to instill into cooperative learning groups through teacher's and students' activities in class.
- Pitfalls to watch out for in a cooperative learning classroom and how to handle them.

Day 3.

- Mini teaching with a cooperative learning lesson plan.
- Post-class interactions.
- Conclusions and closing.

Experimental group on flipped learning.

Day 1.

- Introduction and purpose of the training.

Overview and discussions on

- Flipped learning and the four pillars.
- Steps in organizing and ensuring an effective flipped learning classroom.
- Managing out-of-class activities during flipped learning.

Day 2.

Discussions on

- The objectives and content of the flipped learning lesson plans and corresponding video lessons.
- Teacher's and students' activities in the flipped learning process.

- Key elements to instill into flipped learning groups through Teacher's and students' activities in class.
- Pitfalls to watch out for in a flipped learning classroom and how to handle them.

Day 3.

- Mini teaching with a flipped learning teaching plan and corresponding video lesson.
- Post-class interactions.
- Conclusions and closing.

Stage two: Teaching of the students. After acquaintance, administration of MAT / MINTIV as pretest, and briefing/orientation of the students by the researcher and respective class teachers in the first week, effective teaching commenced in the second week. The orientation enabled each student to play his/her role appropriately during the application of the respective methods. The two groups used the same quizzes, though at different stages of the lesson. Each quiz covered the basic concepts of the lesson and lasted for five minutes. Students were informed that the quiz marks were to be considered for individual students in the case of flipped learning and for groups in the case of cooperative learning. The teaching lasted for four weeks with two contacts in each group per week following their respective class time tables. It was conducted as described below.

For the flipped learning group, students were encouraged to bring any electronic storage device (flash drive, VCD or DVD) at least three days to the mathematics lesson. This enabled the researcher and the class teacher to copy the video lesson whose content the students were required to study before coming for the mathematics lesson. This also enabled the researcher and respective class teacher to make alternative arrangements for students who did not have the possibility of watching the video lessons at home for one reason or the other; such were required to make use of the school computer laboratory. The first part of each lesson (in class) was focused on clarifying students' difficulties from the video lesson watched out of

class. To ensure that the students actually carried out their assignment of studying the content of the video lesson, they were required to write a short quiz within five minutes in each lesson relating to the content of the video watched at home. This was immediately after the clarification of their difficulties. The quiz was followed by individual and/or group work focused on higher level cognitive activities such as applying, analyzing, evaluating and creating. The teacher played a guiding role and provided step-by-step clarification of students' doubts when they were unable to proceed. The teacher also 'scaffolded' most classroom activities. This was aimed at enabling the students to better master the concepts studied in the video lesson.

With regard to the cooperative group, subjects were shared into six groups of 7, 7, 7, 7, 6, 6 members each. At the beginning of each week, some members from groups which were not active, were swabbed with others from more active groups. Group leadership changed during every lesson to ensure that every member became a group leader in at least one lesson. The grouping was done by the class teacher and took into consideration gender, age, intelligence, race, friendships, as directed by the researcher, so that each group was indeed heterogeneous in all aspects. Since this study adopted the Student Team-Achievement Divisions (STAD) method of cooperative learning, the class teacher first presented the objectives and key concepts of each lesson after which a copy of the learning task was given to each group leader with group tasks clearly defined. They were required to study concepts and solve the exercises through face-to-face interactions among group members. Furthermore, the teacher moved from group to group providing assistance where necessary and checking for the "free rider" effect and diffusion of responsibility. Groups were also encouraged to seek for assistance from the teacher. Furthermore, the teacher from time to time, intervened on some key aspects of the lesson. At the end of the learning task, groups were expected to solve some exercises. The teacher randomly selected one member from each group to present the solution to any of the exercises to the whole class. This was followed by whole class debates as to whether the solutions presented were right or wrong. Immediately after group studies, students wrote a short

quiz (same for the other groups) for five minutes. The quizzes were used to ensure that students participate actively in group activities. Students wrote quizzes as individuals but their scores in those quizzes contributed to their respective group scores. At the beginning of each week, the mean group scores were announced by the class teacher. The first three groups were recognized while the others were encouraged. This 'group responsibility' during learning and 'individual responsibility' during quizzes went a long way to check for the 'learning a part of task specialization' effect. That is, it discouraged the situation where a group member concentrates only on a unique aspect of the group's task. This therefore encouraged each group to support its members in every aspect of the learning task during the learning process**.**

Stage three: Evaluation and testing of the students. At the end of the experiment; during the sixth week from the administration of the pretests, all the students in the two intact classes were again tested using the MAT and MINTIV. Their scores in these tests served as the posttest scores for the study.

Control of Extraneous Variables

According to Akudolu cited in Martins-Umeh (2012), a major strength of the non-equivalent or non-randomized control group design is its ability to control sources of internal invalidity like history, maturation, testing instrument and selection. The researcher therefore adopted the following procedures in order to control some identifiable variables so as to increase the internal validity of the experiment.

Non-randomization effect: Due to already existing intact classes in secondary schools, randomization of research subjects into the experimental groups was not possible. Thus the Analysis of Covariance (ANCOVA) was used to analyze the data, using the pre-tests scores on the various measures as covariates. Ngozi (2009) argues that this technique makes necessary adjustments. To her, researchers who find it very difficult or impossible to equate the experimental and control groups from the onset of the experiment for one reason or the other, can easily apply ANCOVA during data

analysis at the end, in order to correct any initial differences which might have existed between the experimental and control groups.

Experimental bias: The research subjects were not taught by the researcher. They were rather taught by their respective class teachers with the same objectives for each lesson in all the two groups. Thus, although the two groups differed in the teachers' and students' activities (for the same lesson numbers) with the flipped group watching same content on video out of class and interacting (during application of video concepts) with the teacher during class time, both groups had the same objectives for each lesson. Furthermore, they both had the same number of lessons each week; two lessons, one for 40 minutes and the other, a double period for 80 minutes each week, giving a total of eight lessons taught for the six weeks in each group. The first week was used for acquaintance and pretest administration while the sixth week was used for posttest administration in both the groups.

Hawthorne effect: The Hawthorne effect also known as observer effect is a phenomenon in which individuals modify or improve an aspect of their behavior in response to their awareness of being observed (McCarney, 2007). To minimize this effect, the two intact classes involved in this study were taught by their respective mathematics class teachers. The teaching was carried out in all the classes according to their respective time tables.

Pre-test/ post-test sensitization: Pre-test sensitization was minimized by the administration of the pre-test following the normal sequence test calendar. The six week period during which the experiment was conducted, was expected to be long enough to eliminate the possibility of any response set being carried over from the pre-test to the post-test. Furthermore, the pre-test items were rearranged and paper colour changed before being administered as the post-test.

Contamination effect: To avoid experimental contamination, the two intact classes used in this study were selected from two different sub divisions. It was

therefore not possible for subjects in one group to interact or exchange ideas with those of the other groups. Interaction of experimental conditions was thus seriously checked.

Teacher variable: A training programme was organized for the two mathematics teachers involved in this study. Since two different methods were used in teaching the the intact classes, the training took place in all the two sampled schools involved in this study. That is, each teacher was trained only on how to apply the method to be used for his particular class. The validated lesson plans and video lessons as well as other related materials were discussed by the researcher and the respective mathematics teachers. The training programme ended with trial teaching by the two teachers in their various classes, supervised by the researcher. The researcher did not expose the pre-test or post-test items to any of the teachers during training. A reasonable degree of equivalence on the attainment of objectives among the two groups was therefore established.

Administration and Scoring of the Instruments

For identification purposes, different codes were affixed against each name on the class list (for the two classes which took part in this study). These codes were written on the MAT and MINTIV before handing them to students. The MAT was administered as a pretest to all the two groups, as the first activity, prior to the administration of treatment. The pre-test lasted for 45 minutes in each of the classes. At the end of the experiment, the MAT was again administered as a post-test and also lasted for 45 minutes. Each of the 20 questions on the MAT was scored 1 mark, giving a maximum of 20 marks.

The MINTIV was also administered both as a pre-test and as a post-test alongside the respective MAT administrations. The time duration was not specified. Under the directives of the researcher, the class teachers instructed their students to respond independently and objectively and submit within a maximum of 20 minutes

after submitting their MAT scripts. Each of the items on the MINTIV has 4 options. Positive items were scored as follows: LVM-4points, L- 3points, D- 2points and DVM- 1point. The scores were reversed for negative items. An individual's interest score was obtained by summing his/her scores for all the items. A maximum of 80 points could be scored on the MINTIV.

Method of Data Analysis

The data for this study was analyzed using means to answer the research questions. The Analysis of Covariance (ANCOVA) was used to test the hypotheses of this study with the pretest scores used as the covariates. The analysis was aided by Statistical Pakage for Social Sciences (SPSS) version 20.0, with all the hypotheses tested at 0.05 level of significance. The null hypothesis was rejected if the p-value in the ANCOVA test was less than 0.05, otherwise, it was not rejected. The norm or bench mark for the MINTIV was considered at 50 (that is 2.5x20 items). Thus any learning method having mean interest above 50 out of 80, was considered to be effective. On the other hand, with regard to the MAT, any learning method yielding a mean achievement score above 10 out of 20 was also considered to be effective. Furthermore, any learning method was considered more effective if it produced a higher mean gain than the other.

CHAPTER FOUR

PRESENTATION AND ANALYSIS OF DATA

In this chapter, the data collected from the field for this study (See data on Appendices X, pp. 222-223 & summary of variable characteristics on Appendix Y, p 224) were analyzed and the summaries were presented in Tables to highlight the findings. The presentation was in accordance with the research questions and the hypotheses that guided the study. Table 1 was used to answer Research Questions 1, 2 and 3, while Table 2 was used to answer Research Questions 4, 5 and 6. Table 3 was further used to test hypotheses 1, 2, 7 and 8.

Research Question 1: How effective is the flipped learning method in enhancing students' achievements in mathematics when compared with the cooperative learning method?

Table 1

Mean Mathematics Achievement Scores of Male and Female Students taught with Flipped and Cooperative Learning Methods

GROUP	GENDER	N	Pretest Mean	Posttest Mean	Mean Gain
Cooperative Learning Method	Male	17	6.12	12.18	6.06
	Female	23	3.96	10.13	6.17
	Total	40	5.04	11.15	6.12
Flipped Learning Method	Male	21	5.95	12.00	6.05
	Female	26	4.15	12.12	7.97
	Total	47	5.05	12.06	7.01
Total	Male	38	6.03	12.09	6.06
	Female	49	4.06	11.13	7.07
	Total	87	5.05	11.61	6.57

Table 1 reveals that the pretest mean mathematics achievement score for students taught using the flipped learning method was 5.05. Their posttest mean was 12.06, giving a mean gain of 7.01. With regard to those taught mathematics using the cooperative learning method, they had a pretest mean of 5.04 and a posttest mean of 11.15, giving a mean gain of 6.12. This shows that although both methods were effective, considering the bench mark of 10, the flipped learning method was more effective in enhancing students' achievements in mathematics when compared with the cooperative learning method.

Research Question 2: What are the mean achievement scores of male and female students taught mathematics using the flipped learning method?

Table 1 also indicates that for students taught mathematics using the flipped learning method, the males had a pretest mean achievement score of 5.95 and a posttest mean achievement score of 12.00, giving a mean difference of 6.05. On the other hand, the pretest mean mathematics achievement score for the females was 4.15 and their posttest mean was 12.12, giving a higher mean difference of 7.97. This shows that the flipped learning method was more effective in enhancing the mean achievement score of female students than that of male students.

Research Question 3: What are the mean achievement scores of male and female students taught mathematics using the cooperative learning method?

Table 1 shows that for students taught mathematics using the cooperative learning method, the males had a pretest mean achievement score of 6.12 and a posttest mean achievement score of 12.18, giving a mean difference of 6.06. Furthermore, the pretest mean achievement score for the females was 3.96 and their posttest mean was 10.13. Although the males had a higher posttest mean achievement score, the females had a slightly higher mean difference in achievement of 6.17. This suggests that the cooperative learning method was also more effective in enhancing the achievement of female students than that of male students.

Research Question 4: How effective is the flipped learning method in enhancing students' interests in mathematics when compared with the cooperative learning method?

Table 2

Mean Mathematics Interest Scores of Male and Female Students taught with Flipped and Cooperative Learning Methods

GROUP	GENDER	N	Pretest Mean	Posttest Mean	Mean Gain
Cooperative Learning Method	Male	17	57.00	61.24	4.24
	Female	23	49.39	58.48	9.09
	Total	40	52.62	59.65	7.03
Flipped Learning Method	Male	21	60.14	65.43	5.29
	Female	26	53.88	65.81	11.93
	Total	47	56.68	65.64	8.96
Total	Male	38	58.74	63.55	4.81
	Female	49	51.78	62.37	10.59
	Total	87	54.82	62.89	8.07

Table 2 indicates that the pretest mean mathematics interest score for students taught using the flipped learning method was 56.68. Their posttest mean was 65.64. This gave a mean gain of 8.96. With regard to students taught mathematics using the cooperative learning method, their pretest mean mathematics interest score was 52.62, while their posttest mean was 59.65, giving a mean gain of 7.03. Thus although the two methods were effective in enhancing students' interests in mathematics, considering the bench mark of 50, the flipped learning method was more effective in

enhancing students' interests in mathematics when compared with the cooperative learning method.

Research Question 5: What are the mean interest scores of male and female students taught mathematics using the flipped learning method?

Table 2 further reveals that for students taught mathematics using the flipped learning method, the males had a pretest mean interest score of 60.14 and a posttest mean interest score of 65.43, giving a mean difference of 5.29. On the other hand, the pretest mean interest score for the females was 53.88 and their posttest mean was 65.81. This gave a much higher mean difference of 11.93. This indicates that the flipped learning method was more effective in enhancing the mean interest score of female students than that of the males.

Research Question 6: What are the mean interest scores of male and female students taught mathematics using the cooperative learning method?

Table 2 indicates that for students taught mathematics using the cooperative learning method, the males had a pretest mean interest score of 57.00 and a posttest mean interest score of 61.24, giving a mean difference of 4.24. As regards the females, their pretest mean interest score was 49.39 and their posttest mean score was 58.48. This gave a much higher mean difference of 9.09. This shows that the cooperative learning method was also more effective in enhancing the mean interest score of female students than that of the males.

Null hypothesis 1: There is no significant difference between the effectiveness of the flipped learning method and that of the cooperative learning method in enhancing students' achievements in mathematics.

Table 3
ANCOVA Table showing Main Effects of Variables

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	MATPOSTTEST	639.688	5	127.938	17.870	.000
	MINTIVPOTTEST	3731.260	5	746.252	19.352	.000
Intercept	MATPOSTTEST	.259	1	.259	.036	.850
	MINTIVPOTTEST	1916.041	1	1916.041	49.686	.000
MATPRETEST	MATPOSTTEST	196.326	1	196.326	27.422	.000
	MINTIVPOTTEST	26.015	1	26.015	.675	.414
MINTIVPRETEST	MATPOSTTEST	40.644	1	40.644	5.677	.020
	MINTIVPOTTEST	1470.592	1	1470.592	38.135	.000
GROUP	**MATPOSTTEST**	**7.357**	**1**	**7.357**	**1.028**	**.314**
	MINTIVPOTTEST	**251.616**	**1**	**251.616**	**6.525**	**.013**
GENDER	MATPOSTTEST	70.491	1	70.491	9.846	.002
	MINTIVPOTTEST	208.670	1	208.670	5.411	.023
GROUP * GENDER	**MATPOSTTEST**	**10.790**	**1**	**10.790**	**1.507**	**.223**
	MINTIVPOTTEST	**25.689**	**1**	**25.689**	**.666**	**.417**
Error	MATPOSTTEST	579.921	81	7.160		
	MINTIVPOTTEST	3123.591	81	38.563		
Total	MATPOSTTEST	12806.000	87			
	MINTIVPOTTEST	350899.000	87			
Corrected Total	MATPOSTTEST	1219.609	86			
	MINTIVPOTTEST	6854.851	86			

Table 3 shows that the F-ratio for the test is 1.028, giving a p-value of 0.314 ($p > 0.05$). Thus, the F-ratio is not significant at the 0.05 level of significance. Consequently, null hypothesis 1 was not rejected. Therefore there is no significant difference between the effectiveness of the flipped learning method and that of the cooperative learning method in enhancing students' achievements in mathematics, athough the flipped learning method had a higher mean gain than the cooperative learning method (Table 1).

Null hypothesis 2: There is no significant difference between the effectiveness of the flipped learning method and that of the cooperative learning method in enhancing students' interests in mathematics.

Table 3 indicates that the F-ratio for the test is 6.525, giving a p-value of 0.013 ($p < 0.05$). Thus, the F-ratio is significant at the 0.05 level of significance. Consequently, null hypothesis 2 was rejected. Therefore, there is a significant difference between the effectiveness of the flipped learning method and that of the cooperative learning method in enhancing students' interests in mathematics, with the flipped learning method being a more effective enhancer than the cooperative learning method (Table 1).

Null hypothesis 3: There is no significant difference in the mean mathematics achievement scores of male and female students taught mathematics using the flipped learning method.

Table 4

ANCOVA Test of Significant Difference in the Mean Mathematics Achievement Scores of Male and Female Students taught using Flipped Learning Method.

Dependent Variable: MATPOSTTEST

Source of Variation	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	330.119	2	165.060	20.135	.000	
Intercept	80.934	1	80.934	9.873	.003	
MATPRETEST	329.965	1	329.965	40.252	.000	
GENDER	**78.151**	**1**	**78.151**	**9.534**	**.003**	**S**
Error	360.689	44	8.197			
Total	7531.000	47				
Corrected Total	690.809	46				

Table 4 indicates that the F-ratio for the test is 9.534. This gives a p-value of 0.003. Thus the F-ratio is significant (S) at the 0.05 level of significance. For this reason, null hypothesis 3 was rejected. Hence, there is a significant difference in the mean mathematics achievement scores of male and female students taught mathematics using the flipped learning method. Therefore the flipped learning method was a significantly more effective enhancer of female students' achievement than that of the males (Table 1).

Null hypothesis 4: There is no significant difference in the mean mathematics achievement scores of male and female students taught mathematics using the cooperative learning method.

Table 5

ANCOVA Test of Significant Difference in the Mean Mathematics Achievement Scores of Male and Female Students taught using Cooperative Learning Method.

Dependent Variable: MATPOSTTEST

Source of Variation	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	250.318	2	125.159	17.562	.000	
Intercept	51.570	1	51.570	7.236	.011	
MATPRETEST	209.397	1	209.397	29.383	.000	
GENDER	**8.109**	**1**	**8.109**	**1.138**	**.293**	**NS**
Error	263.682	37	7.127			
Total	5354.000	40				
Corrected Total	514.000	39				

Table 5 indicates that the F-ratio for the test is 1.138, giving a p-value of 0.293. This means that the F-ratio is not significant (NS) at the 0.05 level of significance. Thus, null hypothesis 4 was not rejected. Therefore, there is no significant difference in the mean mathematics achievement scores of male and female students taught mathematics using the cooperative learning method, although the females had a slightly higher mean gain in achievements (Table 1).

Null hypothesis 5: There is no significant difference in the mean interest scores of male and female students taught mathematics using the flipped learning method.

Table 6

ANCOVA Test of Significant Difference in the Mean Mathematics Interest Scores of Male and Female Students taught using Flipped Learning Method.

Dependent Variable: MINTIVPOSTTEST

Source of Variation	Type III Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	1219.461	2	609.731	14.943	.000	
Intercept	1579.708	1	1579.708	38.714	.000	
MINTIVPRETEST	1217.792	1	1217.792	29.845	.000	
GENDER	**145.400**	**1**	**145.400**	**3.563**	**.066**	**NS**
Error	1795.390	44	40.804			
Total	205509.000	47				
Corrected Total	3014.851	46				

Table 6 shows that the F-ratio for the test is 3.563. This gives a p-value of 0.066, indicating that the F-ratio is not significant at the 0.05 level of significance. Consequently, null hypothesis 5 was not rejected. Therefore, there is no significant difference in the mean interest scores of male and female students taught mathematics using the flipped learning method, although there is a higher mean gain in favour of the females (Table 2).

Null hypothesis 6: There is no significant difference in the mean interest scores of male and female students taught mathematics using the cooperative learning method.

Table 7

ANCOVA Test of Significant Difference in the Mean Mathematics Interest Scores of Male and Female Students taught using Cooperative Learning Method.

Dependent Variable: MINTIVPOSTTEST

Source of Variation	Type III Sum of Squares	df	Mean Square	F	Sig.	Decision
Corrected Model	1792.774	2	896.387	26.067	.000	
Intercept	424.447	1	424.447	12.343	.001	
MINTIVPRETEST	1718.472	1	1718.472	49.974	.000	
GENDER	**71.148**	**1**	**71.148**	**2.069**	**.159**	**NS**
Error	1272.326	37	34.387			
Total	145390.000	40				
Corrected Total	3065.100	39				

Table 7 reveals that the F-ratio for the test is 2.069. This gives a p-value of 0.159, which is not significant at the 0.05 level of significance. Consequently, null hypothesis 6 was not rejected. Therefore, there is no significant difference in the mean interest scores of male and female students taught mathematics using the cooperative learning method, although the females had a higher mean gain score (Table 2).

Null hypothesis 7: There is no significant interaction effect between learning methods used and gender on students' achievement scores in mathematics.

Table 3 reveals that the F-ratio for the test is 1.507, giving a p-value of 0.223. Thus the F-ratio is not significant at the 0.05 level of significance. As a result, null hypothesis 7 was not rejected. Therefore, there is no significant interaction effect between learning methods used and gender on students' achievements scores in mathematics.

Null hypothesis 8: There is no significant interaction effect between learning methods used and gender on students' interest scores in mathematics.

Table 3 further shows that the F-ratio for the test is 0.666, giving a p-value of 0.417, indicating that the F-ratio is not significant at the 0.05 level of significance. Consequently, null hypothesis 8 was not rejected. Therefore, there is no significant interaction effect between learning methods used and gender on students' interests scores in mathematics.

Summary of the Findings

The following findings emerged from this study:

1. The flipped learning method was more effective in enhancing students' achievements in mathematics when compared with the cooperative learning method.
2. The flipped learning method was more effective in enhancing students' interests in mathematics when compared with the cooperative learning method.
3. For students in the flipped learning method, females had a higher mean gain in achievement than the males.
4. With regard to those in the cooperative learning method females also had a slightly higher mean gain in achievement than the males.
5. Females obtained a higher mean gain in interest than the males in the flipped learning method.

6. Although males had a higher pretest and posttest mean interest scores, females had a higher mean gain in interest.
7. There was no significant difference between the effectiveness of the flipped learning method and that of the cooperative learning method in enhancing students' achievements in mathematics.
8. The flipped learning method enhanced students' interests in mathematics significantly better than the cooperative learning method.
9. For students taught mathematics using the flipped learning method, the females achieved significantly better than the males.
10. There is no significant difference in the mean mathematics achievement scores of male and female students taught mathematics using the cooperative learning method.
11. There is no significant difference in the mean interest scores of male and female students taught mathematics using the flipped learning method.
12. There is no significant difference in the mean interest scores of male and female students taught mathematics using the cooperative learning method.
13. There is no significant interaction effect between the learning methods and gender on students' achievements in mathematics.
14. There is no significant interaction effect between the learning methods and gender on students' interests in mathematics.

CHAPTER FIVE

DISCUSSION CONCLUSION AND RECOMMENDATIONS

This chapter adopts the thematic approach in the discussion of the findings. The chapter also highlights the implications of the findings. Based on the findings, recommendations and suggestions for further studies are presented. Limitations and summary of the study are also presented.

Discussion of Findings

The discussion of results or findings is presented under the following sub-headings:

- Comparative effectiveness of cooperative and flipped learning methods on students' achievements in mathematics.
- Comparative effectiveness of cooperative and flipped learning methods on students' interests in mathematics.
- Comparative effectiveness of cooperative and flipped learning methods in enhancing achievement and interest across Gender.
- Interaction effects of learning methods and gender on students' achievements and interests in mathematics.

Comparative effectiveness of cooperative and flipped learning methods on students' achievements in mathematics. The findings of this study show that both the flipped learning and the cooperative learning methods are effective enhancers of students' achievements in mathematics. The findings further show that no method enhanced students' achievements significantly better than the other. Evidence of consonance between the findings of this study and those of earlier studies abound in the works of Nawaz et al. (2014), Zakaria et al. (2010), Kolawole (2008) and Effandi et al. (2013) who all established that the cooperative learning learning method was an effective enhancer of students' achievements. Talley and Scherer (2013), Tune et al. (2013) and Wilson (2013) also established similar results using the flipped learning

method. The possibility of the flipped and the cooperative learning methods being effective enhancers of students' achievements in mathematics is certainly not unconnected with the active involvement of students in the activities embedded in the methods. Specifically, a probable reason for the enhanced achievements in cooperative learning is that when students study, explain and receive explanations from one another in a group, they understand better what they have learned and therefore improve on their performances. With regard to flipped learning, the present day Cameroonian students seem to be good digital natives and according to Ferriman (2014), they view pictures and videos in the same way students of old viewed textbooks. Thus they turn to relate well with technology.

The findings further indicate that although the flipped learning method produced a higher mean gain in achievements than the cooperative learning method, there is no significant difference between the effectiveness of the flipped learning method and that of the cooperative learning method in enhancing students' achievements in mathematics. Strayer (2009) showed that in addition to producing higher learning gains, flipped learning also met the personal learning styles of students. Perhaps students in the flipped method in this study had slightly higher achievement means partly because their personal learning styles were met. Going further, working on concepts at the lower level of the Bloom's taxonomy out of class, before lessons, may also have given a slight advantage to the students in the flipped method. However, while cooperative learning produces an intellectual synergy of many minds coming together to bear on a problem, flipped learning enables individual minds to reflect on the problem over and over, and as many times as possible, with both methods yielding almost the same outcomes, as suggested by the above finding of this study.

Comparative effectiveness of cooperative and flipped learning methods on students' interests in mathematics. The findings of the study indicate that both the cooperative and the flipped learning methods of teaching mathematics are more

effective enhancers of students' interests. Furthermore, the flipped learning method significantly enhanced the interests of students better than the cooperative learning method. This suggests that the flipped learning method provides the desired intellectual curiosity and attention needed for effective learning as indicated by Okigbo (2010), significantly better than the cooperative learning method. The above assertion can be justified by the higher mean in achievement obtained by students in the flipped learning method. The assertion could also be understood from the report of Semaya (2013), who indicated that high levels of student interest were positively associated with academic achievement.

The above finding gives credence to what was earlier found by Opara (2002), and Adodo and Gbore (2012). While Opara showed that students' interests in mathematics can be improved through the use of appropriate teaching-learning methods, Adodo and Gbore demonstrated that interest is one of the variables which possess the strongest strength for predicting the mathematics performance of students with varying abilities. In line with Opara, the above finding in this study also provides support to the works of Zakaria et al. (2010) and DesLauriers et al. (2011), who established that cooperative learning and flipped learning, were effective enhancers of students' interests in mathematics. Going by the findings of Opara, one can say that the flipped learning method is a more appropriate learning method with regard to enhancing students' interests than the cooperative learning method.

Comparative effectiveness of cooperative and flipped learning methods in enhancing achievement and interest across Gender. For students taught mathematics using the flipped learning method, females achieved significantly better than the males. This finding does not agree with those of other researchers (Martins-Umeh, 2012; Naderi et al., 2008; Okigbo, 2010) who studied the effects of gender on students' achievement using other active teaching-learning methods. They all concluded that gender had no significant effects on students' achievements. Female students appear to be better digital natives than the males in the Cameroonian society.

This may be a possible justification to the above finding of this study. On the other hand, there is no significant difference in the achievemenets of male and female students taught mathematics using the cooperative learning method. This finding is in line with that of Nawaz et al. (2014) who did not find any significant difference in achievements across gender for students in the cooperative learning group.

This study also established that there is no significant difference in the mean interest scores of male and female students taught mathematics using either the flipped learning method or the cooperative learning method, despite the fact that there was a slightly higher mean gain in interests in favour of female students in both methods. These findings corroborate those of Okigbo (2010) who used two active teaching-learning methods in teaching mathematics; mathematical game and instructional analogy, and established that no significant difference exists in the interest of male and female mathematics students taught with either game or analogy.

The findings in this section suggest that the cooperative learning method has the potential of minimizing gender differences in achievement and interest among secondary school students better than the flipped learning method. On the other hand, flipped learning plays a more significant role in enhancing the achievements of female secondary school students when compared to the cooperative learning method.

Interaction effects of learning methods and gender on students' achievements and interests in mathematics. The result from the analyses revealed a non significant interaction effect between learning methods and gender, on students' achievements in mathematics. This finding agrees with the findings of Okigbo (2010) and Martins-Umeh (2012). Okigbo reported that there was no significant interaction between teaching methods and gender, on students' achievement in mathematics. Martins-Umeh reported a similar finding in social studies.

The finding of the study also revealed that the interaction effect between the learning methods used and gender on students' interests in mathematics is not

significant. This finding buttresses that of Okigbo (2010) who used mathematical games and instructional analogy as methods in teaching mathematics, and found that there was no significant interaction effect of teaching methods used and gender on students' interest in mathematics. Since no significant interaction as measured by the MAT and the MINTIV was observed in this study, one can appreciate the fact that the simple main effects of cooperative learning and flipped learning on the achievements and interests of students do not change as a function of variations in gender. Thus the flipped and the cooperative learning methods enhance both the interests and achievements of students in mathematics, irrespective of their gender.

Conclusions

The following conclusions can be drawn from this study which was designed to compare the effectiveness of flipped learning and cooperative learning methods in enhancing students' interests and achievements in mathematics in Cameroon.

Both the flipped learning and the cooperative learning methods are effective enhancers of students' achievements in mathematics. Furthermore, neither the flipped nor the cooperative method is a significantly better enhancer of students' achievement than the other; athough the flipped method had a slightly higher mean gain. In relation to interests, both the cooperative and the flipped learning methods of teaching mathematics are also effective enhancers of students' interests with the flipped learning method enhancing interest significantly better than the cooperative learning method.

Both methods are effective in minimizing gender inequalities with regard to students' interest in mathematics. As concerns students' achievements in mathematics, the flipped learning method is more effective in enhancing the achievements of female students than the cooperative method. In relation to interaction effects, no significant interaction effects exist between learning methods and gender on either students' achievements or on their interests. Therefore the methods all enhance both students' achievements and their interests irrespective of gender.

Implications of the Study

The findings of this study have numerous implications for teachers, learners, curriculum planners and policy makers in education, and the government of Cameroon.

The flipped learning method and the cooperative learning method enhanced both the achievement and the interest of students in mathematics irrespective of their gender. This implies that teachers are likely to be more effective when these methods are used. Thus if teachers continue to use non active and non communicative methods in teaching mathematics, the benefits of the flipped learning and the cooperative learning methods such as active participation and interactivity, will continue to elude teachers and learners. On the other hand, if these methods are effectively implemented, then similar remarkable improvements in learners' achievements are expected in both methods. Also, significant improvement in their interest in mathematics will be assured, especially within the flipped learning method. Consequently, many more students will not only pass mathematics at the GCE O/L but will want to study mathematics or related courses at higher levels.

The findings of this study also imply that emphasis should turn from teachers and content, towards the learners. The mathematics teacher should cease from being a 'sage on the stage' but should rather be a 'guide on the side', who needs to display different sets of skills in the process of facilitating learning. If emphasis is turned towards the learners as illustrated in the methods used in this study, the learners will not only acquaint themselves with, but will also use the ubiquitous technological gadgets such as mobile phones, computers, ipads and televisions to facilitate their learning, instead of using them for less beneficial activities. The use of these gadgets in learning, especially within the flipped classroom, will definitely have a significantly more positive influence on their interest in mathematics as suggested by the findings of this study.

Furthermore, the fact that group work enhanced students' achievements and interests implies that group work can help these students to acquire qualities for

harmonious coexistence in a multi-religious and multi-ethnic society like Cameroon, which counts more than 250 ethnic groups. Therefore the studied methods will enhance not only the interests and achievements of students in mathematics, but will also help them to develop 21st century skills such as communication, critical thinking and collaboration, needed to help them cope in today's world, considered a global village.

The findings of this study are expected to spur curriculum planners and policy makers in education to consider effective alternative teaching-learning methods to be used in teaching mathematics, especially the two considered in this study. These two methods did not only prove to be enhancers of students' interests and achievements in mathematics but also provided activities which enabled the females to be as competent as or even more competent than the males as shown especially in the flipped method. This consideration should also include the materials which need to be provided to various schools for the effective mastery or implementation of the methods and for all learners to actually benefit from them.

Another implication of the finding of this study is that present day mathematics teacher preparatory programs in Cameroon need to be tilted towards guiding students to independently and collectively discover meaning within mathematics. This further implies the government, Parents Teachers Organizations (PTA) and other stake holders in education, need to provide both teacher training colleges and secondary schools with computer laboratories, mathematics laboratories, generators, internet and other adequate facilities which will help not only pre-service and in-service mathematics teachers to develop a mastery during training and retraining on how to adequately implement the flipped and the cooperative learning methods, but will also enable learners to individually and collectively grasp mathematical concepts in the course of learning using the methods.

Recommendations

Based on the findings of the present study and their implications, the following recommendations are proffered:

1. English-speaking secondary school mathematics teachers in Cameroon should adopt the flipped and the cooperative learning methods as some of the common and alternative methods of teaching mathematic, and should use them more frequently than the conventional method of teaching mathematics. If their interest is to reduce gender inequality in achievement, then the cooperative learning method is recommended. On the other hand, if they desire to improve students' interest significantly, then the flipped learning method is recommended. This pedagogical shift will also enable students to use available technological gadgets in facilitating their learning and also help them to reap the benefits of group work. These will among other things, help students to do away with some of the social apathy towards mathematics.
2. In order to assure teachers, students and other stake holders in education on the efficiency of the methods in enhancing achievements and interests in mathematics, the ministry of secondary education should create pilot schools and centers throughout the country, in which mathematics will be taught exclusively using the flipped and the cooperative learning methods. To guarantee expected results from the aforementioned schools and centers, and from other teachers, it is also recommended that government should encourage and censor the production, importation and distribution of mathematics video lessons on all topics and in all classes of the secondary school.
3. Curriculum planners and policy makers in education should include the cooperative and the flipped learning methods as some of the teaching/learning methods to be mandatorily taught and learned in all teacher training schools and all faculties of education in universities as they are both equally effective in enhancing achievement of learners. Furthermore, compulsory in-service training seminars on flipped and cooperative learning methods should be organized by the

ministry of secondary education, for service mathematics teachers. All these in a bid to provide mathematics teachers and student teachers with the required skills necessary for effective implementation of these alternative and effective learning methods.

4. Government, NGOs, PTAs and other stake holders in education who expect better achievements in mathematics should help provide teacher training colleges and secondary schools with computer laboratories, mathematics laboratories, internet and other adequate facilities. This will go a long way to facilitate the training of mathematics teachers and teaching/learning of students especially within the flipped learning method, proven in this study to have a slight advantage over the cooperative learning method.

Limitations of the Study

Many students developed a phobic attitude towards mathematics as far back as during their early years of schooling. Six weeks may not be long enough to overturn this phobic attitude. Thus the interests and achievements scores obtained in this study may have been considerably higher if the study was carried out over a longer period of time. In spite of the above shortcoming, the findings of this study are still very relevant.

Suggestions for Further Studies

The researcher suggests that further studies could be carried out in the following areas:

1. Compare the effectiveness of cooperative learning and flipped learning in meeting the individual learning styles of Cameroonian students.
2. Replicate this study in non public secondary schools, university institutions and using different topics (teaching-learning content) other than those used in this study.

3. Compare the effectiveness of cooperative learning and flipped learning methods on students' retention of mathematical concepts and also examine their attitudes towards the methods.

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APPENDICES

Appendix A

Success Rate (%) in Mathematics Compared with GCE O/L Success Rate for the Past 12 years in Cameroon.

Year	Total N^{o} of GCE O/L Candidates	GCE O/L Success Rate (%)	Success Rate in Mathematics(%)
O/L Candidates			
2016	102857	62.17	8.90
2015	99069	48.93	11.80
2014	86724	45.77	9.40
2013	81675	47.57	15.32
2012	79384	42.88	14.56
2011	65678	43.51	18.49
2010	60875	58.02	15.00
2009	55890	53.87	20.46
2008	50419	48.61	15.35
2007	44676	55.49	18.38
2006	40613	51.35	23.99
2005	35530	45.37	16.83

Source: GCE Board examination statistics booklets of listed years.

Appendix B

GCE O/L Performance by Gender (reported only for 2 years)

	Males		Females		GCE O/L
Year	**N^{o} Sat**	**% Passed**	**N^{o} Sat**	**% Passed**	**Success Rate**
2010	25908	62.52	34967	54.79	58.02
2009	24327	59.79	31563	49.69	53.87
Average	25118	61.16	33265	52.24	55.95

Source: Cameroon GCE Board examination statistics booklets of listed years.

Appendix C

Location of Cameroon

Appendix D

Population of English-speaking secondary schools in Mezam Division

Subdivisions	Public Schools	Denominational Schools	Lay Private Schools	Total
Bamenda 1	3	0	1	4
Bamenda 2	8	5	9	22
Bamenda 3	2	5	5	12
Bafut	9	3	0	12
Bali	4	2	2	8
Santa	13	0	7	20
Tubah	7	0	1	8
Total	46	15	25	86

Source: Regional Delegation for Secondary Education North West Region of Cameroon (2016)

Appendix E

First Five Divisions in terms of number of candidates and success rate at the GCE O/L exams (reported only for listed years).

Division	**2010**		**2005**		**2004**	
	Sat	passed	Sat	passed	Sat	passed
Mezam	**11642**	**6229**	**8209**	**3487**	**8301**	**3836**
Fako	11326	4885	6831	2319	6674	2692
Meme	6965	2979	4473	1291	4336	1595
Nfoundi	5343	2581	2450	861	2305	852
Bui	3887	2204	2070	956	1987	1053

Source: Cameroon GCE Board examination statistics booklets of listed years.

Appendix F

Sampled Schools and Sample Distribution

School	Class	Number of Subjects		
		Males	Females	Total
GBHS Mankon **(E_f)**	**3D**	21	26	47
GHS Akum **(E_c)**	**3B**	17	23	40
Total		38	49	87

Appendix G

MATHEMATICS INTEREST INVENTORY (MINTIV)

Preliminary Information

School_____

Code_____

Sex_____ Age_____

Instruction: Every statement has four options; **I Like Very Much (LVM), I Like (L), I Dislike (D) and I Dislike Very Much (DVM). Please indicate how much you would like to engage in the activities indicated in each statement by providing a tick (√) in the spaces provided.**

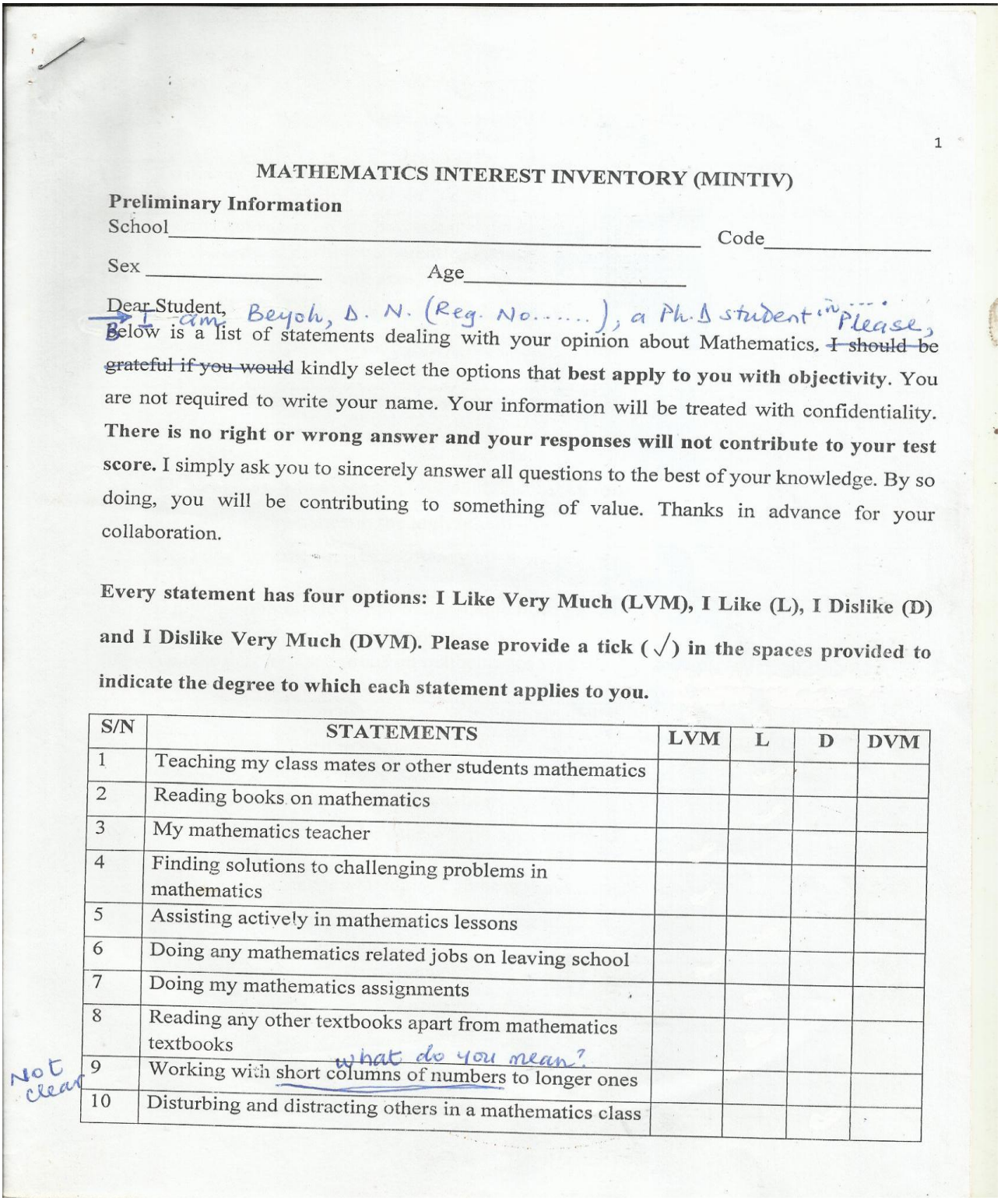
S/N	STATEMENTS	LVM	L	D	DVM
1	Teaching my class mates or other students mathematics				
2	Taking part in discussions on mathematics related issues				
3	Finding solutions to challenging problems in mathematics				
4	Assisting actively in mathematics lessons				
5	Doing any mathematics related jobs on leaving school				
6	Doing mathematics assignments				
7	Reading textbooks on mathematics				
8	Revising my mathematics notes many times at home before the next mathematics class				
9	Devoting my free time to solving mathematical problems				
10	Asking questions on mathematical steps or problems which I do not understand during mathematics lessons				
11	Being with friends who always talk about mathematics				

12	Being in class when it is time for mathematics lessons				
13	Studying mathematics in the high school				
14	Copying solutions to mathematics assignments from more intelligent class mates				
15	Mathematics teacher who always gives assignments				
16	Leading a study group in mathematics				
17	Working in an office where there is no application of any concept of mathematics				
18	Watching mathematics or science related videos				
19	Becoming a professor and/or teacher of mathematics				
20	Leaving the class when it is time for mathematics lessons				

Appendix H

Ratings, Suggestions and Comments of 4 Validators on MINTIV

Validator 1



1

MATHEMATICS INTEREST INVENTORY (MINTIV)

Preliminary Information

School_____ Code_____

Sex _____ Age_____

Dear Student, I am Beyoh, D. N. (Reg. No.....), a Ph.D student in..... Please, Below is a list of statements dealing with your opinion about Mathematics. ~~I should be grateful if you would~~ kindly select the options that **best apply to you with objectivity**. You are not required to write your name. Your information will be treated with confidentiality. **There is no right or wrong answer and your responses will not contribute to your test score.** I simply ask you to sincerely answer all questions to the best of your knowledge. By so doing, you will be contributing to something of value. Thanks in advance for your collaboration.

Every statement has four options: I Like Very Much (LVM), I Like (L), I Dislike (D) and I Dislike Very Much (DVM). Please provide a tick (√) in the spaces provided to indicate the degree to which each statement applies to you.

S/N	STATEMENTS	LVM	L	D	DVM
1	Teaching my class mates or other students mathematics				
2	Reading books on mathematics				
3	My mathematics teacher				
4	Finding solutions to challenging problems in mathematics				
5	Assisting actively in mathematics lessons				
6	Doing any mathematics related jobs on leaving school				
7	Doing my mathematics assignments				
8	Reading any other textbooks apart from mathematics textbooks				
9	Working with short columns of numbers to longer ones				
10	Disturbing and distracting others in a mathematics class				

Not clear — what do you mean?

11	To devote my free time to solving mathematical problems				
12	Asking questions on mathematical steps or things I do not understand during mathematics lessons				
13	Friends who always talk about mathematics				
14	To engage in activities related to mathematics				
15	To work in an office were mathematical knowledge is required on leaving school				
16	Revising my mathematics notes as many times as possible at home before the next maths class				
17	To go on an excursion to study mathematics				
18	To be in class when it is time for mathematics lessons				
19	To study mathematics in the high school				
20	Devoting my free time to study any other subject apart from mathematics				
21	Copying solutions to maths assignments from my friends or from more intelligent class mates				
22	To take part in discussions on mathematics related issues				
23	Asking questions on difficult areas in mathematics				
24	To hide what I learn in mathematics from my younger ones and parents for fear of challenges				
25	Leading a study group in mathematics				
26	To work in an office where there is no application of mathematics				
27	Mathematics teacher who always gives assignments				
28	Finding out and understanding the meaning of most words used in mathematics				
29	Watching mathematics or science related videos				
30	To become a professor and/or teacher of mathematics				
31	To leave the class when it is time for mathematics lessons				
32	Mathematics teacher who is always punctual				

check item 11

Drop see item 15

* You did not introduce yourself properly in the "Request for Validation of MINTIV" and in the questionnaire - Your Name, Registration number and the purpose of the study (ie Ph.D student in the Department of....).

* How do you obtain standard deviations and mean gain scores in achievement of students without an achievement test. Don't you need to validate the achievement test also?

* Limit your MINTIV items between 20 to 25.

Dr. Nekang Fabian N.
(PhD - UNN)
University of Buea

Validator 2

QUESTIONNAIRE ON **MATHEMATICS INTEREST INVENTORY (MINTIV)** (QUOMINTIV) OR (QOMINTIV)[1]

Preliminary Information

School_____ Code_____

Sex _____ Age_____

Dear Student,

below is a list of statements ~~dealing with~~ about your opinion ~~about~~ on Mathematics. I should be grateful if you would kindly select the options that **best apply to you with objectivity**. You are not required to write your name. Your information will be treated with confidentiality. **There is no right or wrong answer ~~and your~~ so the responses will not contribute to ~~your~~ any test score.** I simply ~~ask~~ want you to sincerely answer all questions to the best of your knowledge. By so doing, you will be contributing to something ~~of value~~ valuable to this research project. Thanks in advance for your collaboration.

Every statement has four options: I Like Very Much (LVM), I Like (L), I Dislike (D) and I Dislike Very Much (DVM). Please provide a tick (√) in the spaces provided to indicate the degree to which each statement applies to you.

S/N	STATEMENTS	LVM	L	D	DVM
1	Teaching ~~my class mates or other students~~ us mathematics				
2	Reading books on mathematics				
3	~~My~~ Our mathematics teacher				
4	Finding solutions to challenging problems in mathematics				
5	Assisting actively in mathematics lessons				
6	Doing any mathematics related jobs on leaving school				
7	Doing ~~my~~ mathematics assignments				
8	Reading any other textbooks apart from mathematics textbooks				
9	Working ~~with~~ on short columns of numbers to longer ones				
10	Disturbing and distracting others in a mathematics class				

11	To devote my free time to solving mathematical problems				
12	Asking questions on mathematical steps ~~or things~~ (problem) that I do not understand during mathematics lessons				
13	Friends who always talk about mathematics				
14	To engage in activities related to mathematics				
15	To work in an office ~~were~~ where mathematical knowledge is required on leaving school				
16	Revising my mathematics notes as many times ~~as possible~~ at home before the next maths class				
17	To go on an excursion ~~to~~ for study mathematics study.				
18	To be always in class when it is time for mathematics lessons				
19	To study mathematics in the high school				
20	Devoting my free time to study the of any other subject apart from mathematics See No 8 - repetition				
21	Copying solutions to maths assignments from my ~~friends or from~~ more intelligent class mates				
22	To take part in discussions on mathematics related issues				
23	Asking questions on difficult areas in mathematics				
24	To hide what I learn in mathematics from ~~my younger ones and parents~~ others people for fear of challenges				
25	Leading a study group in mathematics				
26	To work in an office where there is no application of ~~the mathematics~~ any concept of Mathematics				
27	Mathematics teacher who always gives assignments				
28	Finding out and understanding the meaning of most ~~words~~ concepts or used in mathematics				
29	Watching mathematics or science related videos				
30	To become a professor and/or teacher of mathematics				
31	To leave the class when it is time for mathematics lessons				
32	Mathematics teacher who is always punctual				

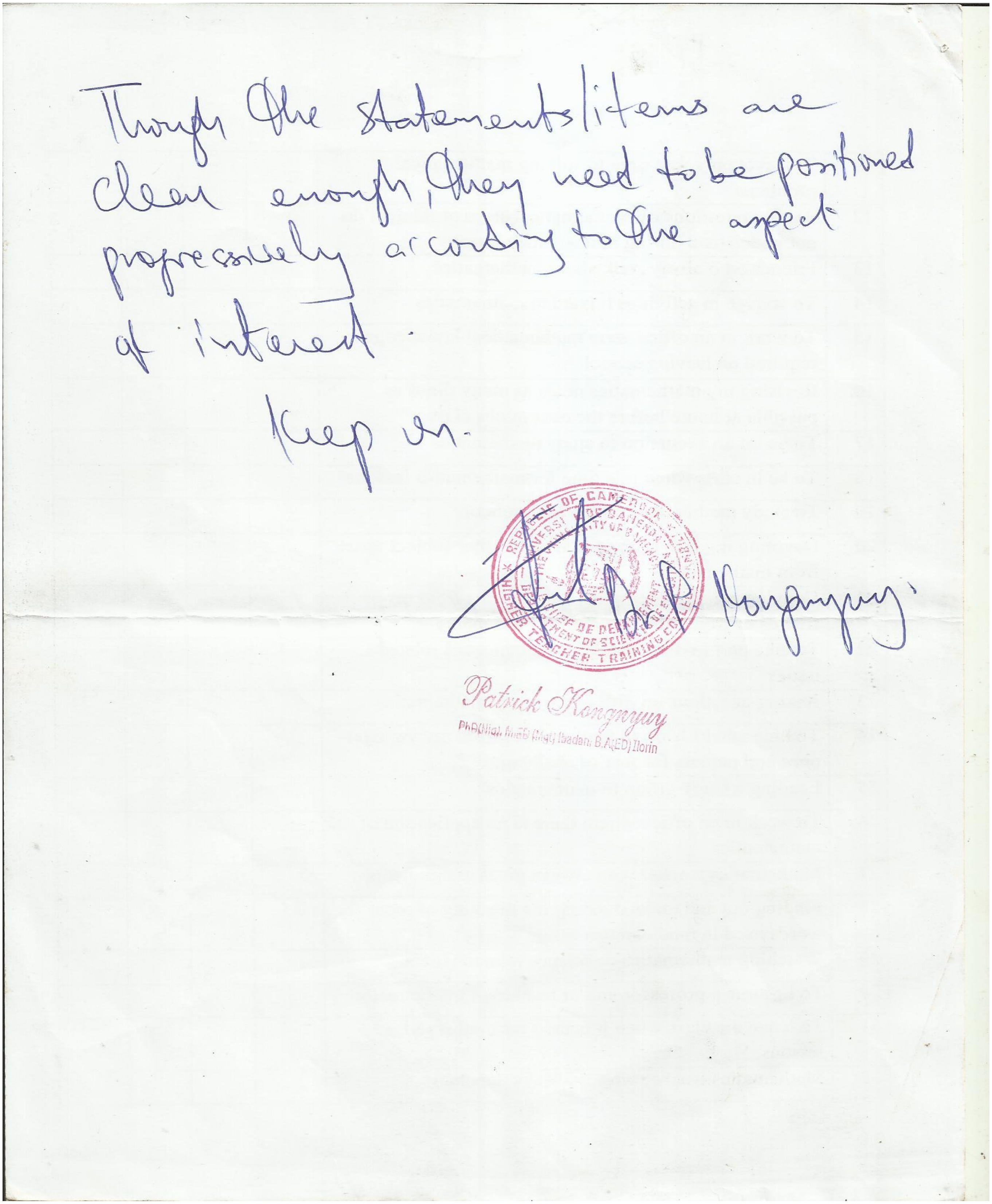
P.T.O.

The corrections made is better than 4/4 or 1 2 or 3 quantitatively but make sure that the statements reflect the Objectives of the study according to the topic!!

Chief Off. Anja Simon
Senator

26/08/2015

Validator 3



Though the statements/items are clear enough, they need to be positioned progressively according to the aspect of interest.

Keep on.

Dr P. Kongnyuy

Patrick Kongnyuy
PhD(Nig), M.Ed (Nig) Ibadan, B.A(ED) Ilorin

Validator 4

1

MATHEMATICS INTEREST INVENTORY (MINTIV)

Preliminary Information

School_____ Code_____

Sex _____ Age_____

Dear Student,

below is a list of statements dealing with your opinion about Mathematics. I should be grateful if you would kindly select the options that **best apply to you with objectivity**. You are not required to write your name. Your information will be treated with confidentiality. **There is no right or wrong answer and your responses will not contribute to your test score.** I simply ask you to sincerely answer all questions to the best of your knowledge. By so doing, you will be contributing to something of value. Thanks in advance for your collaboration.

Every statement has four options: I Like Very Much (LVM), I Like (L), I Dislike (D) and I Dislike Very Much (DVM). Please provide a tick (√) in the spaces provided to indicate the degree to which each statement applies to you.

S/N	STATEMENTS what is the leading statement?	LVM	L	D	DVM
1	Teaching my class mates or other students mathematics				
2	Reading books on mathematics				
3	My mathematics teacher				
4	Finding solutions to challenging problems in mathematics				
5	Assisting actively in mathematics lessons				
6	Doing any mathematics related jobs on leaving school				
7	Doing my mathematics assignments				
8	Reading any other textbooks apart from mathematics textbooks				
9	Working with short columns of numbers to longer ones				
10	Disturbing and distracting others in a mathematics class				

* Your instrument should have a leading statement.
* You should arrange your ~~instrument~~ items according to your Research Questions.

11	To devote my free time to solving mathematical problems				
12	Asking questions on mathematical steps or things I do not understand during mathematics lessons				
13	Friends who always talk about mathematics				
14	To engage in activities related to mathematics				
15	To work in an office were mathematical knowledge is required on leaving school				
16	Revising my mathematics notes as many times as possible at home before the next maths class				
17	To go on an excursion to study mathematics				
18	To be in class when it is time for mathematics lessons				
19	To study mathematics in the high school				
20	Devoting my free time to study any other subject apart from mathematics				
21	Copying solutions to maths assignments from my friends or from more intelligent class mates				
22	To take part in discussions on mathematics related issues				
23	Asking questions on difficult areas in mathematics				
24	To hide what I learn in mathematics from my younger ones and parents for fear of challenges				
25	Leading a study group in mathematics				
26	To work in an office where there is no application of mathematics				
27	Mathematics teacher who always gives assignments				
28	Finding out and understanding the meaning of most words used in mathematics				
29	Watching mathematics or science related videos				
30	To become a professor and/or teacher of mathematics				
31	To leave the class when it is time for mathematics lessons				
32	Mathematics teacher who is always punctual				

* You also need to have an instrument on Achievement in Mathematics?

Dr. H.E. Adelsola

Adelsola 15-12-16

Appendix I

MINTIV Introductory Letter

Department of Educational Foundations,

Faculty of Education,

Nnamdi Azikiwe University, Awka,

Nigeria.

14th January, 2016.

Dear Student,

I am Beyoh, D. N. (Reg. N°: 2013177006F), a Ph.D student in the Department of Educational Foundations in Nnamdi Azikiwe University, Awka-Nigeria. I am researching on the Comparative Effectiveness of Flipped Learning and Cooperative Learning Methods on Students' Interest and Achievement in Mathematics in Cameroon.

Attached to this letter, is a list of statements dealing with your opinion about Mathematics. Please kindly select the options that **best apply to you with objectivity**. You are not required to write your name. Your information will be treated with confidentiality. **There is no right or wrong answer and your responses will not contribute to your test score.** I simply want you to sincerely answer all questions to the best of your knowledge, by indicating the degree to which each statement applies to you. By so doing, you will be contributing something valuable to this research work. Thanks in advance for your collaboration.

Beyoh Dieudone Nkepah,

Researcher.

Appendix J
Mathematics Achievement Test (MAT) (Pretest) / Key

School _____ **Code** _____

Sex _____ **Age** _____

Instruction: Circle the letter that corresponds to the best answer. **Time: 45 minutes**

1) Given that the three angles of a triangle are, a, b and c, which of the following equations concerning the triangle is correct.

A. $a + b + c = 360^0$ B. $a + b - c = 180^0$ C. $a + b = c$ D. $a + b + c = 180^0$

2) Nfor had x oranges. He ate 2 and shared the remainder equally with Ngala. Express in terms of x the information that Ngala's share is at least 5 oranges.

A. $\frac{x-2}{2} \leq 5$ B. $\frac{x-2}{2} > 5$ C. $\frac{x}{2} - 2 < 5$ D. $\frac{x-2}{2} \geq 5$

3) Given the equation $E = \frac{1}{2}mv^2$ and that $v = rw$, express r in terms of E, m and w

A. $r = \pm\sqrt{\frac{2E}{mw^2}}$ B. $r = \left(\frac{2E}{mw^2}\right)^2$ C. $r = \frac{2E}{mw}$ D. $r = \pm\sqrt{\frac{E}{2mw}}$

4) Express $4 - \frac{y-x}{x}$ as a single fraction.

A. $\frac{3x-y}{x}$ B. $\frac{5x-y}{x}$ C. $\frac{4-y+x}{x}$ D. $\frac{4-y-x}{x}$

5) The largest angle of any triangle

A. Must always be acute B. Can sometimes be acute C. Can never be Right angled D. Must always be obtuse

6) In Figure 1, what is the size of angle ACB?

A. 40^0 B. 50^0 C. 60^0 D. 80^0

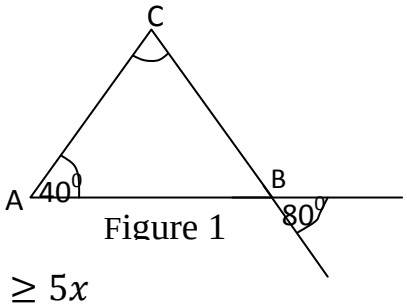


Figure 1

7) Find the range of values of x for which $3x - 8 \geq 5x$

A. $x \leq 4$ B. $x \geq 1$ C. $x \leq -4$ D. $x \geq -4$

8) p and q are two positive numbers such that $p > 2q$. Which one of the following is **not** true?

A. $-p < -2q$ B. $-p > 2q$ C. $-p < 2p$ D. $-q < \frac{1}{2}p$

9) Given that $F = \frac{9a}{r^{10}} - \frac{b}{r^2}$,the value of a, when F = 10, r = 1 and b = 7 is;

A. 3 B. $\frac{17}{9}$ C. 9 D. $\frac{20}{7}$

10) Simplify $\frac{1}{2}(2^n - 2^{n+1})$

A. $2^{n-1} - 2^n$ B. $2^{n-1}(1 - 2^n)$ C. $2^{n+1} + 2$ D. 2^n

11) Simplify $5y^2 \times 4y^3$

A. $20y^6$ B. $20y^5$ C. $9y^5$ D. $20y^{23}$

12) Simplify $0.027^{-\frac{1}{3}}$

A. 3 B. $\frac{3}{10}$ C. $\frac{10}{3}$ D. $\frac{1}{3}$

13) Expressing n in terms of p, v, r and t in the formula $pv = nrt$ gives

A. $n = \frac{pvt}{r}$ B. $n = \frac{pvr}{t}$ C. $n = \frac{pv}{rt}$ D. $n = pv - rt$

14) Given that $x = -3,$ and $y = -7,$ evaluate $\frac{x^2 - y}{y^2 - x}$

A. $-\frac{1}{11}$ B. $\frac{1}{23}$ C. $\frac{4}{13}$ D. $\frac{12}{17}$

15) Calculate the value of $16^{\frac{5}{4}} \times 2^{-3} \times 3^0$

A. 20 B. 2 C. 4 D. 10

16) Simplify $\frac{4}{a-3} - \frac{1}{a+2}$

A. $\frac{3a+11}{(a+3)(a-2)}$ B. $\frac{3a-11}{(a-3)(a+2)}$ C. $\frac{3a+11}{(a-3)(a-2)}$ D. $\frac{3a+11}{(a+3)(a+2)}$

17) Two variables x and y, and three constants, a, b and c are such that the sum of ax and by equals c. Use this information to express x in terms of a, b, c and y.

A. $x = \frac{by-c}{a}$ B. $x = c - by - a$ C. $x = \frac{c+by}{a}$ D. $x = \frac{c-by}{a}$

18) Evaluate $\frac{3}{6p} + \frac{3}{4p}$, given that the value of p is 1

A. $\frac{17}{12}$ B. 12 C. $\frac{1}{6}$ D. $\frac{5}{4}$

19) Evaluate $\left(27^{\frac{1}{3}}\right)^2$

A. 81 B. 6 C. 18 D. 9

20)

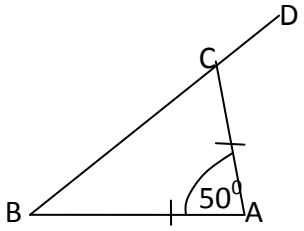


Figure 2

In $\triangle ABC$ in Figure 2, BC is produced to D, $AB = AC$ and $\angle BAC = 50^0$, $Find\ \angle ACD$.

A. 50^0 B. 60^0 C. 65^0 D. 115^0

Key to MAT Pretest Items

1. D	**2.D**	**3.A**	**4.B**	**5.B**	**6.C**	**7.C**	**8.B**	**9.B**	**10. A**
11.B	**12.C**	**13.C**	**14.C**	**15.C**	**16A**	**17.D**	**18.D**	**19.D**	**20.D**

Appendix K
Mathematics Achievement Test (MAT) (Posttest) / Key

School _____ **Code** _____

Sex _____ **Age** _____

Instruction: Tick the letter that corresponds to the best answer. **Time: 45 minutes**

1) Simplify $5y^2 \times 4y^3$

A. $20y^6$ B. $20y^5$ C. $9y^5$ D. $20y^{23}$

2) Mary had x oranges. She ate 2 and shared the remainder equally with Ngala. Express in terms of x the information that Ngala's share is at least 5 oranges.

A. $\frac{x-2}{2} \leq 5$ B. $\frac{x-2}{2} > 5$ C. $\frac{x}{2} - 2 < 5$ D. $\frac{x-2}{2} \geq 5$

3) Expressing n in terms of p, v, r and t in the formula $pv = nrt$ gives

A. $n = \frac{pvt}{r}$ B. $n = \frac{pvr}{t}$ C. $n = \frac{pv}{rt}$ D. $n = pv - rt$

4) Given that $x = -3,$ and $y = -7,$ evaluate $\frac{x^2-y}{y^2-x}$

A. $-\frac{1}{11}$ B. $\frac{1}{23}$ C. $\frac{4}{13}$ D. $\frac{12}{17}$

5) Express $4 - \frac{y-x}{x}$ as a single fraction.

A. $\frac{3x-y}{x}$ B. $\frac{5x-y}{x}$ C. $\frac{4-y+x}{x}$ D. $\frac{4-y-x}{x}$

6) Calculate the value of $16^{\frac{5}{4}} \times 2^{-3} \times 3^0$

A. 20 B. 2 C. 4 D. 10

7) Given that the three angles of a triangle are, a, b and c, which of the following equations concerning the triangle is correct.

A. $a + b + c = 360^0$ B. $a + b - c = 180^0$ C. $a + b = c$ D. $a + b + c = 180^0$

8) In Figure 1, what is the size of angle PQR?

A. 40^0 B. 50^0 C. 60^0 D. 80^0

9) Evaluate $\frac{3}{6p} + \frac{3}{4p}$, given that the value of p is 1

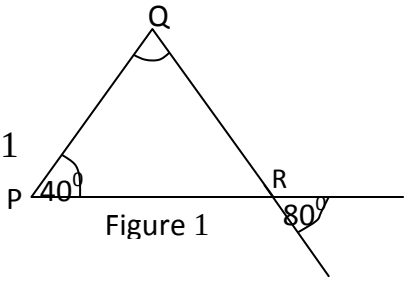


Figure 1

A. $\frac{17}{12}$ B. 12 C. $\frac{1}{6}$ D. $\frac{5}{4}$

10) Find the range of values of x for which $3x - 8 \geq 5x$

A. $x \leq 4$ B. $x \geq 1$ C. $x \leq -4$ D. $x \geq -4$

11) Two variables x and y, and three constants, a, b and c are such that the sum of ax and by equals c. Use this information to express x in terms of a, b, c and y.

A. $x = \frac{by-c}{a}$ B. $x = c - by - a$ C. $x = \frac{c+by}{a}$ D. $x = \frac{c-by}{a}$

12) p and q are two positive numbers such that $p > 2q$. Which one of the following is **not** true?

A. $-p < -2q$ B. $-p > 2q$ C. $-p < 2p$ D. $-q < \frac{1}{2}p$

13) Evaluate $\left(27^{\frac{1}{3}}\right)^2$

A. 81 B. 6 C. 18 D. 9

14) The largest angle of any triangle

A. Must always be acute B. Can sometimes be acute C. Can never be Right angled D. Must always be obtuse

15)

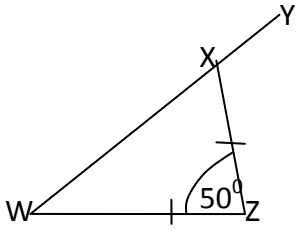


Figure 2

In $\triangle WXZ$ in Figure 2, WX is produced to Y, $WZ = XZ$ and $\angle WZX = 50^0$, $Find\ \angle ZXY$.

A. 50^0 B. 60^0 C. 65^0 D. 115^0

16) Given that $F = \frac{9a}{r^{10}} - \frac{b}{r^2}$,the value of a, when F = 10, r = 1 and b = 7 is;

A. 3 B. $\frac{17}{9}$ C. 9 D. $\frac{20}{7}$

17) Simplify $0.027^{-\frac{1}{3}}$

A. 3 B. $\frac{3}{10}$ C. $\frac{10}{3}$ D. $\frac{1}{3}$

18) Simplify $\frac{4}{a-3} - \frac{1}{a+2}$

A. $\frac{3a+11}{(a+3)(a-2)}$ B. $\frac{3a-11}{(a-3)(a+2)}$ C. $\frac{3a+11}{(a-3)(a-2)}$ D. $\frac{3a+11}{(a+3)(a+2)}$

19) Given the equation $E = \frac{1}{2}mv^2$ and that $v = rw$, express r in terms of E, m and w

A. $r = \pm\sqrt{\frac{2E}{mw^2}}$ B. $r = \left(\frac{2E}{mw^2}\right)^2$ C. $r = \frac{2E}{mw}$ D. $r = \pm\sqrt{\frac{E}{2mw}}$

20) Simplify $\frac{1}{2}(2^n - 2^{n+1})$

A. $2^{n-1} - 2^n$ B. $2^{n-1}(1 - 2^n)$ C. $2^{n+1} + 2$ D. 2^n

Key to MAT Posttest Items

1. B	**2.D**	**3.C**	**4.C**	**5.B**	**6.C**	**7.D**	**8.C**	**9.D**	**10.C**
11.D	**12.B**	**13.D**	**14.B**	**15.D**	**16B**	**17.C**	**18.A**	**19.A**	**20.A**

Appendix L

Table of Specifications for Mathematics Achievement Test (MAT).

	Mental Skills						
Content area	*Remem-bering 10%*	*Understan-ding 10%*	*Applying 30%*	*Analy-zing 10%*	*Evalua-ting 30%*	*Creating 10%*	**Total**
Indices	1	0	1	2	1	0	5
Inequalities	0	1	0	0	1	1	3
Algebraic expressions	0	0	2	0	2	0	4
Transposition of formulae	0	1	1	0	1	1	4
Triangles	1	0	2	0	1	0	4
Total	2	2	6	2	6	2	**20**

Appendix M

Scheme of Work from where Lesson Plans were Developed

Topic	Lesson	N^{o} of Periods	Lesson N^{o}
Indices	➢ Laws of indices	2	1
	➢ Odd, even and fractional indices	1	2
Inequalities	➢ Linear Inequalities	1	3
Algebraic Expressions	➢ Algebraic fractions	2	4
Subject of a Formula	➢ Subject of a formula with power one	1	5
	➢ Subject of formula with power two or more	2	6
Triangles	➢ Types of triangles	1	7
	➢ Some properties of triangles	2	8

APPENDIX N

Lesson plans for Cooperative Learning

Lesson Number: 1
Class: Form 3
Duration: 80 minutes
Topic: INDICES
Lesson: Law of Indices
Specific objectives: By the end of the lesson, students should be able to:
- State the laws of indices
- Apply the laws in solving at least 50% of the exercises and assignments correctly.

Previous knowledge: Students are able to add, subtract, multiply and divide real numbers ($\Re$)

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
Stage I: Introduction Write answers to the following 1) -4+8= 2) 5-13= 3) -6-3= 4) -8x-5= 5) 6x-7= 6) $\frac{-10}{-2}$ = 7). $\frac{12}{-3}$=	-Teacher marches into the class while counting his steps. - Copies questions on the chalkboard and uses them to test the entry behavior of students. -Asks students to write answers to questions independently. - Calls students to give answers to questions. - Discusses the answers with the students.	-Look at the teacher as he marches. -Copy and write answers to questions. - Give answers to questions when asked to do so by the teacher. - Discuss answers with the teacher.	Chalkboard	-Set induction method. -To test the entry behavior of students using appropriate questioning skills.
Stage II: Pre-cooperative learning activities	- Presents the objectives of the lesson verbally. - Gives a verbal presentation of the learning task. -Gives the modalities of learning and the expectations of each group/group member. - Helps students to form mixed-ability	- Listen to lesson objectives and presentation of learning task. - Listen to learning modalities and expectations. -Ask questions if any. - Identify their group members.		Class presentations. -Activities preceding cooperative

	groups to learn task. -Assigns sitting positions to each group. -Assigns a number to each group for easy identification. -Asks each group to choose their leader. - Presents the learning task to each group on papers.	- Move to their respective sitting positions. -Take note of their group numbers. - Select their leader in each group. - Each group leader collects learning task from the teacher.		learning. - Group formation.
Stage III: Learning Task **Laws of Indices** 1) $x^a \text{x}\, x^b = x^{a+b}$ 2) $x^a \div x^b = x^{a-b}$ 3) $\text{x}^0 = 1$ 4) $x^{-a} = \frac{1}{x^a}$ 5) $(x^a)^b = x^{ab}$	-Teacher explains each law in order to facilitate group learning. -Asks students to study the laws in their groups. - Moves around monitoring students as they work in their groups and helping them implement the approach to work which they have chosen	- Listen to the teacher's explanation and ask questions if any. -Each group engages in learning the task; helping each group member to learn, following whatever approach adopted.	-Sheets of papers containing learning tasks.	-For systematic acquisition of required facts knowledge, information and cognitive skills. -Group/team interactions for maximal learning.
Stage IV: Examples on Learning Task Simplify the following leaving your answers in the simplest possible form. 1) $10^5 \text{x} 10^4 = 10^{5+4} = 10^9$ 2) 5y x 4y = 5 x 4 x y x y^4 =20 x y^{1+4} = 20y^5 3) $m^8 \div m^5 = m^{8-5} = m^3$ 4) $4^{-3} = \frac{1}{4^3} = \frac{1}{4 \text{ x } 4 \text{ x } 4} = \frac{1}{64}$ 5) $\left(\frac{1}{4}\right)^{-2} = \frac{1}{\left[\frac{1}{4}\right]^2} = \frac{1}{\frac{1 \text{x} 1}{4 \text{x} 4}} = 1\text{x}\frac{16}{1} = 16$ 6) $a^{-9} \div b^0 = a^{-9} \div 1 = a^{-9} = \frac{1}{a^9}$ 7) $(3x)^{-3} = \frac{1}{(3x)^3} = \frac{1}{3 \text{ x } 3 \text{ x } 3 \text{ x } x\text{x } x\text{x } x} =$ $\frac{1}{27x^3}$ 8) $9a^{-5} \text{x}\, 4a^6 = 9\text{x}4\text{x}a^{-5} \text{x}\, a^6 =$ $36 \text{ x } a^{-5+6} = 36a$ 9) $(g^{-2})^5 = 9^{-2x5} = g^{-10} = \frac{1}{g^{10}}$	-Asks each group to apply the appropriate laws in solving/following up the solutions of each example. -Moves around monitoring students as they work in their groups and assisting them in their difficulties. - Provides regular general interventions on the board on identified areas of difficulty to all groups.	-Each group engages in solving the examples helping each group member to learn. - Call for teacher's assistance in case of any difficulty.	-Sheets of papers containing learning tasks.	To facilitate understanding of the laws and also to reinforce them. Stimulus variation skill. -Group/team work.
Stage V: Practice Simplify the following by applying the laws of indices.	- Copies exercise on the board. - Asks each group to attempt solutions to exercise.	-Groups copy exercise and attempt solutions. - Call for assistance	Red pen	For consolidation/ stimulus variation skills.

1) a^3x a^9 2) $C^7 \div C$ 3) $\frac{24x^6}{8x^4}$ 4) $3x^{-3}$ 5) $x^3 \div x^{-5}$ 6) $(f^0)^8$ 7) $(3^{-2})^2$ 8) $15 \times 10^4 \div (3 \times 10^{-2})$	- Moves around the class assisting groups. - Randomly selects one member from each group to present the solution to any of the exercises to the whole class. -Calls for reactions from other groups. -Concludes on presented solution.	where need be. -Present solution to any exercise upon request from the teacher. -React to presented solution.		
Stage VI: Assessment (Quiz 1) Simplify the following: 1) k^9x k^3 = 2) $n^7 \div n$ = 3) 4^{-2} = 4)$(e^0)^{25}$ = 5) $(u^5)^{-2}$=	-Asks students to move back to their sitting positions, keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes, using group leaders.	- Move back to their sitting positions, keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher through their group leaders standing in front of the class.	Evaluation exercise books	-To ensure that students participate actively in group activities -Consolidation of group gains.
Stage VII: Assessment/Follow Up 1) Simplify the following: i) $56x^{-4} \div 14x^{-8}$ ii) $\frac{1}{4}(2^n - 2^{n+2})$ iii) $(0.25)^2$ iv) $3^{(1-2n)} \times 9^n \times 5^0$ 2) Given that $\left(\frac{1}{4}\right)^{2-y} = 1$, find the value of y. 3) Evaluate the following: i) $\frac{2^{\frac{1}{2}} \times 8^{\frac{1}{2}}}{4}$ ii) $5\frac{2}{5} \times \left(\frac{2}{3}\right)^2 \div \left(1\frac{1}{2}\right)^{-1}$	- Teacher puts up card board containing assignment for students. - Asks students to copy assignment and attempt solutions at home.	 - Copy assignments in their notebooks to solve at home.	Cardboard	-Time management skills. For reinforcement
Stage VIII: Closure	-Summarizes the laws of indices verbally. -Informs students on the next lesson; Odd, even and fractional indices.	-Listen as the teacher summarizes the lesson and gives next lesson. -Feel happy by		-To end the lesson. -Students can prepare adequately for next lesson at home.

	- Appreciates students' efforts during the lesson by clapping 5 times for them.	smiling or laughing.		-To leave students happy and encouraged.

Lesson Number: 2
Class: Form 3
Duration: 40 minutes
Topic: Indices
Lesson: Odd, even and fractional indices
Specific objectives: By the end of the lesson, students should be able to:
-Identify the effects of odd and even powers on negative numbers.

-Apply the laws of indices in solving at least 80% of exercises on indices correctly.

Previous knowledge: Students are able to find the square root and other higher roots of numbers.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
Stage 1:Introduction 1) What is the square root of 4 and -4? 2) What is the cube root of 8 and -8?	-Teacher counts square numbers while entering the class. -Teacher finds out and clarifies students' difficulties in the assignment. -Asks questions 1 and 2 verbally to test entry behavior of students. -Uses students' answers and calculator to emphasize that the even root of a negative number does not exist.	-Students look at the teacher counting. -Present difficulties faced in solving assignment if any. -Put up their hands to answer the teacher's questions. -Listen to teacher's emphasis and ask questions if any.	Scientific calculators	-Set induction method. -To test entry behavior and to ensure effective reinforcement. -Test of entry behavior of students using appropriate questioning skills.
Stage II: Pre-cooperative learning activities	- Presents the objectives of the lesson verbally. - Gives a verbal presentation of the learning task. -Gives the modalities of learning and the	- Listen to lesson objectives and presentation of learning task. - Listen to learning modalities and expectations.		-Class presentations.

	expectations of each group/group member. - Modifies existing groups if need be. -Assigns sitting positions to each group. -Asks each group to choose a new leader. - Presents the learning task to each group on papers.	-Ask questions if any. - Identify their group members. - Move to their respective sitting positions. - Select new leaders. - Each group leader collects learning task from the teacher.		-Activities preceding cooperative learning.
Stage III: Learning Task **Odd, even and fractional indices.** Note the following: 1) $x^{\frac{1}{a}} = \sqrt[a]{x}$ and $x^{\frac{a}{b}} = (\sqrt[b]{x})^a$ Thus $4^{\frac{1}{2}} = \sqrt{4} = \pm 2$ and $8^{\frac{2}{3}} = (\sqrt[3]{8})^2 = (2)^2 = 4$ 2) $(-x)^a$ is positive if a is even and negative if a is odd. Thus $(-3)^2 = 9$ and $(-3)^3 = -27$	-Teacher explains the procedures and concepts in order to facilitate group learning. -Asks students to study the learning task in their groups. - Moves around monitoring students as they work in their groups and assisting them in their difficulties.	- Listen to the teacher's explanation and ask questions if any. -Each group engages in learning the task and helping each group member to master the concepts.	-Sheets of papers containing learning tasks.	-For systematic acquisition of required facts knowledge, information and cognitive skills. -Group/team interactions for maximal learning.
Stage IV: Examples on Learning Task Simplify the following. 1) $27^{\frac{1}{3}} = \sqrt[3]{27} = 3$ 2) $(3m^4)^2 = 3^2 \times m^{4x2} = 9m^8$ 3) $(-2b^2)^3 = -2^3 b^{2x3} = -8b^6$ 4) $(-u^3v^2)^4 = (-u^3)^4 \times (v^2)^4$ $= u^{3x4} \times v^{2x4}$ $= u^{12}v^8$ 5) $(5mn^3)^3 = 5^3 \times m^3 \times n^{3x3}$ $= 125m^3n^9$ 6) $2^{-2} = \frac{1}{2^2} = \frac{1}{4}$ 7) $2a^{-1} = 2 \times \frac{1}{a^1} = \frac{2}{a}$ 8) $9^{\frac{-1}{2}} = \frac{1}{9^{\frac{1}{2}}} = \frac{1}{\sqrt{9}} = \frac{1}{\pm 3}$	-Asks each group to apply the appropriate procedures in solving/following up the solutions of each example. -Moves around monitoring students as they work in their groups and assisting them in their difficulties. - Provides regular general interventions on the board on identified areas of difficulty to all groups.	-Each group engages in solving the examples helping each group member to learn. - Call for teacher's assistance in case of any difficulty.	-Sheets of papers containing learning tasks.	To facilitate understanding of procedures and also to reinforce them/ Stimulus variation skill.
Stage V: Practice Simplify the following 1) $(4v^3)^2$ 2) $-2(a^2)^3$ 3) $(-c^3)^2$ 4) $(a^2b)^3$ 5) $(x^2y^3)^4$ 6) $-3(de^3)^4$ 7) 3^{-3} 8) $(25a^2)^{\frac{1}{2}}$ 9) $\frac{a^6}{(-a)^4}$ 10) $\frac{(-c)^2 \times c^4}{(-c)^5}$	- Copies exercise on the board. - Asks each group to attempt solutions to exercise. - Moves around the class assisting groups. - Randomly selects one member from each	-Groups copy exercise and attempt solutions. - Call for assistance where need be. -Present solution to	Red pen	For consolidation/ Skill of stimulus variation.

	group to present the solution to any of the exercises to the whole class. -Calls for reactions from other groups. -Concludes on presented solution.	any exercise upon request from the teacher. -React to presented solution.		
Stage VI:Assessment (Quiz 2) Simplify the following : 1) $(-r^3)^2$ 2) $9^{\frac{1}{2}}$ 3) $(25y^2)^{\frac{1}{2}}$ 4) $\frac{(-c)^2 \times c^4}{(-c)^5}$	-Asks students to move back to their sitting positions, keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes, using group leaders.	- Move back to their sitting positions, keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher through their group leaders standing in front of the class.	- Evaluation exercise books.	-To ensure that students participate actively in group activities -Consolidation of group gains.
Stage VII: Assessment/Follow Up 1)Simplify the following : i) $0.125^{\frac{1}{3}}$ ii) $\left(\frac{16}{81}\right)^{\frac{1}{4}}$ iii) $\frac{4^{\frac{-1}{2}} \times 16^{\frac{3}{4}}}{4^{\frac{1}{2}}}$ 2) If $2\sqrt{x} = 4$, then find the value of x. 3) Given that $81x2^{2n-2} = k$, find $\sqrt{k}$	- Teacher puts up card board containing assignment for students. - Asks students to copy assignment and attempt solutions at home	- Copy assignments in their notebooks to solve at home.	Card board	-Time management skills. For reinforcement
Stage VIII: Closure	Informs students on the next lesson; linear inequalities. - Appreciates students' efforts during the lesson by singing for them a short song.	-Listen to teacher's information. -Listen as the teacher sings. -Feel happy by smiling, laughing or clapping.		-To end the lesson. -Students to prepare adequately for next lesson at home. -To leave students happy and encouraged/ Musical skills.

Lesson Number: 3
Class: Form 3
Duration: 40 minutes
Topic: INEQUALITIES
Lesson: Linear Inequalities

Specific objective: By the end of the lesson, students should be able to:

- Apply their knowledge of linear equations in solving simple linear inequalities.
- Change the inequality sign when dividing or multiplying both sides of the inequality by a negative number.

Previous knowledge: Students are able to:

- Solve simple linear equations.
- Identify inequality signs.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
Stage 1:Introduction 1) Identify the following symbols found on the cardboard: $<, >, \leq, \geq$. 2) Given the equation $2x - 5 = 4 - 5x$ a) What name is given to this equation? b) Solve for the value of x.	-Holds cardboard containing inequality signs and staggers into class. Moves around with the cardboard. -Asks for and clarifies students' difficulties in solving the assignment. - Asks question 1 verbally and copies question 2 on the board for use in testing the entry behaviour of students. -Asks students to answer questions. -Discusses students' answers together with them.	-Students watch the teacher staggering and notice what he carries. -Present difficulties in the assignment if any and listen to teacher's clarifications. -Students put up their hands and answer teacher's questions.	Cardboard	-Set induction method. -To clarify difficulties and misconceptions -To test the entry behavior of students using appropriate questioning skills.
Stage II: Pre-cooperative learning activities	- Presents the objectives of the lesson verbally. - Gives a verbal presentation of the	- Listen to lesson objectives and presentation of learning task. - Listen to learning		-Class presentations.

	learning task. -Gives the modalities of learning and the expectations of each group/group member. - Modifies existing groups if need be. -Assigns sitting positions to each group. -Asks each group to choose a new leader. - Presents the learning task to each group on papers.	modalities and expectations. -Ask questions if any. - Identify their group members. - Move to their respective sitting positions. - Select new leaders. - Each group leader collects learning task from the teacher.		-Activities preceding cooperative learning.
Stage III: Rules for solving Linear Inequalities Linear inequalities are solved in the same way as linear equations but for the fact that: when multiplying or dividing both sides of the inequality by a negative number, the inequality sign changes.	-Teacher explains rules in order to facilitate group learning. -Asks students to discuss rules in their groups. - Moves around monitoring students as they work in groups and assisting them if need be.	- Listen to the teacher's explanation and ask questions if any. -Each group engages in discussing rules and helping each group member to master it.	-Sheets of papers containing learning tasks.	For systematic acquisition of required facts knowledge, information and cognitive skills.
Stage IV: Examples on Learning Task **Example 1:** Solve the inequality $x + 5 \leq -10$ Solution: $x \leq -10 - 5$ $x \leq -15$ **Example 2:** Evaluate $6 < 3(x+7)$ **Solution:** $6 < 3x+21$ $-3x < 21-6$ $-3x < 15$ $\frac{-3x}{-3} < \frac{15}{-3}$ $x > -5$ **<u>Example 3</u>:** Evaluate $\frac{1}{3}x + \frac{5}{8} \geq \frac{1}{2}x - \frac{5}{24}$ **Solution** $\frac{8x+15}{24} \geq \frac{12x-5}{24}$ $8x+15 \geq 12x-5$ $8x-12x \geq -5-15$ $-4x \geq -20$ $\frac{-4x}{-4} \leq \frac{-20}{-4}$ $x \leq 5$	-Asks each group to apply the appropriate rules in solving/following up the solutions of each example. -Moves around monitoring students as they work in their groups and assisting them in their difficulties. - Provides regular general interventions on the board on identified areas of difficulty to all groups.	-Each group engages in solving the examples helping each group member to learn. - Call for teacher's assistance in case of any difficulty.	-Sheets of papers containing learning tasks.	To facilitate understanding of the rules and also to reinforce them/ Stimulus variation skill.

Stage V: Practice Solve the following inequalities 1) $3(2x+1) \geq \frac{1}{3}(2x-9)$ 2) $2(x+4) > 3(x-1)$	-Presents 2 flash cards containing 2 different questions. -Selects 2 students from two groups at random to solve any of the questions on the board. -Asks the other students to solve exercises in their different groups. -Moves round correcting and aiding groups. -Calls for reactions from groups with regard to presented solutions. -Concludes on presented solution.	-2 students from two groups move to the front of the class, pick flash cards, copy the questions on them and present their solutions on the board. - The other students copy questions and attempt solutions in their groups. - Call teacher for assistance where need be. -React to presented solution and do corrections incase of wrong solutions.	Flash cards	For reinforcement/ Skill of stimulus variation
Stage VI:Assessment (Quiz 3) Solve the following inequalities 1) $x-3 < 2$ 2) $5(2-x) \geq 5-7x$ 3) $4-3x > 10$	-Asks students to move back to their sitting positions, keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes, using group leaders.	- Move back to their sitting positions, keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher through their group leaders standing in front of the class.	Evaluation exercise books.	-To ensure that students participate actively in group activities -Consolidation of group gains.
Stage VII: Assessment/Follow Up 1) Evaluate the following a) $\frac{1}{3}(2x-1) < 5$ b) $x - \frac{2}{5} \geq 2\ (x-4)$ c) $\frac{1}{2}(4x+2) - (x-5) \leq \frac{1}{4}(3x-1)$ 2) Ako had P oranges. He ate 2 and shared the remainder equally with Afese. Express in terms of P the information that Afese's share is at least 5 oranges.	- Teacher puts up card board containing assignment for students. - Asks students to copy assignment and attempt solutions at home.	- Copy assignments in their notebooks to solve at home.	Card board	-Time management skills. For reinforcement
Stage VIII: Closure	-Summarizes verbally the rules for solving linear inequalities.	-Listen as the teacher summarizes the lesson.		-To end the lesson. -Students can

	-Informs students that next lesson will be on algebraic fractions. - Appreciates students' efforts during the lesson by dancing for them.	-Listen to teacher's information. -Feel happy by smiling or laughing.		prepare for next lesson at home. -To leave students happy and encouraged.

Lesson Number: 4
Class: Form 3
Duration: 80 minutes
Topic: ALGEBRAIC EXPERESSION
Lesson: Algebraic fractions
Specific objectives: By the end of the lesson, students will be able to:

- Simplify multiple algebraic fractions and write them as a single fraction in its lowest term.

Previous knowledge: Students are able to add, subtract, multiply and divide numerical fractions.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
Stage 1:Introduction Simplify the following: ❖ 3/4 + 1/3 = ❖ -2/5-7/3 = ❖ 3/2×1/3 = ❖ -7/8÷4/7 =	-Teacher asks students to stand up, to clap once, to count in multiples of 1/2 and to sit down. -Asks for and clarifies students' difficulties in solving the assignment. - Copies questions on the board and uses them to test the entry behaviour of students. -Discusses solutions with students.	-Students follow teacher's instructions. -Present difficulties in the assignment if any and listen to teacher's clarifications. -Students put up their hands and answer the teacher's questions. -Listen and participate in discussions.		-Set induction method. -To clarify misconceptions and difficulties. -Test for entry behavior of students using appropriate questioning skills.
Stage II: Pre-cooperative learning activities	- Presents the objectives of the lesson verbally. - Gives a verbal	- Listen to lesson objectives and presentation of learning task.		-Class presentations.

	presentation of the learning task. -Gives the modalities of learning and the expectations of each group/group member. - Modifies existing groups if need be. -Assigns sitting positions to each group. -Asks each group to choose a new leader. - Presents the learning task to each group on papers.	- Listen to learning modalities and expectations. -Ask questions if any. - Identify their group members. - Move to their respective sitting positions. - Select new leaders. - Each group leader collects learning task from the teacher.		-Activities preceding cooperative learning.
Stage III: Algebraic fractions In simplifying algebraic fractions, the LCM of the denominators is obtained and used to evaluate the sums and differences so as to express the fractions as a single fraction.	-Teacher explains procedure in order to facilitate group learning. -Asks students to discuss procedure in their groups. - Moves around monitoring students as they work in groups and assisting them if need be.	- Listen to the teacher's explanation and ask questions if any. -Each group engages in discussing procedure and helping each group member to master it.	-Sheets of papers containing learning tasks.	-For systematic acquisition of required facts knowledge, information and cognitive skills. -Group/team interactions for maximal learning.
Stage IV: Examples on Learning Task **Example 1:** Write $\frac{1}{2r} + \frac{3}{4r}$ as Single fraction **Solution:** $\frac{1}{2r} + \frac{3}{4r}$ $= \frac{2+3}{4r} = \frac{5}{4r}$ **Example 2:** Simplify $\frac{3m}{2n} - \frac{m-1}{5n} + \frac{m-2}{10n}$ **Solution:** $\frac{5(3m) - 2(m-1) + m - 2}{10n}$ $= \frac{15m - 2m + 2 + m - 2}{10n}$ $= \frac{15m - 2m + m + 2 - 2}{10n}$ $= \frac{14m}{10n} = \frac{7m}{5n}$ **Example 3:** Simplify $\frac{4}{a-3} - \frac{1}{a+2}$ **Solution:** $\frac{4(a+2)-(a-3)}{(a-3)(a+2)} =$ $\frac{4a+8-a+3}{(a-3)(a+2)} = \frac{3a+11}{(a-3)(a+2)}$ **Example 4:** Write as a single	-Asks each group to use the appropriate procedure in solving/following up the solutions of each example. -Moves around monitoring students as they work in their groups and assisting them in their difficulties. - Provides regular general interventions on the board on identified areas of difficulty to all groups.	-Each group engages in solving the examples helping each group member to learn. - Call for teacher's assistance in case of any difficulty.	-Sheets of papers containing learning tasks.	To facilitate understanding of the procedures and also to reinforce them/ Stimulus variation skill.

fraction $(\frac{3}{x}-\frac{15}{2y})\div\frac{6}{xy}$ **Solution:** $\frac{3(2y)-15(x)}{2xy}\div\frac{6}{xy}=$ $\frac{6y-15x}{2xy}\div\frac{6}{xy}=\frac{6y-15x}{2xy}\times\frac{xy}{6}=$ $\frac{6y-15x}{2}\times\frac{1}{6}=\frac{6y-15x}{12}=\frac{3(2y-5x)}{12}=$ $\frac{2y-5x}{4}$				
Stage V: Practice Simplify the following: 1) $\frac{2x-1}{3}-\frac{x+3}{2}$ 2) $\frac{1}{x-3}-\frac{2}{x+4}$ 3) $\frac{x}{x-2}-\frac{x+2}{x+3}$ 4) $\frac{1}{M-1}+\frac{9}{2M+3}-\frac{8}{M+4}$	- Copies exercise on the board. - Asks each group to attempt solutions to exercise. - Moves around the class assisting groups. - Randomly selects one member from each group to present the solution to any of the exercises to the whole class. -Calls for reactions from other groups. -Concludes on presented solution.	-Groups copy exercise and attempt solutions. - Call for assistance where need be. -Present solution to any exercise upon request from the teacher. -React to presented solution.	Red pen	For consolidation/ Skill of stimulus variation
Stage VI:Assessment (Quiz 4) Simplify the following 1) $\frac{3}{2p}+\frac{5}{3p}$ 2) $\left(\frac{3}{r}-\frac{15}{2t}\right)\div\frac{6}{rt}$ 3) $\frac{4}{y+1}-\frac{4}{y-1}$	-Asks students to move back to their sitting positions, keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes, using group leaders.	- Move back to their sitting positions, keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher through their group leaders standing in front of the class.	Evaluation exercise books	-To ensure that students participate actively in group activities -Consolidation of group gains.
Stage VII: Assessment/Follow Up Simplify the following 1) $\frac{x}{x-2}-\frac{x+2}{x+3}$ 2) $\frac{1}{x-3}-\frac{3(x-1)}{x-9}$ 3) $4-\frac{y-x}{x}$ 4) $\frac{3x-2}{x-5}-\frac{2x+3}{2(x-5)}$	- Teacher puts up card board containing assignment for students. - Asks students to copy assignment and attempt solutions at home	- Copy assignments in their notebooks to solve at home.	Card board	-Time management skills. For reinforcement

5) $1-\frac{12-3y^2}{2y^2-8}$				
Stage VIII: Closure	-Summarizes the procedure for simplifying algebraic fractions verbally. -Informs students that the next lesson will be on subject of formula with power one. - Appreciates students' efforts during the lesson by drawing a nice diagram on the board for them.	-Listen to the teacher's summary and information. -Observe and feel happy by clapping, smiling or laughing.		-To end the lesson. -Students can prepare for next lesson at home. -To leave students happy and encouraged.

Lesson Number: 5
Form: 3
Duration: 40 minutes
Topic: SUBJECT OF A FORMULA
Lesson: Subject of formula with power one.
Specific objectives: By the end of the lesson students should be able to:

- Express a linear variable in terms of one or more other variables in an equation.
- Calculate the value of a variable given the other (s) in an equation/formula.

Previous knowledge: Students are able to:

- Solve simple linear equations.
- Factorise common terms in expressions.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
Stage 1:Introduction	-Teacher enters the class holding up 2 pencils/ 3 green pens in one hand, and 4 red pens and 2 pencils in the other hand. -Asks students to comment on content of both hands.	-Students watch the teacher as he enters the class. -Take note of what the teacher is holding. -Identify among other things that each hand has 2 pencils.	Red pens, green pens and pencils.	-Set induction method. -To clarify misconceptions and difficulties.

1) Simplify $2x^2y + x^3y^2$ 2) Solve for y in the equation pqy = t	-Asks for and clarifies students' difficulties in solving the assignment. - Copies 2 questions on the board to use in testing entry behaviour of students. -Asks students to solve questions in their note books. -Discusses students' answers together with them.	-Present difficulties in the assignment if any and listen to teacher's clarifications. -Students solve questions and present their solutions. -Participate in the discussion by listening attentively or by asking questions.		-To test entry behavior of the students using appropriate questioning skills.
Stage II: Pre-cooperative learning activities	- Presents the objectives of the lesson verbally. - Gives a verbal presentation of the learning task. -Gives the modalities of learning and the expectations of each group/group member. - Modifies existing groups if need be. -Assigns sitting positions to each group. -Asks each group to choose a new leader. - Presents the learning task to each group on papers.	- Listen to lesson objectives and presentation of learning task. - Listen to learning modalities and expectations. -Ask questions if any. - Identify their group members. - Move to their respective sitting positions. - Select new leaders. - Each group leader collects learning task from the teacher.		-Class presentations. -Activities preceding cooperative learning.
Stage III: Learning Task **Subject of formula with power one.** The subject of a formula is the quantity you want to find in any given formula. We express the subject of the formulae in terms of other quantities.	-Teacher explains procedure in order to facilitate group learning. -Asks students to discuss procedure in their groups. - Moves around monitoring students as they work in their groups and assisting them if need be.	- Listen to the teacher's explanation and ask questions if any. -Each group engages in discussing procedure and helping each group member to master it.	-Sheets of papers containing learning tasks.	-For systematic acquisition of required facts knowledge, information and cognitive skills. -Group/team interactions for maximal learning.
Stage IV: Examples on Learning Task **Example 1:** Make y the subject of the formula ax +by = c **Solution:** by = c-ax $\frac{by}{b} = \frac{c-ax}{b}$	-Asks each group to use the appropriate procedure in solving/following up the solutions of each example.	-Each group engages in solving the examples helping each group member to learn.	-Sheets of papers	To facilitate understanding of the procedures and also to reinforce them/

$y = \frac{c - ax}{b}$ **Example 2:** From the equation $E = \frac{w(R - r)}{2Rp}$ a) Make R the subject of the formula. b) Find R when r =12, p=60, w=1024 and E=5/6 **Solution:** a) 2RpE = w(R-r) 2RpE = wR - wr wr = wR-2RpE wr = R(w-2pE) $\frac{wr}{w - 2Ep} = \frac{R(w - 2pe)}{w - 2Ep}$ $\frac{wr}{w - 2Ep} RorR = \frac{wr}{w - 2Ep}$ b) R= $\frac{wr}{w-2EP}$ R= $\frac{1024x12}{1024-2(60 \times \frac{5}{6})} = \frac{12288}{1024-2(10x5)}$ $= \frac{12288}{1024-100} = \frac{12288}{924}$ R= 13.29	-Moves around monitoring students as they work in their groups and assisting them in their difficulties. - Provides regular general interventions on the board on identified areas of difficulty to all groups.	- Call for teacher's assistance in case of any difficulty.	containing learning tasks.	Stimulus variation skill.
Stage V: Practice Given the formula F = $\frac{mv-mu}{t}$ a) Make M the subject of the formula b) Hence find m when F=25, u=0, v=15 and t=45 c) Make t the subject of the formula. d) Given that v – u =Δs. Express Δs in terms of F, m and t.	- Copies exercise on the board. - Asks each group to attempt solutions to exercise. - Moves around the class assisting groups. - Randomly selects one member from each group to present the solution to any of the exercises to the whole class. -Calls for reactions from other groups. -Concludes on presented solution.	-Groups copy exercise and attempt solutions. - Call for assistance where need be. -Present solution to any exercise upon request from the teacher. -React to presented solution.	Red pen	For consolidation/ Skill of stimulus variation
Stage VI:Assessment (Quiz 5) From the equation s = ut + $\frac{1}{2}$ at^2 , a) Find s given that u=25, t=4 and a=1.5 b) Express a in terms of s, u and t.	-Asks students to move back to their sitting positions, keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve	- Move back to their sitting positions, keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books.	Evaluation exercise	-To ensure that students participate actively in group activities -Consolidation

	them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes, using group leaders.	-Submit evaluation books as demanded by the teacher through their group leaders standing in front of the class.	books.	of group gains.
Stage VII: Assessment/Follow Up A certain motion is represented by the formula T+ mg = $\frac{mv^2}{r}$ a) Make m the subject of the formula b) Given T=50 when g=10, v=8 and r=4, hence find the value of m. c) Make r the subject of the formula d) Express g in terms of T, m, v and r.	- Teacher puts up card board containing assignment for students. - Asks students to copy assignment and attempt solutions at home	- Copy assignments in their notebooks to solve at home.	Card board	-Time management skills. For reinforcement
Stage VIII: Closure	-Verbally summarizes the procedure for obtaining the subject of a formula. -Informs students about next lesson; Subject of formula with power two or more. - Appreciates students' efforts during the lesson by asking them to clap for themselves.	-Listen to the teacher's summary and information on next lesson. -Feel happy by clapping and smiling or laughing.		-To end the lesson. -Students can prepare for next lesson at home. -To leave students happy and encouraged.

Lesson Number: 6
Form: 3
Duration: 80 minutes
Topic: SUBJECT OF A FORMULA
Lesson: Subject of formula with power two or more.
Specific objectives: By the end of the lesson students should be able to:

- Express a variable with power 2 or more, in terms of one or more than variables in an equation.
- Calculate the numerical value of variable given the other(s)

Previous knowledge: Students are able to

- Solve simple linear equations
- Find the square root of numbers.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
Stage 1:Introduction Give the square roots of: 4, 9, 36, 121, etc.	-Teacher marches into class while counting his steps using square numbers. -Checks attempted solutions from students. -Identifies and discusses students' difficulties in solving the assignment together with them. -Points particular students to give the square roots of some numbers. -Indicates how to use calculators for large numbers.	-Students watch the teacher and notice his irregular pattern of counting. -Present attempted solutions to assignment at the teacher's request. -Present difficulties faced. -Listen, contribute and ask questions if any.	Calculators	- Set induction method. -To clarify misconceptions and difficulties. -To test the entry behavior of students using questioning skills.
Stage II: Pre-cooperative learning activities	- Presents the objectives of the lesson verbally. - Gives a verbal presentation of the learning task. -Gives the modalities of learning and the expectations of each group/group member. - Modifies existing groups if need be. -Assigns sitting positions to each group. -Asks each group to choose a new leader - Presents the learning task to each group on papers..	- Listen to lesson objectives and presentation of learning task. - Listen to learning modalities and expectations. -Ask questions if any. - Identify their group members. - Move to their respective sitting positions. - Select new leaders. - Each group leader collects learning task from the teacher.		-Class presentations. -Activities preceding cooperative learning.
Stage III: Learning Task **Subject of formula with power two or more** **Note:**	-Teacher explains procedure in order to facilitate group learning.	- Listen to the teacher's explanation and ask questions if any.		-For systematic acquisition of required facts

1) If $x^2 = 9, then$ $x = \pm\sqrt{9}$($\pm$ for even powers) 2) If $x^3 = 8, then\ x = \sqrt[3]{8}$ $x = 2$ (no$\pm$ for odd powers)	-Asks students to discuss procedure in their groups. - Moves around monitoring students as they work in their groups and assisting them if need be.	-Each group engages in discussing procedure and helping each group member to master it.	-Sheets of papers containing learning tasks.	knowledge, information and cognitive skills. -Group/team interactions for maximal learning.
Stage IV: Examples on Learning Task **Example1**: Given that $v=3t^2+5$ Express t in terms of v. **Solution:** $v-5=3t^2$ $\frac{v-5}{3} = t^2, t = \pm\sqrt{\frac{v-5}{3}}$ **Example 2:** From the equation D= $\frac{LM}{K} + \frac{LU^2}{25}$, a) Make u the subject of the formula. b) Hence calculate the values of U if D=8, L=2, M=-5 and K=1 **Solution:** a) D = $\frac{25LM+KLU^2}{25K}$ $25LM + KLU^2 = 25KD$ $KLU^2 = 25KD - 25LM$ $U^2 = \frac{25KD - 25LM}{KL}$ $U^2 = \frac{25D}{L} - \frac{25M}{K}$ $U^2 = 25(\frac{D}{L} - \frac{M}{K})$ $U = \pm\sqrt{25\left(\frac{D}{L} - \frac{M}{K}\right)}$ $U = \pm 5\sqrt{\left(\frac{D}{L} - \frac{M}{K}\right)}$ b) $U = \pm 5\sqrt{\left(\frac{8}{2} - \frac{-5}{1}\right)}$ $u = \pm 5\sqrt{4+5} = \pm 5\sqrt{9}$ $u = \pm 5\ (3)$ $u = \pm 15$ **Example 3:** Express y in terms of x in the equation $x-45+8y^5 = 5x^2-6$ **solution**: $8y^5 = 5x^2 - 6-x+45$ $8y^5 = 5x^2 - x+39$ $y^5 = 5x^2-x+39$ $y = \sqrt[5]{\frac{5x^2 - x + 39}{8}}$	-Asks each group to use the appropriate procedure in solving/following up the solutions of each example. -Moves around monitoring students as they work in their groups and assisting them in their difficulties. - Provides regular general interventions on the board on identified areas of difficulty to all groups.	-Each group engages in solving the examples helping each group member to learn. - Call for teacher's assistance in case of any difficulty.	-Sheets of papers containing learning tasks.	To facilitate understanding of the procedures and also to reinforce them/ Stimulus variation skill.

Stage V: Practice 1) Make k the subject of the formula $pgr = 1 + dlk^2 - p$ 2) Given the formula $x^3 - y^3 = 9 - z^3$ a) Make x the subject of the formula b) Express y in terms of x and z c) Find the value of z when x=2 and y =1	- Copies exercise on the board. - Asks each group to attempt solutions to exercise. - Moves around the class assisting groups. - Randomly selects one member from each group to present the solution to any of the exercises to the whole class. -Calls for reactions from other groups. -Concludes on presented solution.	-Groups copy exercise and attempt solutions. - Call for assistance where need be. -Present solution to any exercise upon request from the teacher. -React to presented solution.	Red pen	For consolidation/ Skill of stimulus variation
Stage VI:Assessment (Quiz 6) 1) Given the formula $2y = 5r^2 - 7$ a) Make r the subject of the formula b) Find r when y=6 2) Express p interms of v,k and t in the equation $v^2 = \frac{4kp^3}{t}$	-Asks students to move back to their sitting positions, keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes, using group leaders.	- Move back to their sitting positions, keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher through their group leaders standing in front of the class.	Evaluation books.	-To ensure that students participate actively in group activities -Consolidation of group gains.
Stage VII: Assessment/Follow Up 1) Make t the subject of the formula $p = \frac{1-t^2}{1+t^2}$ 2) Make a the subject of the formula $\frac{v}{t} = \frac{\pi p a^4}{8nl}$ 3) Given that $\theta^7 - 5r = 6a - (k^2 - 2)\theta^7$, a) Express k in terms of θ, r and a. b) Make θ the subject of the formula. c) Hence find θ when k=0, a=1 and r = -2	- Teacher puts up card board containing assignment for students. - Asks students to copy assignment and attempt solutions at home.	- Copy assignments in their notebooks to solve at home.	Cardboard	-Time management skills. For reinforcement
Stage VIII: Closure	-Summarizes procedure for obtaining the subject	-Listen to the teacher's summary and information on		-To end the lesson.

	of the formula for powers greater than2. -Informs students that next lesson will be on Types of triangle. - Appreciates students' efforts during the lesson by telling them a story.	next lesson. -Feel happy by smiling or laughing.		-Students can prepare adequately for next lesson at home. -To leave students happy and encouraged.

Lesson Number: 7
Form: 3
Duration: 40 minutes
Topic: TRIANGLE
Lesson: Types of Triangles
Specific objectives: By the end of the lesson, students should be able to
- Identify the different types of triangles

- Draw the different types of triangles.

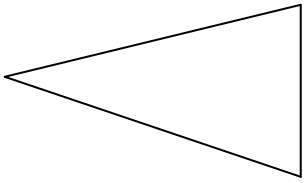
Previous knowledge: Students are able to

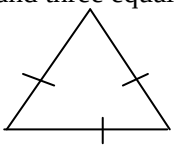
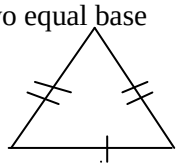
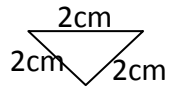
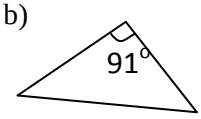
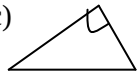
- Draw straight lines and identify angles.
- Differentiate a triangle from any other plane figures.

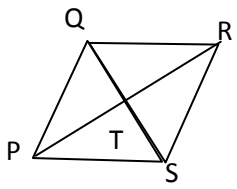
References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
Stage 1:Introduction 1) Draw the following figures, labeling the vertices with letters of your choice. a) Rectangle b) Trapezium c) Triangle d) Cone 2) Name any 2 angles in any of the figures.	-Teacher enters the class rotating a set square as if he is driving. -Uses questions 1 and 2 to test the entry behavior of students. -Asks questions and selects students to present solutions on the board. -Uses the set square to differentiate a triangle from other plane	-Students watch teacher's actions. -Put up their hands to answer teacher's questions. -Observe and ask questions if any.	Set square Board ruler	- Set induction method. -To test the entry behavior of students using questioning skills.

	figures.			
Stage II: Pre-cooperative learning activities	- Presents the objectives of the lesson verbally. - Gives a verbal presentation of the learning task. -Gives the modalities of learning and the expectations of each group/group member. - Modifies existing groups if need be. -Assigns sitting positions to each group. -Asks each group to choose a new leader. - Presents the learning task to each group on papers.	- Listen to lesson objectives and presentation of learning task. - Listen to learning modalities and expectations. -Ask questions if any. - Identify their group members. - Move to their respective sitting positions. - Select new leaders. - Each group leader collects learning task from the teacher.		-Class presentations. -Activities preceding cooperative learning.
Stage III : Learning Task **Types of triangles** **1) scalene triangle** It is a triangle in which none of the sides are equal and no angle measures up to 90^o  **2) Obtuse triangle** It is a triangle in which one of its three angles measures more than 90o x>90° x **3) Right-angle triangle.** It is a triangle in which one of its three angles measures exactly 90^o. 90^o **4)Equilateral triangle.** It is a triangle having three equal	-Asks students to study the different types of triangles in their groups. - Moves around monitoring students as they work in their groups and assisting them where need be.	-Each group engages in learning the task and helping each group member to learn.	-Sheets of papers containing learning tasks.	-For systematic acquisition of required facts knowledge, information and cognitive skills. -Group/team interactions for maximal learning.

sides and three equal angles (60^o)  **5)Isosceles triangle** It is a triangle which has two equal sides and two equal base angles 				
Stage 1V: Practice 1) Identify the following triangles a) b)   c)  2) Draw and name the triangles described below. a) A triangle with sides 2cm, 3cm and 5cm. b) A triangle with sides 3cm, 6cm and 3cm	- Copies exercise on the board. - Asks each group to attempt solutions to exercise. - Moves around the class assisting groups. - Randomly selects one member from each group to present the solution to any of the exercises to the whole class. -Calls for reactions from other groups. -Concludes on presented solution.	-Groups copy exercise and attempt solutions. - Call for assistance where need be. -Present solution to any exercise upon request from the teacher. -React to presented solution.	Red pen.	For consolidation/ Skill of stimulus variation
Stage V:Assessment (Quiz 7) Name and draw 5 different types of triangles.	-Asks students to move back to their sitting positions, keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes, using group leaders.	- Move back to their sitting positions, keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher through their group leaders standing in front of the class.	Evaluation exercise books.	-To ensure that students participate actively in group activities -Consolidation of group gains.
Stage VI: Assessment/Follow Up	- Teacher puts up card board containing assignment for students.		Cardboard	-Time management skills.

Given that figure PQRS is a rhombus.  1) Identify and name all the possible triangles created by the diagonals. 2) Name and indicate 4 different angles in figure PQRS.	- Asks students to copy assignment and attempt solutions at home	- Copy assignments in their notebooks to solve at home.		For reinforcement
Stage VII: Closure	-Summarizes the different types of triangles verbally. -Informs students that the next lesson will be on some properties of triangles - Appreciates students' efforts during the lesson by dancing for them.	-Listen to the teacher's summary and information on next lesson. -Feel happy by clapping and smiling or laughing.		-To end the lesson. -Students can prepare adequately for next lesson at home. -Use of psychomotor skills to leave students happy and encouraged.

Lesson Number: 8
Class: Form 3
Duration: 80 minutes
Topic: TRIANGLES
Lesson: Some properties of triangles
Specific objectives: By the end of the lesson, students should be able to:

- State the two main properties of any triangle
- Apply the above properties in finding missing angles in a triangle.

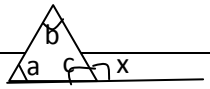
Previous knowledge: Students are able to:

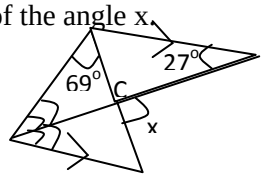
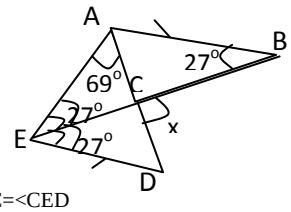
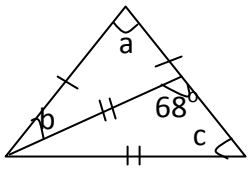
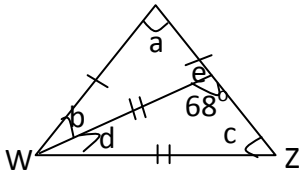
- Identify and draw the different types of triangles.
- Identify angles.
- Solve simple linear equations.

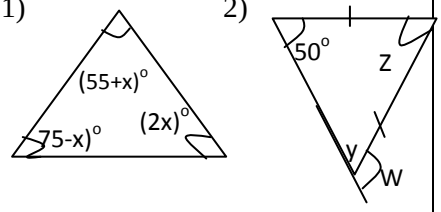
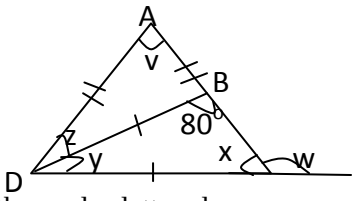
References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

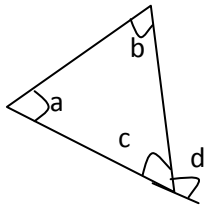
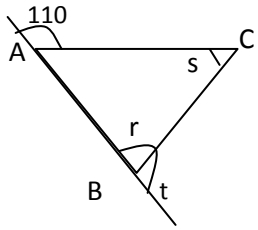
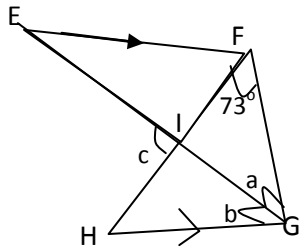
2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional**

				Strategies and Skills
Stage I:Introduction 1) State and explain the different types of triangles.	-Teacher moves very fast into the class carrying a set square as if will break pass the wall. - Checks students' attempted solutions. -Teacher tests entry behavior of students by discussing assignment together with them and also by asking question 1.	-Students watch teacher with set square to see what will happen. -Present attempted solutions to assignment at the teacher's request. -Listen, contribute and ask questions if any. -Do corrections accordingly. -Put up their hands to answer the teacher's questions.	Chalkboard ruler.	- Set induction method. -To test the entry behavior of students using questioning skills.
Stage II: Pre-cooperative learning activities	- Presents the objectives of the lesson verbally. - Gives a verbal presentation of the learning task. -Gives the modalities of learning and the expectations of each group/group member. - Modifies existing groups if need be. -Assigns sitting positions to each group. -Asks each group to choose a new leader. - Presents the learning task to each group on papers.	- Listen to lesson objectives and presentation of learning task. - Listen to learning modalities and expectations. -Ask questions if any. - Identify their group members. - Move to their respective sitting positions. - Select new leaders. - Each group leader collects learning task from the teacher.		-Class presentations. -Activities preceding cooperative learning.
Stage III: Learning Task **Some properties of triangles** 1) The sum of the three interior angles in a triangle equals$180^{0.}$ e.g in the triangle below, $a+b+c=180^0$ 2) The exterior angle of a triangle is equal to the sum of the two oppose interior angles 	-Teacher explains properties in order to facilitate group learning. -Asks students to study the properties in their groups. - Moves around	- Listen to the teacher's explanation and ask questions if any. -Each group engages in learning the task	-Sheets of papers containing	-For systematic acquisition of required facts knowledge, information and cognitive skills.

x= a + b	monitoring students as they work in their groups and assisting them in their difficulties.	and helping each group member to learn.	learning tasks.	-Group/team interactions for maximal learning.
Stage IV: Examples on Learning Task **Example 1** From the diagram below, find the value of the angle x.  **Solution** °  < ABC=<CED (Reason: alternate angles) $27^0 + 69^0 + y = 180^0$ (Reason: sum of angles of a triangle) $96^o + y=180^o$ $y=180^o – 96^o$ $y=84^o$ $\therefore y = x = 84^o$ (Reason: vertically opposite angles) **Example2.** Find the values of the lettered angles in the diagram below.  **Solution**  $c = 68^0$ (Reason: base angles of an isosceles triangle) $c + 68^o + d = 180^0$ $d=180^o-136^0$ $d=44^o$ $e + 68^o =180^0$ (Reason: angles on a straight line) $e =180^o – 68^0$, $e=112^o$ $68^o = 44^o + b$ (Reason: base angle an	-Asks each group to apply the appropriate properties in solving/following up the solutions of each example. -Moves around monitoring students as they work in their groups and assisting them in their difficulties. - Provides regular general interventions on the board on identified areas of difficulty to all groups.	-Each group engages in solving the examples helping each group member to learn. - Call for teacher's assistance in case of any difficulty.	-Sheets of papers containing learning tasks.	To facilitate understanding of the properties and also to reinforce them/ Stimulus variation skill.

isosceles triangle) $68^o - 44^0 = b$, $b = 24^o$ From Δ XWY, $112^o + 24^o + a = 180^o$ (Reason: sum of angles in a triangle) $a = 180^o - 136^o$, $a = 44^o$ **$\therefore a = 44^o, b = 24^o, c = 68^o$**				
Stage V: Practice Find the values of the missing angles in the triangle below, and name the triangles. 1) 2)  	- Copies exercise on the board. - Asks each group to attempt solutions to exercise. - Moves around the class assisting groups. - Randomly selects one member from each group to present the solution to any of the exercises to the whole class. -Calls for reactions from other groups. -Concludes on presented solution.	-Groups copy exercise and attempt solutions. - Call for assistance where need be. -Present solution to any exercise upon request from the teacher. -React to presented solution.	Chalkboard ruler and red pen	For consolidation/ Skill of stimulus variation.
Stage VI:Assessment (Quiz 8) Given the diagram below  Find the angles lettered v,w,x,y and z, giving reasons where necessary.	-Asks students to move back to their sitting positions, keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes, using group leaders.	- Move back to their sitting positions, keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher through their group leaders standing in front of the class.	Chalkboard ruler. Evaluation books.	-To ensure that students participate actively in group activities -Consolidation of group gains.
Stage VII: Assessment/Follow Up 1) Given the triangle below	- Teacher puts up card board containing assignment for students.			-Time management skills.

 Form equations linking i) a,b and c ii) a,b and d iii) c and d 2)  a) Given that in the figure above <s = <r, find the values of the angles r, s, t. b) Name ΔABC. 3) Given the diagram below and that the angles a and b are equal, find the values of a, b and c, giving reasons where possible. 	- Asks students to copy assignment in their note books and attempt solutions at home.	- Copy assignments in their notebooks to solve at home.	Cardboard	For reinforcement
Stage VIII: Closure	-Summarizes the properties of a triangle verbally. -Informs students on when the sequence test will be written. - Appreciates students' efforts during the lesson by clapping for them.	-Listen as the teacher summarizes the lesson. -Take note of when test will be written -Feel happy by smiling or laughing.		-To end the lesson. -To enable students prepare adequately for the test. -To leave students happy and encouraged.

APPENDIX O

Lesson plans for Flipped Learning

Lesson Number: 1

Class: Form 3

Duration: 80 minutes

Topic: INDICES

Lesson: Laws of indices

Specific objectives: By the end of the lesson, students should be able to:

- State the laws of indices
- Apply the laws in solving at least 50% of the exercises and assignments correctly.

Previous knowledge: Students are able to add, subtract, multiply and divide real numbers ($\Re$)

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	Teacher's Activities	Students' Activities	Instructional Materials	Rationale/Instructional Strategies and Skills
PRE-CLASS ACTIVITIES				
Stage I: Video lesson on Laws of Indices 1) $x^a \text{x } x^b = x^{a+b}$ 2) $x^a \div x^b = x^{a-b}$ 3) $x^0 = 1$ 4) $x^{-a} = \frac{1}{x^a}$ 5) $(x^a)^b = x^{ab}$	-Informs students to bring any electronic storage device to school. -Takes students to the computer laboratory at least three days to the start of experiment -Tells students what will be expected of them during the experimental period. -Teaches them how to play a DVD and flash drive using a desktop, laptop and television set. -Copies the video lessons for the week on students' storage devices 3 days to class period. **-Instructs students to study the content of the video by watching,**	-Come along with any electronic storage device. -Listen as the teacher gives expectations and teaches on how to play a flash drive and DVD. -Ask questions if any. -Present their storage devices.	-Electronic storage devices containing video lessons.	-Activities preceding in-class activities on Flipped learning. -Systematic acquisition of required facts knowledge, information and cognitive skills. -For reinforcement
Stage II: Examples Simplify the following leaving your answers in the simplest possible form. 1) $10^5 \text{x} 10^4 = 10^{5+4} = 10^9$ 2) 5y x 4y = 5 x 4 x y x y^4 =20 x y^{1+4} = 20y^5 3) $m^8 \div m^5 = m^{8-5} = m^3$ 4) $4^{-3} = \frac{1}{4^3} = \frac{1}{4 \text{ x } 4 \text{ x } 4} = \frac{1}{64}$				

5) $\left(\frac{1}{4}\right)^{-2}=\frac{1}{\left[\frac{1}{4}\right]^2}=\frac{1}{\frac{1\text{x}1}{4\text{x}4}}=1\text{x}\frac{16}{1}=16$ 6) $a^{-9}\div b^0=a^{-9}\div 1=a^{-9}=\frac{1}{a^9}$ 7) $(3x)^{-3}=\frac{1}{(3x)^3}=\frac{1}{3\text{ x }3\text{ x }3\text{ x }x\text{x }x\text{x }x}=\frac{1}{27x^3}$ 8) $9a^{-5}\text{x }4a^6=9\text{x}4\text{x}a^{-5}\text{x }a^6=36\text{ x }a^{-5+6}=36a$ 9) $(g^{-2})^5=9^{-2x5}=g^{-10}=\frac{1}{g^{10}}$	**taking down notes and practicing as many times as possible in preparation for in-class activities.** -Finds out the number of students who cannot watch the video at home for whatever reason, and makes alternative arrangements for them to watch video lesson in the computer laboratory.	-Study the content of the video lesson as many times as possible at home. - Students who cannot watch the video lesson at home, do so in the computer lab at their free time.	Computers, laptops and television sets.	
Stage III: Practice Simplify the following by applying the laws of indices. 1) $a^3\text{x }a^9$ 2) $\text{C}^7\div\text{C}$ 3) $\frac{24x^6}{8x^4}$ 4) $3x^{-3}$ 5) $x^3\div x^{-5}$ 6) $(f^0)^8$ 7) $(3^{-2})^2$ 8) $15\text{ x }10^4\div(3\text{ x}10^{-2})$				Practice for consolidation.
IN-CLASS ACTIVITIES				
Stage IV: Introduction **Write answers to the following** **1) -4+8=** **2) 5-13=** **3) -6-3=** **4) -8x-5=** **5) 6x-7=** **6)** $\frac{-10}{-2}=$ **7)** $\frac{12}{-3}=$	-Teacher marches into the class while counting his steps. - The teacher copies questions on the chalkboard and uses them to test the entry behavior of students. -Asks students to write answers to questions independently. - Calls students to give answers to questions. - Discusses the answers with the students. -Asks students to present their difficulties from the video lesson watched. -Clarifies students' difficulties from the video lesson watched.	-Look at the teacher as he marches. -Copy and write answers to questions. - Give answers to questions when asked to do so by the teacher. - Discuss answers with the teacher. -Present their difficulties from the video lesson watched. -Listen to clarifications and ask questions if any.		-Set induction method. -To test the entry behavior of students using appropriate questioning skills. -Clarification of misconceptions and difficulties arising from the video lesson.
Stage V: Assessment (Quiz 1) Simplify the following: 1) $k^9\text{x }k^3=$ 2) $\text{n}^7\div\text{n}=$ 3) $4^{-2}=$ 4) $(e^0)^{25}=$ 5) $(u^5)^{-2}=$	-Asks students to keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve	- Keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books.	Evaluation exercise books	-To verify if students studied the content of the video. If not the quizzes will cause them to do so subsequently.

	them and submit within 5 minutes. -Supervises quiz and collects evaluation books after 5 minutes to mark out of class.	-Submit evaluation books as demanded by the teacher.		-Also, to ensure that students participate actively in class.
Stage VI: Assessment/Follow Up **Exercises** 1) Simplify the following: i) $56x^{-4} \div 14x^{-8}$ ii) $\frac{1}{4}(2^n - 2^{n+2})$ iii) $(0.25)^2$ iv) $3^{(1-2n)} \times 9^n \times 5^0$ 2) Given that $\left(\frac{1}{4}\right)^{2-y} = 1$, find the value of y. 3) Evaluate the following: i) $\frac{2^{\frac{1}{2}} \times 8^{\frac{1}{2}}}{4}$ ii) $5\frac{2}{5} \times \left(\frac{2}{3}\right)^2 \div \left(1\frac{1}{2}\right)^{-1}$	- Teacher puts up card board containing exercises for students. - Randomly selects some students to present solutions to the exercises on the board while others solve exercises in their note books. - Moves round correcting and aiding weaker students. Calls for reactions from students with regard to presented solutions. -Concludes on presented solutions.	-Present solutions to exercises on the board upon request from the teacher, while others solve in their note books. -Call for assistance from the teacher if need be. -React to presented solutions. -Follow conclusions and do corrections if need be.	Cardboard	-Time management skills. For reinforcement of the video lesson watched at home/ Stimulus variation skills.
Stage VII: Closure	-Summarizes the laws of indices verbally. -Informs students on the next lesson; Odd, even and fractional indices. -Tells students when to collect or watch the next video lesson. - Appreciates students' efforts during the lesson by clapping 5 times for them.	-Listen as the teacher summarizes the lesson and gives next lesson. -Listen in order to act accordingly. -Feel happy by smiling or laughing.		-To end the lesson. -Students can prepare adequately for next lesson at home. -To leave students happy and encouraged.

Lesson Number: 2
Class: Form 3
Duration: 40 minutes
Topic: Indices
Lesson: Odd, even and fractional indices.
Specific objectives: By the end of the lesson, students should be able to:
-Identify the effects of odd and even powers on negative numbers.

-Apply the laws of indices in solving at least 80% of exercises on indices correctly.

Previous knowledge: Students are able to find the square root and other higher roots of numbers.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
PRE-CLASS ACTIVITIES				
Stage 1: Video Lesson on odd, even and fractional indices. Note the following: 1) $x^{\frac{1}{a}} = \sqrt[a]{x}$ and $x^{\frac{a}{b}} = (\sqrt[b]{x})^a$ Thus $4^{\frac{1}{2}} = \sqrt{4} = \pm 2$ and $8^{\frac{2}{3}} = (\sqrt[3]{8})^2 = (2)^2 = 4$ 2) $(-x)^a$ is positive if a is even and negative if a is odd. Thus $(-3)^2 = 9$ and $(-3)^3 = -27$	-Copies video lesson into students' electronic storage devices.	-Hand electronic storage devices to teacher for video lesson to be copied into. -Students study the content of the video out of class by watching, taking down notes and practicing as many times as possible in preparation for in-class activities. - Students who cannot watch the video lesson at home, do so in the computer lab at their free time. -Follow-up solutions to examples and also practice them.	-Electronic storage devices containing video lessons. Computers, laptops and television sets.	-Activities preceding in-class activities on Flipped learning. -Systematic acquisition of required facts knowledge, information and cognitive skills. -For reinforcement. Practice for consolidation.
Stage II:Examples Simplify the following. 1) $27^{\frac{1}{3}} = \sqrt[3]{27} = 3$ 2) $(3m^4)^2 = 3^2 \times m^{4x2} = 9m^8$ 3) $(-2b^2)^3 = -2^3 b^{2x3} = -8b^6$ 4) $(-u^3v^2)^4 = (-u^3)^4 \times (v^2)^4$ $= u^{3x4} \times v^{2x4}$ $= u^{12}v^8$ 5) $(5mn^3)^3 = 5^3 \times m^3 \times n^{3x3}$ $= 125m^3n^9$ 6) $2^{-2} = \frac{1}{2^2} = \frac{1}{4}$ 7) $2a^{-1} = 2 \times \frac{1}{a^1} = \frac{2}{a}$ 8) $9^{\frac{-1}{2}} = \frac{1}{9^{\frac{1}{2}}} = \frac{1}{\sqrt{9}} = \frac{1}{\pm 3}$	-Finds out the number of students who cannot watch the video at home for whatever reason, and makes alternative arrangements for them to watch video lesson in the computer laboratory.			
Stage III:Practice Simplify the following 1) $(4v^3)^2$ 2) $-2(a^2)^3$ 3) $(-c^3)^2$ 4) $(a^2b)^3$ 5) $(x^2y^3)^4$ 6) $-3(de^3)^4$ 7) 3^{-3} 8) $(25a^2)^{\frac{1}{2}}$ 9) $\frac{a^6}{(-a)^4}$ 10) $\frac{(-c)^2 \times c^4}{(-c)^5}$				
IN-CLASS ACTIVITIES				
Stage IV:Introduction	-Teacher counts square numbers while entering the class.	-Students look at the teacher counting.		-Set induction method.

1) What is the square root of 4 and -4? 2) What is the cube root of 8 and -8?	-Asks questions 1 and 2 verbally to test entry behavior of students. -Uses students' answers and calculator to emphasize that the even root of a negative number does not exist. -Asks students to present their difficulties from the video lesson watched. -Clarifies students' difficulties from the video lesson watched out of class.	-Put up their hands to answer the teacher's questions. -Listen to teacher's emphasis and ask questions if any. -Present their difficulties from the video lesson watched. -Listen to clarifications and ask questions if any.	Scientific calculators	-Test of entry behavior of students using appropriate questioning skills. -Clarification of misconceptions and difficulties.
Stage V:Assessment (Quiz 2) Simplify the following : 1) $(-r^3)^2$ 2) $9^{\frac{1}{2}}$ 3) $(25y^2)^{\frac{1}{2}}$ 4) $\frac{(-c)^2 \times c^4}{(-c)^5}$	-Asks students to keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes to mark out of class.	- Keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher.	-Evaluation exercise books.	-To verify if students studied the content of the video. If not the quizzes will cause them to do so subsequently. -Also to ensure that students participate actively in class.
Stage VI: Assessment/Follow Up **Exercises** 1)Simplify the following : i) $0.125^{\frac{1}{3}}$ ii) $\left(\frac{16}{81}\right)^{\frac{1}{4}}$ iii) $\frac{4^{\frac{-1}{2}} \times 16^{\frac{3}{4}}}{4^{\frac{1}{2}}}$ 2) If $2\sqrt{x} = 4$, then find the value of x. 3) Given that $81x2^{2n-2} = k$, find $\sqrt{k}$	- Teacher puts up card board containing exercises for students. - Randomly selects some students to present solutions to the exercises on the board while others solve exercises in their note books. - Moves round	-Present solutions to exercises on the board upon request from the teacher, while others solve in their note books. -Call for assistance from the teacher if need be.	Cardboard	-Time management skills. For reinforcement/ Stimulus variation skills.

	correcting and aiding weaker students. -Calls for reactions from students with regard to presented solutions. -Concludes on presented solutions.	 -React to presented solution. -Follow conclusions and do corrections if need be.	Red pen	
Stage VII: Closure	Informs students on the next lesson; linear inequalities. -Tells students when to collect or watch the next video lesson. - Appreciates students' efforts during the lesson by singing for them a short song.	-Listen to teacher's information. -Listen in order to act accordingly. -Listen as the teacher sings. -Feel happy by smiling, laughing or clapping.		-To end the lesson. -Students to prepare adequately for next lesson at home. -To leave students happy and encouraged/ Musical skills.

Lesson Number: 3
Class: Form 3
Duration: 40 minutes
Topic: INEQUALITIES
Lesson: Linear Inequalities

Specific objective: By the end of the lesson, students should be able to:

- Apply their knowledge of linear equations in solving simple linear inequalities.
- Change the inequality sign when dividing or multiplying both sides of the inequality by a negative number.

Previous knowledge: Students are able to:

- Solve simple linear equations.

- Identify inequality signs.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**

<table>
<tr><th colspan="5">PRE-CLASS ACTIVITIES</th></tr>
<tr>
<td>Stage 1: Video Lesson on Rules for solving Linear Inequalities.

Linear inequalities are solved in the same way as linear equations but for the fact that: when multiplying or dividing both sides of the inequality by a negative number, the inequality sign changes.</td>
<td rowspan="3">-Copies video lesson into students' electronic storage devices.

-Finds out the number of students who cannot watch the video at home for whatever reason, and makes alternative arrangements for them to watch video lesson in the computer laboratory.</td>
<td rowspan="3">-Hand electronic storage devices to teacher for video lesson to be copied into.

-Students study the content of the video out of class by watching, taking down notes and practicing as many times as possible in preparation for in-class activities.

- Students who cannot watch the video lesson at home, do so in the computer lab at their free time.

-Follow-up solutions to examples and also practice them.</td>
<td rowspan="3">-Electronic storage devices containing video lessons.

Computers, laptops and television sets.</td>
<td rowspan="3">-Activities preceding in-class activities on Flipped learning.

-Systematic acquisition of required facts knowledge, information and cognitive skills.

-For reinforcement.

Practice for consolidation.</td>
</tr>
<tr>
<td>Stage II:Examples
Example 1:
Solve the inequality
$x + 5 \leq -10$
Solution: $x \leq -10 - 5$
$x \leq -15$

Example 2:
Evaluate $6 < 3(x+7)$
Solution: $6 < 3x+21$
$-3x < 21-6$
$-3x < 15$
$\frac{-3x}{-3} < \frac{15}{-3}$
$x > -5$
<u>Example 3</u>:
Evaluate $\frac{1}{3}x + \frac{5}{8} \geq \frac{1}{2}x - \frac{5}{24}$
Solution
$\frac{8x+15}{24} \geq \frac{12x-5}{24}$
$8x+15 \geq 12x-5$
$8x-12x \geq -5-15$
$-4x \geq -20$
$\frac{-4x}{-4} \leq \frac{-20}{-4}$
$x \leq 5$</td>
</tr>
<tr>
<td>Stage III:Practice
Solve the following inequalities

1) $3(2x+1) \geq \frac{1}{3}(2x-9)$

2) $2(x+4) > 3(x-1)$</td>
</tr>
<tr><th colspan="5">IN-CLASS ACTIVITIES</th></tr>
<tr>
<td>Stage 1V:Introduction</td>
<td>-Holds cardboard containing inequality signs and staggers into class. Moves around with the cardboard.</td>
<td>-Students watch the teacher staggering and notice what he carries.</td>
<td>Cardboard</td>
<td>-Set induction method.</td>
</tr>
</table>

1) Identify the following symbols found on the cardboard: <, >, ≤, ≥. 2) Given the equation 2x -5 = 4- 5x a) What name is given to this equation? b) Solve for the value of x.	- Asks question 1 verbally and copies question 2 on the board for use in testing the entry behaviour of students. -Discusses students' answers together with them. -Asks students to present their difficulties from the video lesson watched. -Clarifies students' difficulties.	-Students put up their hands and answer teacher's questions. -Present their difficulties from the video lesson watched. -Listen to clarifications and ask questions if any.		-To test the entry behavior of students using appropriate questioning skills. -Clarification of misconceptions and difficulties.
Stage V:Assessment (Quiz 3) Solve the following inequalities. 1) x-3 < 2 2) 5(2-x) ≥ 5-7x 3) 4-3x >10	-Asks students to keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes to mark and send back before next lesson.	- Keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher.	Evaluation exercise books.	-To verify if students studied the content of the video. If not the quizzes will cause them to do so subsequently. -Also to ensure that students participate actively in class.
Stage VI: Assessment/Follow Up **Exercises** 1) Evaluate the following a) $\frac{1}{3}(2x-1) < 5$ b) $x - \frac{2}{5} \geq 2\ (x-4)$ c) $\frac{1}{2}(4x+2) - (x-5) \leq \frac{1}{4}(3x-1)$ 2) Ako had P oranges. He ate 2 and shared the remainder equally with Afese. Express in terms of P the information that Afese's share is at least 5 oranges.	- Teacher puts up card board containing exercises for students. - Randomly selects some students to present solutions to the exercises on the board while others solve exercises in their note books. - Moves round correcting and aiding weaker students. -Calls for reactions from students with regard to presented solutions. -Concludes on presented solutions.	-Present solutions to exercises on the board upon request from the teacher, while others solve in their note books. -Call for assistance from the teacher if need be. -React to presented solution. -Follow conclusions and do corrections if need be.	Cardboard Red pen	-Time management skills. For reinforcement/ Stimulus variation skills.
Stage VII: Closure	-Summarizes verbally the rules for solving linear	-Listen as the teacher summarizes		-To end the lesson.

	inequalities. -Informs students that next lesson will be on algebraic fractions. -Tells students when to collect or watch the next video lesson. - Appreciates students' efforts during the lesson by dancing for them.	the lesson. -Listen to teacher's information. -Listen in order to act accordingly. -Feel happy by smiling or laughing.		-Students can prepare adequately for next lesson at home. -To leave students happy and encouraged.

Lesson Number: 4
Class: Form 3
Duration: 80 minutes
Topic: ALGEBRAIC EXPERESSION
Lesson: Algebraic fractions
Specific objectives: By the end of the lesson, students will be able to:

- Simplify multiple algebraic fractions and write them as a single fraction in its lowest term.

Previous knowledge: Students are able to add, subtract, multiply and divide numerical fractions.

References: **1)** Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
PRE-CLASS ACTIVITIES				
Stage 1: Video Lesson on Algebraic fractions In simplifying algebraic fractions, the LCM of the denominators is obtained and used to evaluate the sums and differences so as to express the fractions as a single fraction.	-Copies video lesson into students' electronic storage devices.	-Hand electronic storage devices to teacher for video lesson to be copied into.	-Electronic storage devices containing video lessons.	-Activities preceding in-class activities on Flipped learning. -Systematic acquisition of required facts knowledge, information and cognitive
Stage II:Examples **Example 1:** Write $\frac{1}{2r} + \frac{3}{4r}$ as Single fraction **Solution:** $\frac{1}{2r} + \frac{3}{4r}$	-Finds out the number of students who cannot	-Students study the content of the video out of class		

$= \frac{2+3}{4r} = \frac{5}{4r}$ **Example 2:** Simplify $\frac{3m}{2n} - \frac{m-1}{5n} + \frac{m-2}{10n}$ **Solution:** $\frac{5(3m) - 2(m-1) + m - 2}{10n}$ $= \frac{15m - 2m + 2 + m - 2}{10n}$ $= \frac{15m - 2m + m + 2 - 2}{10n}$ $= \frac{14m}{10n} = \frac{7m}{5n}$ **Example 3:**Simplify $\frac{4}{a-3} - \frac{1}{a+2}$ **Solution:**$\frac{4(a+2)-(a-3)}{(a-3)(a+2)} =$ $\frac{4a+8-a+3}{(a-3)(a+2)} = \frac{3a+11}{(a-3)(a+2)}$ **Example 4:** Write as a single fraction $(\frac{3}{x} - \frac{15}{2y}) \div \frac{6}{xy}$ **Solution:**$\frac{3(2y)-15(x)}{2xy} \div \frac{6}{xy} =$ $\frac{6y-15x}{2xy} \div \frac{6}{xy} = \frac{6y-15x}{2xy} \times \frac{xy}{6} =$ $\frac{6y-15x}{2} \times \frac{1}{6} = \frac{6y-15x}{12} =$ $\frac{3(2y-5x)}{12} = \frac{2y-5x}{4}$	watch the video at home for whatever reason, and makes alternative arrangements for them to watch video lesson in the computer laboratory.	by watching, taking down notes and practicing as many times as possible in preparation for in-class activities. - Students who cannot watch the video lesson at home, do so in the computer lab at their free time. -Follow-up solutions to examples and also practice them.	Computers, laptops and television sets.	skills. -For reinforcement.
Stage III:Practice Simplify the following: 1) $\frac{2x-1}{3} - \frac{x+3}{2}$ 2)$\frac{1}{x-3} - \frac{2}{x+4}$ 3)$\frac{x}{x-2} - \frac{x+2}{x+3}$ 4) $\frac{1}{M-1} + \frac{9}{2M+3} - \frac{8}{M+4}$				Practice for consolidation.
IN-CLASS ACTIVITIES				
Stage IV:Introduction Simplify the following: ❖ 3/4 + 1/3 = ❖ -2/5-7/3 = ❖ 3/2×1/3 = ❖ -7/8÷4/7 =	-Teacher asks students to stand up, to clap once, to count in multiples of 1/2 and to sit down. - Copies questions on the board and uses them to test the entry behaviour of students. -Discusses solutions with students. -Asks students to present their	-Students follow teacher's instructions. -Students put up their hands and answer the teacher's questions. -Listen and participate in discussions. -Present their difficulties from the video lesson		-Set induction method. -Test for entry behavior of students using appropriate questioning skills.

	difficulties from the video lesson watched. -Clarifies students' difficulties from the video lesson watched out of class.	watched. -Listen to clarifications and ask questions if any.		-Clarification of misconceptions and difficulties.
Stage V:Assessment (Quiz 4) Simplify the following 1) $\frac{3}{2p}+\frac{5}{3p}$ 2) $\left(\frac{3}{r}-\frac{15}{2t}\right)\div\frac{6}{rt}$ 3) $\frac{4}{y+1}-\frac{4}{y-1}$	-Asks students to keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes to mark at home and send back before next lesson.	- Keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher.	Evaluation exercise books	-To verify if students studied the content of the video. If not the quizzes will cause them to do so subsequently. -Also to ensure that students participate actively in class.
Stage VI: Assessment/Follow Up **Exercises** Simplify the following 1) $\frac{x}{x-2}-\frac{x+2}{x+3}$ 2) $\frac{1}{x-3}-\frac{3(x-1)}{x-9}$ 3) $4-\frac{y-x}{x}$ 4) $\frac{3x-2}{x-5}-\frac{2x+3}{2(x-5)}$ 5) $1-\frac{12-3y^2}{2y^2-8}$	- Teacher puts up card board containing exercises for students. - Randomly selects some students to present solutions to the exercises on the board while others solve exercises in their note books. - Moves round correcting and aiding weaker students. -Calls for reactions from students with regard to presented solutions. -Concludes on presented solutions.	-Present solutions to exercises on the board upon request from the teacher, while others solve in their note books. -Call for assistance from the teacher if need be. -React to presented solution. -Follow conclusions and do corrections if need be.	Cardboard Red pen	-Time management skills. For reinforcement/ Stimulus variation skills.
Stage VII: Closure	-Summarizes the procedure for simplifying algebraic fractions verbally. -Informs students that the next lesson will be on subject of formula with power one. -Tells students when to collect or watch the next video lesson.	-Listen to the teacher's summary and information. -Listen in order to act accordingly. -Observe and feel happy by		-To end the lesson. -Students can adequately prepare for next lesson at home.

	- Appreciates students' efforts during the lesson by drawing a nice diagram on the board for them.	clapping, smiling or laughing.		-To leave students happy and encouraged.

Lesson Number: 5
Form: 3
Duration: 40 minutes
Topic: SUBJECT OF A FORMULA
Lesson: Subject of formula with power one.
Specific objectives: By the end of the lesson students should be able to:

- Express a linear variable in terms of one or more other variables in an equation.
- Calculate the value of a variable given the other (s) in an equation/formula.

Previous knowledge: Students are able to:

- Solve simple linear equations.
- Factorize common terms in expressions.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
PRE-CLASS ACTIVITIES				
Stage 1: Video Lesson on Subject of formula with power one. The subject of a formula is the quantity you want to find in any given formula. We express the subject of the formulae in terms of other quantities.	-Copies video lesson into students' electronic storage devices.	-Hand electronic storage devices to teacher for video lesson to be copied into. -Students study the content of the video out of class by watching, taking down notes and practicing as many times as possible in preparation for in-class activities.	-Electronic storage devices containing video lessons.	-Activities preceding in-class activities on Flipped learning. -Systematic acquisition of required facts knowledge, information and cognitive skills.
Stage II:Examples **Example 1:** Make y the subject of the formula ax +by = c **Solution:** by = c-ax $\frac{by}{b} = \frac{c-ax}{b}$ $y = \frac{c-ax}{b}$ **Example 2:** From the equation	-Finds out the number of students who cannot watch the video at home for whatever reason, and makes alternative arrangements for them to watch video lesson	- Students who	Computers,	

$E = \frac{w(R-r)}{2Rp}$ a) Make R the subject of the formula. b) Find R when r =12, p=60, w=1024 and E=5/6 **Solution:** a) 2RpE = w(R-r) 2RpE = wR - wr wr = wR-2RpE wr = R(w-2pE) $\frac{wr}{w-2Ep} = \frac{R(w-2pe)}{w-2Ep}$ $\frac{wr}{w-2Ep} RorR = \frac{wr}{w-2Ep}$ b) R= $\frac{wr}{w-2EP}$ R= $\frac{1024x12}{1024-2(60\times\frac{5}{6})} = \frac{12288}{1024-2(10x5)}$ $= \frac{12288}{1024-100} = \frac{12288}{924}$ R= 13.29	in the computer laboratory.	cannot watch the video lesson at home, do so in the computer lab at their free time. -Follow-up solutions to examples and also practice them.	laptops and television sets.	-For reinforcement.
Stage III: Practice Given the formula F = $\frac{mv-mu}{t}$ a) Make M the subject of the formula b) Hence find m when F=25, u=0, v=15 and t=45 c) Make t the subject of the formula. d) Given that v – u =Δs. Express Δs in terms of F, m and t.				Practice for consolidation.
IN-CLASS ACTIVITIES				
Stage IV: Introduction 1) Simplify $2x^2y + x^3y^2$ 2) Solve for y in the equation pqy = t	-Teacher enters the class holding up 2 pencils/ 3 green pens in one hand, and 4 red pens and 2 pencils in the other hand. -Asks students to comment on content of both hands. - Copies 2 questions on the board to use in testing entry behaviour of students. -Asks students to solve questions in their note books. -Discusses students' answers together with	-Students watch the teacher as he enters the class. -Take note of what the teacher is holding. -Identify among other things that each hand has 2 pencils. -Students solve questions and present their solutions. -Participate in the discussion by listening attentively or by asking questions.	Red pens, green pens and pencils.	-Set induction method. -To test entry behavior of the students using appropriate questioning skills. -Clarification of misconceptions

	them. -Asks students to present their difficulties from the video lesson watched. -Clarifies students' difficulties from the video lesson watched out of class.	-Present their difficulties from the video lesson watched. -Listen to clarifications and ask questions if any.		and difficulties in the video lesson watched at home.
Stage V:Assessment (Quiz 5) From the equation s = ut + $\frac{1}{2}$ at^2 , a) Find s given that u=25, t=4 and a=1.5 b) Express a in terms of s, u and t.	-Asks students to keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes.	- Keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher.	Evaluation exercise books.	-To verify if students studied the content of the video. If not the quizzes will cause them to do so subsequently. -Also to ensure that students participate actively in class.
Stage VI: Assessment/Follow Up **Exercises** A certain motion is represented by the formula T+ mg =$\frac{mv^2}{r}$ a) Make m the subject of the formula b) Given T=50 when g=10, v=8 and r=4, hence find the value of m. c) Make r the subject of the formula d) Express g in terms of T, m, v and r.	- Teacher puts up card board containing exercises for students. - Randomly selects some students to present solutions to the exercises on the board while others solve exercises in their note books. - Moves round correcting and aiding weaker students. -Calls for reactions from students with regard to presented solutions. -Concludes on presented solutions.	-Present solutions to exercises on the board upon request from the teacher, while others solve in their note books. -Call for assistance from the teacher if need be. -React to presented solution. -Follow conclusions and do corrections if need be.	Cardboard Red pen	-Time management skills. For reinforcement/ Stimulus variation skills.
Stage VII: Closure	-Verbally summarizes the procedure for obtaining the subject of a formula. -Informs students about next lesson; Subject of formula with power	-Listen to the teacher's summary and information on next lesson.		-To end the lesson. -Students can prepare adequately for the next lesson

	two or more. -Tells students when to collect or watch the next video lesson. - Appreciates students' efforts during the lesson by asking them to clap for themselves.	-Listen in order to act accordingly. -Feel happy by clapping and smiling or laughing.		at home. -To leave students happy and encouraged.

Lesson Number: 6

Form: 3

Duration: 80 minutes

Topic: SUBJECT OF A FORMULA

Lesson: Subject of formula with power two or more.

Specific objectives: By the end of the lesson students should be able to:

- Express a variable with power 2 or more, in terms of one or more than variables in an equation.
- Calculate the numerical value of variable given the other(s)

Previous knowledge: Students are able to

- Solve simple linear equations
- Find the square root of numbers.

References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
PRE-CLASS ACTIVITIES				
Stage I: Video Lesson on Subject of formula with power two or more **Note:** 1) If $x^2 = 9, then$ $x = \pm\sqrt{9}$($\pm$ for even powers) 2) If $x^3 = 8, then\ x = \sqrt[3]{8}$ $x = 2$ (no$\pm$ for odd	-Copies video lesson into students' electronic storage devices.	-Hand electronic storage devices to teacher for	-Electronic	-Activities preceding in-class activities on Flipped learning. -Systematic acquisition of

powers) **Stage II: Examples** **Example1**: Given that $v=3t^2+5$ Express t in terms of v. **Solution:** $v-5=3t^2$ $\frac{v-5}{3}=t^2, t=\pm\sqrt{\frac{v-5}{3}}$ **Example 2:** From the equation D= $\frac{LM}{K}+\frac{LU^2}{25}$, a) Make u the subject of the formula. b) Hence calculate the values of U if D=8, L=2, M=-5 and K=1 **Solution:** a) D = $\frac{25LM+KLU^2}{25K}$ $25LM+KLU^2=25KD$ $KLU^2=25KD-25LM$ $U^2=\frac{25KD-25LM}{KL}$ $U^2=\frac{25D}{L}-\frac{25M}{K}$ $U^2=25(\frac{D}{L}-\frac{M}{K})$ $U=\pm\sqrt{25\left(\frac{D}{L}-\frac{M}{K}\right)}$ $U=\pm5\sqrt{\left(\frac{D}{L}-\frac{M}{K}\right)}$ b) $U=\pm5\sqrt{\left(\frac{8}{2}-\frac{-5}{1}\right)}$ $u=\pm5\sqrt{4+5}=\pm5\sqrt{9}$ $u=\pm5\,(3)$ $u=\pm15$ **Example 3:** Express y in terms of x in the equation $x-45+8y^5=5x^2-6$ **solution**: $8y^5=5x^2-6-x+45$ $8y^5=5x^2-x+39$ $y^5=5x^2-x+39$ $y=\sqrt[5]{\frac{5x^2-x+39}{8}}$	-Finds out the number of students who cannot watch the video at home for whatever reason, and makes alternative arrangements for them to watch video lesson in the computer laboratory.	video lesson to be copied into. -Students study the content of the video out of class by watching, taking down notes and practicing as many times as possible in preparation for in-class activities. - Students who cannot watch the video lesson at home, do so in the computer lab at their free time. -Follow-up solutions to examples and also practice them.	storage devices containing video lessons. Computers, laptops and television sets.	required facts knowledge, information and cognitive skills. -For reinforcement.
Stage III:Practice 1) Make k the subject of the formula $pgr=1+dlk^2-p$ 2) Given the formula $x^3-y^3=9-z^3$ a) Make x the subject of the formula b) Express y in terms of x and z c) Find the value of z when x=2 and y =1				Practice for consolidation.

IN-CLASS ACTIVITIES				
Stage IV:Introduction Give the square roots of: 4, 9, 36, 121, etc.	-Teacher marches into class while counting his steps using square numbers. -Points particular students to give the square roots of some numbers. -Indicates how to use calculators for large numbers. -Asks students to present their difficulties from the video lesson watched. -Clarifies students' difficulties from the video lesson watched out of class.	-Students watch the teacher and notice his irregular pattern of counting. -Listen, contribute and ask questions if any. -Present their difficulties from the video lesson watched. -Listen to clarifications and ask questions if any.	Calculators	- Set induction method. -To test the entry behavior of students using questioning skills. -Clarification of misconceptions and difficulties from the video watched at home.
Stage V:Assessment (Quiz 6) ❖ Given the formula $2y = 5r^2 - 7$ a) Make r the subject of the formula b) Find r when y=6 2) Express p interms of v,k and t in the equation $v^2 = \frac{4kp^3}{t}$	-Asks students to keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes.	- Keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher.	Evaluation books.	-To verify if students studied the content of the video. If not the quizzes will cause them to do so subsequently. -Also to ensure that students participate actively in class.
Stage VI: Assessment/Follow Up **Exercises** 1) Make t the subject of the formula $p = \frac{1-t^2}{1+t^2}$ 2) Make a the subject of the formula $\frac{v}{t} = \frac{\pi p a^4}{8nl}$ 3) Given that $\theta^7 - 5r = 6a - (k^2 - 2)\theta^7$, a) Express k in terms of θ, r and a. b) Make θ the subject of the formula. c) Hence find θ when k=0, a=1 and	- Teacher puts up card board containing exercises for students. - Randomly selects some students to present solutions to the exercises on the board while others solve exercises in their note books. - Moves round correcting and aiding	-Present solutions to exercises on the board upon request from the teacher, while others solve in their note books. -Call for assistance from the teacher if need be.	Cardboard	-Time management skills. For reinforcement/

r = -2	weaker students. -Calls for reactions from students with regard to presented solutions. -Concludes on presented solutions.	-React to presented solution. -Follow conclusions and do corrections if need be.	Red pen	Stimulus variation skills.
Stage VII: Closure	-Summarizes procedure for obtaining the subject of the formula for powers greater than2. -Informs students that next lesson will be on Types of triangles. -Tells students when to collect or watch the next video lesson. - Appreciates students' efforts during the lesson by telling them a story.	-Listen to the teacher's summary and information on next lesson. -Listen in order to act accordingly. -Feel happy by smiling or laughing.		-To end the lesson. -Students can prepare for next lesson at home. -To leave students happy and encouraged.

Lesson Number: 7
Form: 3
Duration: 40 minutes
Topic: TRIANGLE
Lesson: Types of Triangles
Specific objectives: By the end of the lesson, students should be able to
- Identify the different types of triangles

- Draw the different types of triangles.

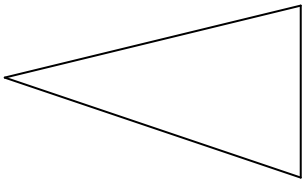
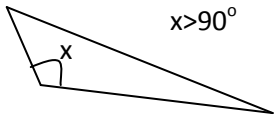
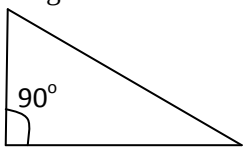
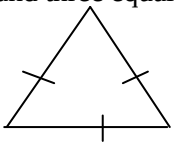
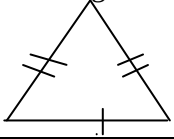
Previous knowledge: Students are able to

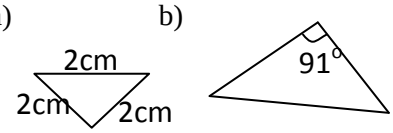
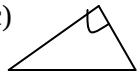
- Draw straight lines and identify angles
- Differentiate a triangle from any other plane figures.

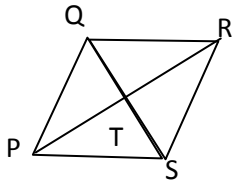
References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and**

				Skills
PRE-CLASS ACTIVITIES				
Stage I: Video Lesson on Types of triangles **1) scalene triangle** It is a triangle in which none of the sides are equal and no angle measures up to 90^o  **2) Obtuse triangle** It is a triangle in which one of its three angles measures more than 90o  **3) Right-angle triangle.** It is a triangle in which one of its three angles measures exactly 90^o.  **4)Equilateral triangle.** It is a triangle having three equal sides and three equal angles (60^o)  **5)Isosceles triangle** It is a triangle which has two equal sides and two equal base angles 	-Copies video lesson into students' electronic storage devices. -Finds out the number of students who cannot watch the video at home for whatever reason, and makes alternative arrangements for them to watch video lesson in the computer laboratory.	-Hand electronic storage devices to teacher for video lesson to be copied into. -Students study the content of the video out of class by watching, taking down notes and practicing as many times as possible in preparation for in-class activities. - Students who cannot watch the video lesson at home, do so in the computer lab at their free time. -Follow-up solutions to examples and also practice them.	-Electronic storage devices containing video lessons. Computers, laptops and television sets.	-Activities preceding in-class activities on Flipped learning. -Systematic acquisition of required facts knowledge, information and cognitive skills.

Stage II: Practice 1) Identify the following triangles a) b)  c)  2) Draw and name the triangles described below. a) A triangle with sides 2cm, 3cm and 5cm. b) A triangle with sides 3cm, 6cm and 3cm				-For reinforcement.
IN-CLASS ACTIVITIES				
Stage III: Introduction 1) Draw the following figures, labeling the vertices with letters of your choice. a) Rectangle b) Trapezium c) Triangle d) Cone 2) Name any 2 angles in any of the figures.	-Teacher enters the class rotating a set square as if he is driving. -Uses questions 1 and 2 to test the entry behavior of students. -Asks questions and selects students to present solutions on the board. -Uses the set square to differentiate a triangle from other plane figures. -Asks students to present their difficulties from the video lesson watched. -Clarifies students' difficulties from the video lesson watched out of class.	-Students watch teacher's actions. -Put up their hands to answer teacher's questions. -Observe and ask questions if any. -Present their difficulties from the video lesson watched. -Listen to clarifications and ask questions if any.	Set square Board ruler	- Set induction method. -To test the entry behavior of students using questioning skills. -Clarification of misconceptions and difficulties.
Stage IV:Assessment (Quiz 7) Name and draw 5 different types of triangles.	-Asks students to keep away their note books and remove their evaluation exercise books. -Writes quiz question on the board. -Asks students to copy question in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and	- Keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher.	Evaluation exercise books.	-To verify if students studied the content of the video. If not the quizzes will cause them to do so subsequently. -Also, to keep

	collects books after 5 minutes to mark out of class.			students focused during lessons.
Stage V: Assessment/Follow Up **Exercises** Given that figure PQRS is a rhombus.  1) Identify and name all the possible triangles created by the diagonals. 2) Name and indicate 4 different angles in figure PQRS.	- Teacher puts up card board containing exercises for students. - Randomly selects some students to present solutions to the exercises on the board while others solve exercises in their note books. - Moves round correcting and aiding weaker students. -Calls for reactions from students with regard to presented solutions. -Concludes on presented solutions.	-Present solutions to exercises on the board upon request from the teacher, while others solve in their note books. -Call for assistance from the teacher if need be. -React to presented solution. -Follow conclusions and do corrections if need be.	Cardboard	-Time management skills. For reinforcement/ Stimulus variation skills.
Stage VI: Closure	-Summarizes the different types of triangles verbally. -Informs students that the next lesson will be on some properties of triangles. -Tells students when to collect or watch the next video lesson. - Appreciates students' efforts during the lesson by dancing for them.	-Listen to the teacher's summary and information on next lesson. -Listen in order to act accordingly. -Feel happy by clapping and smiling or laughing.		-To end the lesson. -Students can prepare adequately for next lesson at home. -Use of psychomotor skills to leave students happy and encouraged.

Lesson Number: 8

Class: Form 3

Duration: 80 minutes

Topic: TRIANGLES

Lesson: Some properties of triangles

Specific objectives: By the end of the lesson, students should be able to:

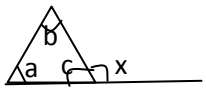
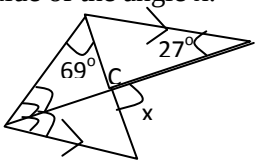
- State the two main properties of any triangle
- Apply the above properties in finding missing angles in a triangle.

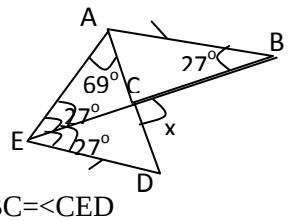
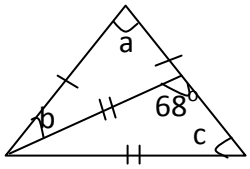
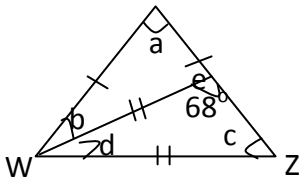
Previous knowledge: Students are able to:

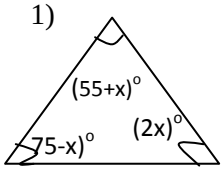
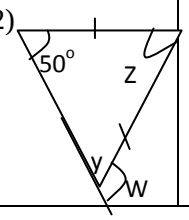
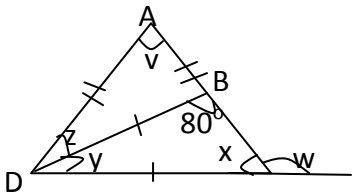
- Identify and draw the different types of triangles.
- Identify angles.
- Solve simple linear equations.

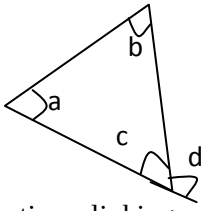
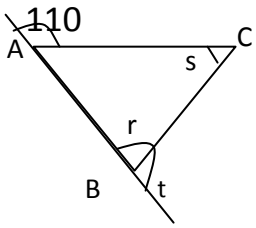
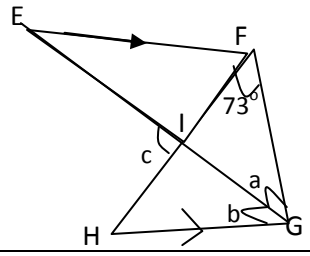
References: 1) Okezounu, J. (producer), & Mbono, O.J. (Director) (n.d.). *The secret of mathematics* [video recording]. Lagos-Nigeria: Shobi Studio.

2) Numfor, E. (Ed.) (2008). *Ordinary level mathematics for Cameroon schools (2nd ed.).* Bamenda-Cameroon: ANUCAM.

Stages/Content Development	**Teacher's Activities**	**Students' Activities**	**Instructional Materials**	**Rationale/Instructional Strategies and Skills**
PRE-CLASS ACTIVITIES				
Stage I: Video Lesson on Some properties of triangles 1) The sum of the three interior angles in a triangle equals $180^{0.}$ e.g in the triangle below, $a+b+c=180^0$ 2) The exterior angle of a triangle is equal to the sum of the two oppose interior angles  x= a + b	-Copies video lesson into students' electronic storage devices. -Finds out the number of students who cannot watch the video at home for whatever reason, and makes alternative arrangements for them to watch video lesson in the computer	-Hand electronic storage devices to teacher for video lesson to be copied into. -Students study the content of the video out of class by watching, taking down notes and practicing as many times as possible in preparation for in-class activities. - Students who cannot watch the video lesson at	-Electronic storage devices containing video lessons. Computers, laptops and television sets.	-Activities preceding in-class activities on Flipped learning. -Systematic acquisition of required facts knowledge, information and cognitive skills. -For reinforcement.
Stage II:Examples **Example 1** From the diagram below, find the value of the angle x.  				

Solution  < ABC=<CED (Reason: alternate angles) $27^0 + 69^0 + y = 180^0$ (Reason: sum of angles of a triangle) $96^o + y=180^o$ $y=180^o – 96^o$ $y=84^o$ $\therefore y = x = 84^o$ (Reason: vertically opposite angles) **Example2.** Find the values of the lettered angles in the diagram below.  **Solution**  $c = 68^0$ (Reason: base angles of an isosceles triangle) $c + 68^o + d = 180^0$ $d=180^o-136^0$ $d=44^o$ $e + 68^o =180^0$ (Reason: angles on a straight line) $e =180^o – 68^0$, $e=112^o$ $68^o = 44^o + b$ (Reason: base angle an isosceles triangle) $68^o- 44^0 =b$, $b=24^o$ From Δ XWY, $112^o + 24^o + a =180^o$ (Reason: sum of angles in a triangle) $a =180^o-136^o$, $a=44^o$ **$\therefore a=44^o, b=24^o, c=68^o$**	laboratory.	home, do so in the computer lab at their free time. -Follow-up solutions to examples and also practice them.		Practice for consolidation.

Stage III:Practice Find the values of the missing angles in the triangle below, and name the triangles. 1)  2) 				
IN-CLASS ACTIVITIES				
Stage IV:Introduction 1) State and explain the different types of triangles.	-Teacher moves very fast into the class carrying a set square as if will break pass the wall. -Teacher uses question 1 to tests the entry behavior of students. -Asks students to present their difficulties from the video lesson watched. -Clarifies students' difficulties from the video lesson watched out of class.	-Students watch teacher with set square to see what will happen. -Put up their hands to answer the teacher's questions. -Present their difficulties from the video lesson watched. -Listen to clarifications and ask questions if any.	Chalkboard ruler.	- Set induction method. -To test the entry behavior of students using questioning skills. -Clarification of misconceptions and difficulties.
Stage V:Assessment (Quiz 8) Given the diagram below  Find the angles lettered v,w,x,y and z, giving reasons where necessary.	-Asks students to keep away their note books and remove their evaluation exercise books. -Writes quiz questions on the board. -Asks students to copy questions in their evaluation books, solve them and submit within 5 minutes. -Supervises quiz and collects books after 5 minutes to correct out of class.	- Keep away their note books and remove their evaluation exercise books. – Copy and solve questions in their evaluation books. -Submit evaluation books as demanded by the teacher.	Chalkboard ruler. Evaluation books.	-To verify if students studied the content of the video. -Also to ensure that students participate actively in class.
Stage VI: Assessment/Follow Up				

Exercises 1) Given the triangle below  Form equations linking i) a,b and c ii) a,b and d iii) c and d 2)  a) Given that in the figure above <s = <r, find the values of the angles r, s, t. b) Name ΔABC. 3) Given the diagram below and that the angles a and b are equal, find the values of a, b and c, giving reasons where possible.  	- Teacher puts up card board containing exercises for students. - Randomly selects some students to present solutions to the exercises on the board while others solve exercises in their note books. - Moves round correcting and aiding weaker students. -Calls for reactions from students with regard to presented solutions. -Concludes on presented solutions.	-Present solutions to exercises on the board upon request from the teacher, while others solve in their note books. -Call for assistance from the teacher if need be. -React to presented solution. -Follow conclusions and do corrections if need be.	Cardboard Red pen	-Time management skills. For reinforcement/ Stimulus variation skills.
Stage VII: Closure	-Summarizes the properties of a triangle verbally. -Informs students on when the sequence test will be written. - Appreciates students' efforts during the lesson by clapping for them.	-Listen as the teacher summarizes the lesson. -Take note of when test will be written -Feel happy by smiling or laughing.		-To end the lesson. -To enable students prepare adequately for the test. -To leave students happy and encouraged.

Appendix P
Request for Validation of Instrument (MAT)

Department of Educational Foundations,

Faculty of Education,

Nnamdi Azikiwe University, Awka,

Nigeria.

14th January, 2015.

Dear Sir/Madam,

Request for Validation of Mathematics Achievement Test (MAT)

As part of a research in education, the researcher intends to administer this Mathematics Achievement Test (20 selected questions in 45 minutes) to some Form 3 mathematics students in Cameroon. It will be administered before and after some topics (Indices, Inequalities, Algebraic expressions, Transposition of formulae and Triangles) found on the Form 3 scheme of work, would have been taught.

Please vet and comment on the attached MAT with regard to the following criteria:

1. The structure of the instrument and the clarity of the instructions,
2. The quality of each question in terms of its length and language clarity, and
3. The content coverage and appropriateness of the questions in measuring students' achievement in mathematics.

You may suggest particular items to be retained, modified or dropped.

Thank you for your cooperation.

Yours faithfully,

Beyoh Dieudone Nkepah

Appendix Q
Ratings, Suggestions and Comments of Three Validators on MAT
Validator 1

1

Mathematics Achievement Test (MAT) Duration??

School _____ **Code** _____

Sex _____ **Age** _____

Instruction: Circle the letter of the best answer to each question.

Use Figure 1 to answer questions 1 and 2.

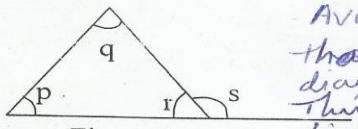


Figure 1

Avoid associating more than one question to a diagram. Thus use two seperate diagrams for questions 1&2.

Which of the following is true in questions 1 and 2?

1) A. $p+q+r+s = 360^0$ B. $p+p-r = 180^0$ C. $p+q = r+s$ D. $p+q+r = 180^0$

2) A. $s = r$ B. $r = p+q$ C. $s = p+q$ D. $p = q+r-s$

3) The largest angle of any triangle

A. Must always be acute B. Can sometimes be acute C. Can never be Right angled D. Must always be obtuse

4) In Figure 2, what is the size of angle ACB?

A. 40^0 B. 50^0 C. 60^0 D. 80^0

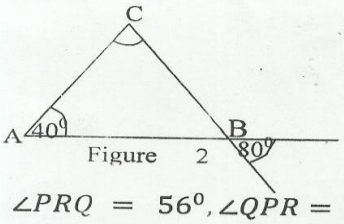


Figure 2

5) In figure 3, QRP is a straight line, $QP \parallel RT$, $\angle PRQ = 56^0, \angle QPR = 84^0, \angle TRS = x^0$. Find x

A. 28^0 B. 40^0 C. 44^0

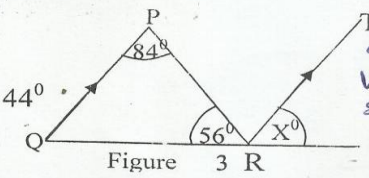


Figure 3

Some symbols in this question may not be very clear to most students. e.g. use Parallel instead of ||.

6)

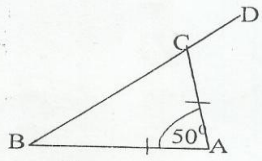


Figure 4

In $\triangle ABC$ in figure 4, BC is produced to D, $AB = AC$ and $\angle BAC = 50^0$, *Find* $\angle ACD$.

A. 50^0 B. 60^0 C. 65^0 D. 115^0

7) In figure 5, PQ=PR=RS and $\angle RPS = 32^0$

Find the value of $\angle QPR$

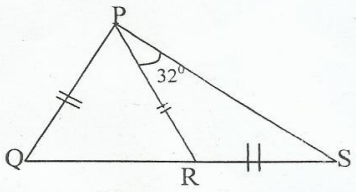


Figure 5

A 64^0 B. 52^0 C. 32^0 D. 26^0

8) Solve the inequality $3m + 3 > 9$

A. $m > 2$ B. $m > 3$ C. $m > 4$ D. $m > 6$

9) Find the range of values of x for which $3x - 8 \geq 5x$

A. $x \leq 4$ B. $x \geq 1$ C. $x \leq -4$ D. $x \geq -4$

10) p and q are two positive numbers such that $p > 2q$. Which one of the following is not true?

A. $-p < -2q$ B. $-p > 2q$ C. $-p < 2p$ D. $-q < \frac{1}{2}p$

11) Nfor had x oranges. He ate 2 and shared the remainder equally with Ngala. Express in terms of x the information that Ngala's share is at least 5 oranges.

A. $\frac{x-2}{2} \leq 5$ B. $\frac{x}{2} - 2 > 5$ C. $\frac{x}{2} - 2 < 5$ D. $\frac{x-2}{2} \geq 5$

12) Given that $P = \frac{3ab^2 - ab}{5}$. a, when expressed in terms of P and b is equal to

A. $\frac{5p}{3b^2-b}$ B. $\frac{5p}{b(3b+1)}$ C. $\frac{p}{5(3b^2-b)}$ D. $\frac{5p}{b-3b^2}$

13) Expressing n in terms of p, v, r and t in the formula $pv = nrt$ gives

A. $n = \frac{pvt}{r}$ B. $n = \frac{pvr}{t}$ C. $n = \frac{pv}{rt}$ D. $n = pv - rt$

14) Two variables x and y and three constants, a, b and c are such that the sum of ax and by equals c. Use this information to express x in terms of a, b, c and y.

A. $x = \frac{by-c}{a}$ B. $x = c - by - a$ C. $x = \frac{c+by}{a}$ D. $x = \frac{c-by}{a}$

15) Make s the subject of the formula in $3s^2 - 7ur = 4$

Question 18 may take care of this one. ie @15

A. $s = 4 + 7yr - 3$ B. $s = \pm\sqrt{\frac{4+7ur}{3}}$ C. $s = \frac{7ur+4}{3}$ D. $s = \pm\sqrt{\frac{4-7ur}{3}}$

16) Given that $= \frac{9a}{r^{10}} - \frac{b}{r^2}$, the value of a, when F = 10, r = 1 and b = 7 is;

A. 3 B. $\frac{13}{9}$ C. 9 D. $\frac{20}{7}$

17) Change the subject of the formula $t^2v^3 - u = 5t^2 - 5$ to v

A. $v = \frac{5t^2-5+u}{3t^2}$ B. $v = \sqrt[3]{\frac{5t^2-5-u}{t^2}}$ C. $v = \sqrt[3]{\frac{5t^2-5+u}{t^2}}$ D. $v = \sqrt[3]{\frac{5t^2-5+u}{t^2}}$

18) Given the equation $E = \frac{1}{2}mv^2$ and that $v = rw$, express r in terms of E, m and w

A. $r = \pm\sqrt{\frac{2E}{mw^2}}$ B. $r = \left(\frac{2E}{mw^2}\right)^2$ C. $r = \frac{2E}{mw}$ D. $r = \pm\sqrt{\frac{E}{2mw}}$

19) Simplify $5y^2 \times 4y^3$

A. $20y^6$ B. $20y^5$ C. $9y^5$ D. $20y^{23}$

20) Simplify $56x^{-4} \div 14x^{-8}$

A. $4x^{\frac{1}{2}}$ B. $4x^{-4}$ C. $4x^4$ D. $4x^{\frac{1}{2}}$

21) Evaluate $\left(27^{\frac{1}{3}}\right)^2$

A. 81 B. 6 C. 18 D. 9

22) Simplify $\left(\frac{16}{81}\right)^{\frac{1}{4}}$

A. $\frac{2}{3}$ B. $\frac{8}{27}$ C. $\frac{1}{3}$ D. $\frac{4}{9}$

23) Calculate the value of $16^{\frac{5}{4}} \times 2^{-3} \times 3^0$

A. 20 B. 2 C. 4 D. 10

24) simplify $\frac{1}{2}(2^n - 2^{n+1})$

A. $2^{n-1} - 2^n$ B. $2^{n-1}(1 - 2^n)$ C. $2^{n+1} + 2$ D. 2^n

25) Simplify $0.027^{-\frac{1}{3}}$

A. 3 B. $\frac{3}{10}$ C. $3\frac{1}{3}$ D. $\frac{1}{3}$

26) Evaluate $\frac{3}{6p} + \frac{3}{4p}$, given that the value of p is 1

A. $\frac{17}{12}$ B. 12 C. $\frac{1}{6}$ D. $\frac{5}{4}$

27) If the expression $\frac{2x-1}{3} - \frac{x+3}{2}$ is simplified, the result is

A. $\frac{x+7}{6}$ B. $\frac{x+8}{6}$ C. $\frac{x-4}{6}$ D. $\frac{x-11}{6}$

28) Express $4 - \frac{y-x}{x}$ as a single fraction.

A. $\frac{3x-y}{x}$ B. $\frac{5x-y}{x}$ C. $\frac{4-y+x}{x}$ D. $\frac{4-y-x}{x}$

29) Simplify $\frac{4}{a-3} - \frac{1}{a+2}$

A. $\frac{3a+11}{(a+3)(a-2)}$ B. $\frac{3a-11}{(a-3)(a+2)}$ C. $\frac{3a+11}{(a-3)(a-2)}$ D. $\frac{3a+11}{(a+3)(a+2)}$

30) Given that $x = -3$, and $y = -7$, evaluate $\frac{x^2-y}{y^2-x}$

A. $-\frac{1}{11}$ B. $\frac{1}{23}$ C. $\frac{4}{13}$ D. $\frac{12}{17}$

Suggestions on your MAT

- The questions are appropriate to the level of the students. The instructions are also very clear.
- Some are however better than others following the criteria you handed to me; I have ticked some very good ones.
- In selecting your final MAT items do take into consideration Bloom's taxonomy of instructional objectives.
- You haven't indicated the duration of your MAT. Do consider it!!!
- Thank you, I feel honoured going through your MAT

Ndamy Kelvin (B.Sc. Maths)

Validator 2

MY COMMENTS ON YOUR MAT

I suggest your instructions should read thus: Circle the letter that corresponds to the best answer.

- In Question 1; B would have been a better distractor if it read as; $P+q-r=180$
- In Question 5: QRP is not a straight line as indicated in figure 3: furthermore, the fourth alternative ie D is not given. 130° would have been a better distractor to 115° in Question 6.
- Again in Question 11; $\frac{x-2}{2}>5$, could be a good distractor
- Question 16 is incomplete; ie F is absent. check!
- Question 24 is also incomplete check it too!

If the above comments are considered; I think MAT items will be very appropriate and clear enough. They can therefore be used to measure students achievements in the topic under Consideration.

Thanks for considering me worthy to go through your MAT

NGESANG NELSON MUSA

HOD MATHS GTHS NKEN

Validator 3

General Comments

Your questions are quite suitable for the level of the students. The activities are varied and the instructions very clear for most of them. Some of the questions are definitely better than others. So according to the criteria you handed to me, I have ticked some very good ones.

However:

- The duration of the test should be considered
- Question 5 has three detractors instead of four.
- Using one stem for more than one question may not be very good. Thus, question 1 and 2 should have separate diagrams.
- In question 10, where a negation in is expected, "**not**" should be highlighted.
- For question 12, letter "a" is used in the formula and "a" in the question. These may be seen as different symbols. Using the same symbol will make the question better.
- In question 17, the first detractor without the cube root sign is too distinct from the other 3, and so learners' attention could be tilted more to it. Also, the detractors C and D are the same.
- Question 24 is incomplete. Only the detractors are given.

If these shortcomings are adjusted, this will be a very good test. However if you intend to administer only part of the test, consider Bloom's taxonomy in selecting the questions.

Thanks for considering me worthy to validate this test.

Pexoh Stephen Nji
PLEG /

Appendix R

Data for Difficulty and Discrimination Indices of MAT/ Printouts

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1
	0	0	1	1	1	0	1	1	1	1	0	0	0	1	0	1	1	1	1	0
	1	0	1	1	1	0	1	1	1	0	1	1	1	1	1	1	0	0	1	0
	1	1	0	0	1	1	0	1	1	0	0	1	1	1	1	0	1	1	0	1
	0	1	1	1	1	0	0	1	1	1	1	0	1	1	0	0	0	0	1	0
	1	0	0	0	1	1	0	1	1	0	1	1	1	1	0	1	0	1	0	1
	0	1	1	1	0	1	0	1	1	0	0	0	1	1	0	0	0	0	1	0
	0	0	0	1	0	1	1	1	1	1	1	0	0	1	1	1	0	0	1	0
	0	1	1	0	0	0	1	1	1	1	1	0	0	1	0	0	0	1	1	1
	1	0	1	1	1	0	0	1	0	1	0	0	0	1	0	0	0	0	1	0
	1	0	0	1	1	0	0	1	0	0	0	1	1	0	1	1	0	0	1	1
	0	1	1	1	0	1	0	0	0	0	1	0	1	0	0	1	0	0	1	1
	1	0	0	0	1	1	0	1	0	0	0	1	0	0	1	0	0	0	0	1
	0	1	1	1	0	0	0	1	1	1	1	0	0	0	0	1	0	0	1	0
	1	0	0	1	0	0	0	1	1	1	1	1	0	0	0	0	0	1	0	1
	0	1	0	0	0	0	1	0	0	1	0	0	1	0	1	0	0	0	1	0
	0	0	0	1	0	0	1	1	0	1	0	0	0	1	1	0	0	0	1	0
	0	0	0	1	0	0	1	1	1	1	0	0	0	1	0	0	0	1	0	0
	1	0	1	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	0	0
	0	0	1	0	0	0	0	1	1	0	0	0	1	1	0	1	0	0	1	0
	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	1	0	0	1	0
	1	0	0	1	1	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0
	0	1	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	1	0	0
	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0	1	1
	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	1	0
	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0
	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0
	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Item Score	11	10	13	15	10	9	8	25	17	13	10	9	13	14	8	10	2	9	18	9

	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	Student's Score
	0	0	1	1	0	1	0	1	0	1	22
	1	1	0	1	1	1	0	0	1	1	19
	1	0	0	1	0	1	1	1	0	0	19
	0	1	1	0	1	0	0	1	1	1	19
	1	1	0	0	1	0	1	0	1	1	17
	0	1	0	1	0	1	0	1	0	1	17
	0	0	1	1	1	1	0	1	1	1	16
	1	0	1	0	0	1	0	0	0	1	15
	1	0	1	1	0	0	0	0	0	0	14
	1	1	0	1	1	0	0	0	0	1	13
	0	0	0	0	0	1	1	1	0	0	13
	0	0	0	1	0	1	0	0	1	1	13
	1	1	1	1	0	0	0	1	0	0	12
	0	0	0	1	0	1	0	0	1	0	12
	0	0	0	0	0	0	0	1	1	0	11
	0	0	1	0	1	0	1	0	1	1	11
	0	0	0	1	1	0	0	0	0	1	10
	0	0	1	0	0	0	0	0	0	1	9
	0	0	0	0	1	0	0	1	0	1	9
	0	0	0	0	1	1	0	0	0	0	9
	1	0	1	0	0	0	0	0	0	0	8
	0	0	0	0	0	0	0	1	0	0	8
	0	0	0	1	0	0	0	0	1	0	7
	0	0	0	0	0	0	1	0	0	1	7
	0	0	0	1	0	0	0	0	0	0	5
	1	0	0	0	0	0	0	0	0	1	5
	0	0	0	0	0	0	0	0	0	1	4
	0	0	0	0	0	0	0	1	0	0	3
	1	0	0	0	0	0	0	0	0	0	3
	0	0	0	0	1	0	0	0	0	0	2
Item Score	10	6	9	13	10	10	5	11	9	16	

Difficulty Indices for MAT Items

$$\textbf{Difficulty Index } (\mathbf{p}) = \frac{\textbf{Number of students who scored item x right}}{\textbf{Number of students who attempted item x}}$$

Item (Q) Number	Difficulty Index (p)	Comments
Q1	0.37	Good
Q2	0.33	Good
Q3	0.43	Good
Q4	0.5	Good
Q5	0.33	Good
Q6	0.3	Good
Q7	0.27	Too Difficult (Drop)
Q8	0.83	Too Easy (Drop)
Q9	0.57	Good
Q10	0.43	Good
Q11	0.33	Good
Q12	0.3	Good
Q13	0.43	Good
Q14	0.47	Good
Q15	0.27	Too Difficult (Drop)
Q16	0.33	Good
Q17	0.07	Too Difficult (Drop)
Q18	0.30	Good
Q19	0.6	Good
Q20	0.3	Good
Q21	0.33	Good
Q22	0.2	Too Difficult (Drop)
Q23	0.3	Good
Q24	0.43	Good
Q25	0.33	Good
Q26	0.33	Good
Q27	0.17	Too Difficult (Drop)
Q28	0.37	Good
Q29	0.3	Good
Q30	0.53	Good

Interpretation

Difficulty Index Ranges from 0% or 0 (difficult) to 100% or 1 (easy)

	Acceptable	Too easy	Too difficulty
Difficulty index	**$0.30 \leq p \leq 0.70$**	**> 0.70**	**< 0.30**
Explanation	**Good**	**• Common sense** **• Modify if possible**	**•Wrong key or Trivial fact** **•Ambiguous/misleading** **• Modify if possible**

Discrimination Indices for MAT Items

Discrimination Index (D) $= \frac{U-L}{T}$

where , U is the n^o of students in high-ability group (33%) who got the item right.

L is the n^o of students in low-ability group (33%) who got the item right.

T is the n^o of students in either the low or high-ability groups (that is, 10).

Item (Q) Number	Discrimination Index(D)	Comments
Q1	0.3	Very Good
Q2	0.3	Very Good
Q3	0.5	Very Good
Q4	0.3	Very Good
Q5	0.6	Very Good
Q6	0.4	Very Good
Q7	0.5	Very Good
Q8	0.3	Very Good
Q9	0.6	Very Good
Q10	0.4	Very Good
Q11	0.5	Very Good
Q12	0.3	Very Good
Q13	0.3	Very Good
Q14	0.9	Very Good
Q15	0.2	Good
Q16	0.4	Very Good
Q17	0.2	Good
Q18	0.3	Very Good
Q19	0.4	Very Good
Q20	0.3	Very Good
Q21	0.3	Very Good
Q22	0.5	Very Good
Q23	0.4	Very Good
Q24	0.5	Very Good
Q25	0.4	Very Good
Q26	0.6	Very Good
Q27	0.1	Low (Drop)
Q28	0.3	Very Good
Q29	0.3	Very Good
Q30	0.5	Very Good

Interpretation

Discrimination index Ranges from 1 to -1

	$0.3 \leq D \leq 1$	$0.2 \leq D < 0.3$	$0 \leq D < 0.20$	$-1 \leq D < 0$
Explanation	**• High Discrimination • Very good item**	**•Moderate •Good item**	**• Low, Modify if possible, else drop**	**•Negative •Drop**

Appendix S
Request for Validation of Instrument (MINTIV)

Department of Educational Foundations,

Faculty of Education,

Nnamdi Azikiwe University, Awka, Nigeria.

14th January, 2015.

Dear Sir/Madam,

Request for Validation of Mathematics Interest Inventory (MINTIV)

As part of a research in education, the researcher intends to administer this Interest Inventory to some Form 3 mathematics students in Cameroon. It will be administered before and after some topics (Indices, Inequalities, Algebraic expressions, Transposition of formulae and Triangles) found on the Form 3 scheme of work, would have been taught.

Please vet and comment on the attached MINTIV with regard to the following criteria:

1. The structure of the instrument and the clarity of the instructions,
2. The quality of each interest statement in terms of its length and language clarity, and
3. The content coverage and appropriateness of the statement for measuring students' interest in mathematics.

Kindly rate each statement quantitatively with four (4) points for the statements which are most satisfactory based on the above criteria, and one (1) point for those that are least satisfactory. Two (2) and three (3) points should be awarded based on the degree to which you judge the statement as satisfying the above criteria.

You may suggest particular items to be retained, modified or dropped.

Thank you for your cooperation.

Yours faithfully,

Beyoh Dieudone Nkepah

Appendix T

Data for Reliability Test of MINTIV / Printout of Cronbach's alpha Reliability

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	TOTAL1
1	3	2	2	3	3	1	3	3	2	1	3	2	3	3	1	3	1	3	2	45
3	4	3	3	3	3	2	3	3	3	3	4	3	3	2	3	3	4	2	3	60
1	1	2	3	2	3	3	2	2	3	3	2	3	3	3	1	2	2	2	3	46
1	2	2	2	1	1	2	2	2	2	2	1	1	2	3	2	1	1	3	2	35
3	1	3	3	2	2	3	2	2	3	3	1	3	3	3	3	2	3	3	3	51
1	1	3	1	3	1	1	2	1	3	2	1	3	3	2	3	3	2	3	3	42
1	2	3	2	1	3	2	3	3	1	3	1	1	2	1	3	2	3	2	3	42
1	1	3	3	3	3	3	2	2	3	3	2	2	2	3	3	3	3	3	2	50
2	1	2	3	1	2	1	2	1	2	2	1	2	1	2	1	2	3	2	1	34
1	1	2	3	2	2	3	2	2	3	3	1	3	4	1	3	1	3	3	2	45
1	2	3	1	3	2	3	2	2	3	1	1	1	2	1	2	1	3	3	2	39
1	2	2	2	2	2	1	2	2	1	1	1	3	2	2	2	2	3	2	1	36
3	3	3	3	4	4	3	2	3	3	4	4	3	3	3	3	4	3	2	1	61
2	2	1	1	1	3	2	3	2	1	1	1	2	2	2	1	1	3	2	3	36
1	2	3	3	2	3	2	2	2	1	2	2	1	2	3	2	2	3	4	2	44
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3	1	3	3	2	2	3	2	2	1	4	3	2	3	1	1	1	3	1	2	43
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3	4	2	1	2	1	1	1	2	2	1	1	1	2	1	2	2	3	2	1	35
1	2	2	2	2	2	2	1	2	2	2	1	1	2	1	2	2	3	1	3	36
1	2	1	3	2	3	3	2	2	3	2	1	3	1	1	1	2	3	2	3	41
2	1	1	2	2	2	2	1	2	3	2	2	1	1	1	1	1	3	3	2	35
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1	2	1	2	2	2	1	2	1	2	1	2	1	2	2	1	2	3	2	1	33
2	1	2	4	1	1	2	2	1	2	2	1	1	2	1	3	2	3	1	1	35
4	2	3	3	3	3	3	4	3	3	3	4	3	3	3	4	3	3	3	3	63
3	2	3	3	3	1	2	2	3	1	1	2	3	3	2	1	3	3	2	3	46
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1	4	3	3	2	2	3	2	2	3	3	2	3	3	1	3	2	3	3	1	49
3	2	1	3	3	1	3	2	2	3	2	1	1	3	2	3	3	3	4	3	48
1	2	3	3	3	3	2	3	3	3	3	1	3	1	1	3	2	3	2	3	48
1	2	1	1	2	1	1	2	2	1	1	2	2	2	1	1	2	3	2	2	32
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3	1	3	2	2	2	3	2	2	1	2	3	2	3	1	1	3	3	3	1	43
3	2	3	3	1	2	3	2	2	3	3	1	3	3	4	2	3	3	1	1	48
1	2	3	1	3	2	2	1	3	2	2	1	1	1	3	4	4	3	2	3	44

Printout of Cronbach's alpha reliability test for MINTIV

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GET DATA /TYPE=XLSX
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  /SHEET=name 'Cronbach's alpha reliability analysis for Beyoh Dieudone Nkepah'
  /CELLRANGE=full
  /READNAMES=on
  /ASSUMEDSTRWIDTH=32767.
EXECUTE.
DATASET NAME DataSet6 WINDOW=FRONT.
RELIABILITY
  /VARIABLES=Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8 Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17 Q18 Q19
Q20
  /SCALE ('ALL VARIABLES') ALL
  /MODEL=ALPHA.
```

Reliability

[Beyoh's Pilot Test Scores for MINTIV]

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	40	100.0
	Excluded[a]	0	.0
	Total	40	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.841	20

Appendix U
Data for Reliability Test for MAT Items/ Calculation of K-R 20 Reliability

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	TOTAL1
1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	4
0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	4
1	0	1	1	0	1	0	1	1	0	1	0	1	1	1	0	1	1	0	0	12
1	0	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	1	0	1	9
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
0	0	1	0	1	1	0	0	0	0	1	1	0	0	0	0	0	1	0	0	6
1	1	0	0	1	1	0	1	1	0	1	0	0	0	0	1	0	1	0	1	10
1	1	1	1	1	0	0	0	1	0	0	0	0	0	1	0	1	1	0	0	9
1	1	1	0	1	0	1	0	1	1	0	0	1	1	1	1	0	1	1	1	14
0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	4
1	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	1	1	0	7
0	1	1	0	1	1	0	0	1	1	1	1	0	0	1	0	1	0	0	1	11
0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	4
1	0	1	1	1	1	0	1	1	0	1	0	1	1	1	0	1	0	0	1	13
1	1	0	0	1	0	1	0	1	0	0	0	1	1	0	0	0	1	1	0	9
0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	3
0	1	1	1	1	0	1	0	1	0	1	0	1	0	1	1	1	1	0	1	13
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0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	1	0	0	5
1	1	0	1	1	1	1	0	0	0	1	1	1	1	1	0	1	1	1	0	14
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1	1	0	0	1	0	1	0	1	0	1	0	0	1	0	0	0	1	1	0	9
0	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	4
0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	4
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0	1	0	1	1	0	1	0	1	0	0	0	1	1	1	0	1	0	0	1	10
1	0	0	0	1	0	1	0	1	0	0	0	0	1	1	0	1	1	1	0	9
0	0	0	0	1	1	1	1	0	0	1	0	0	0	1	0	0	0	0	1	7
0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	4
0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	4
1	1	0	1	0	1	0	1	1	0	1	1	1	0	0	1	0	1	0	0	11
0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	1	0	0	4
1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	1	0	4
0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	3
1	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	5
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	0	0	0	0	4

Procedure for obtaining K-R 20 Reliability for MAT

Item	p	q	pq
1	0.45	0.55	0.2475
2	0.325	0.675	0.2194
3	0.225	0.775	0.1744
4	0.225	0.775	0.1744
5	0.475	0.525	0.2494
6	0.325	0.675	0.2194
7	0.4	0.6	0.24
8	0.2	0.8	0.16
9	0.45	0.55	0.2475
10	0.125	0.875	0.1094
11	0.525	0.475	0.2494
12	0.125	0.875	0.1094
13	0.375	0.625	0.2344
14	0.375	0.625	0.2344
15	0.4	0.6	0.24
16	0.125	0.875	0.1094
17	0.275	0.725	0.1994
18	0.575	0.425	0.2444
19	0.175	0.825	0.1444
20	0.35	0.65	0.2275
		$\sum$**pq** =	**4.0341**

$$\textbf{K} - \textbf{R 20 reliability } (\textbf{r}) = \frac{n}{n-1}\left[1 - \frac{\sum \text{pq}}{S_t^2}\right]$$

Where n is the number of items on the MAT,

P is the proportion of students, who passed the item,

q is the proportion of students who failed the item,

S_t^2 is the variance of the test (calculated using TOTAL1 above).

$$\text{r} = \frac{20}{20-1}\left[1 - \frac{4.0341}{12.974}\right]$$

r = 0.73

Appendix V

Second MINTIV Data (collected 2 weeks after the first) / Printout of test-retest Reliability

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	TOTAL2
3	1	3	3	2	3	1	1	3	3	1	3	1	1	3	2	2	3	3	1	43
3	2	3	3	3	3	4	4	3	2	3	3	4	3	4	3	3	3	3	2	61
3	3	2	2	3	2	2	3	3	3	3	2	2	3	1	2	3	2	3	3	50
1	2	2	2	2	1	1	2	2	3	2	1	1	1	2	2	2	1	1	2	33
2	3	2	4	3	2	3	3	3	3	3	4	3	3	4	3	3	2	3	3	59
1	1	2	1	3	3	2	1	3	2	3	3	2	1	1	3	1	3	1	1	38
3	2	3	3	1	2	3	2	2	1	3	2	3	1	2	3	2	1	3	2	44
3	3	2	2	3	3	3	3	2	3	3	3	3	1	1	3	3	3	3	3	53
2	1	2	1	2	2	1	1	1	2	1	2	1	2	1	2	3	1	2	1	31
2	3	2	2	3	1	2	3	4	1	3	1	2	1	1	2	3	2	2	3	43
2	3	2	2	3	1	1	3	2	1	2	1	1	1	2	3	1	3	2	3	39
2	1	2	2	1	2	1	1	2	2	2	2	1	1	2	2	2	2	2	1	33
4	3	2	3	3	4	4	3	3	3	3	4	4	3	3	3	3	4	4	3	66
3	2	3	2	1	1	3	2	2	2	1	1	3	2	2	1	1	1	3	2	38
3	2	1	2	1	2	2	2	2	2	2	2	2	1	2	3	1	2	2	2	38
1	1	1	2	2	3	2	1	3	2	2	1	2	1	1	2	2	2	1	1	33
2	3	2	2	1	1	4	3	3	1	1	1	4	3	1	3	3	2	2	3	45
1	3	1	2	1	1	1	3	2	2	1	1	1	1	2	2	1	3	1	3	33
1	1	1	2	2	2	1	1	2	1	2	2	1	3	4	2	1	2	1	1	33
2	2	1	2	2	2	2	2	2	1	2	2	2	1	2	2	2	2	2	2	37
3	3	2	2	3	2	2	3	1	1	1	2	2	1	2	1	3	2	3	3	42
2	2	1	2	3	1	1	2	1	1	1	1	1	2	1	1	2	2	2	2	31
3	2	3	3	2	3	2	2	3	2	2	3	2	3	2	2	2	2	3	2	48
2	1	2	1	2	2	2	1	2	2	1	2	2	1	2	1	2	2	2	1	33
1	2	2	1	2	2	2	2	2	1	3	2	2	2	1	2	4	1	1	2	37
3	3	4	3	3	3	4	3	3	3	4	3	4	4	2	3	4	3	4	3	66
1	2	2	3	1	3	2	2	3	2	1	3	2	3	2	3	3	3	1	2	44
2	2	1	1	1	1	2	2	2	2	1	1	2	1	2	2	1	2	2	2	32
3	2	2	1	3	3	1	2	2	1	3	3	1	2	2	3	3	2	3	2	44
2	1	1	1	2	2	2	1	1	2	1	2	2	1	1	2	1	2	2	1	30
2	3	2	2	3	2	2	3	1	3	3	2	2	1	2	1	3	2	2	3	44
2	3	2	2	3	3	1	3	2	3	3	3	1	1	2	2	3	3	2	3	47
2	3	2	2	3	2	3	3	3	1	3	2	3	1	4	3	3	2	2	3	50
1	3	2	2	3	3	1	3	3	2	3	3	1	3	2	1	3	3	1	3	46
3	2	3	3	3	2	2	2	1	1	3	2	2	1	2	3	3	3	3	2	46
1	1	2	2	1	2	2	1	2	1	1	2	2	1	2	1	1	2	1	1	29
2	1	1	3	2	3	2	1	3	2	3	3	2	1	1	1	1	1	2	1	36
2	3	2	2	1	3	1	3	3	1	1	3	1	3	1	3	2	2	2	3	42
2	3	2	2	3	3	2	3	3	4	2	3	2	3	2	3	3	1	2	3	51
2	2	1	3	2	4	2	2	1	3	4	4	2	1	2	3	1	3	2	2	46

Printout of test-retest reliability for MINTIV

CORRELATIONS

/VARIABLES=TOTAL1 TOTAL2

/PRINT=TWOTAIL NOSIG

/MISSING=PAIRWISE.

Correlations

[MINTIV test-retest reliability analysis for Beyoh Dieudone Nkepah]

Correlations

		TOTAL1	TOTAL2
TOTAL1	Pearson Correlation	1	.952
	Sig. (2-tailed)		.000
	N	40	40
TOTAL2	Pearson Correlation	.952	1
	Sig. (2-tailed)	.000	
	N	40	40

Appendix W

Second MAT Data (collected 2 weeks after the first) / Printout of test-retest Reliability

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	TOTAL2
1	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	1	0	0	6
0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	1	4
1	1	0	0	1	0	1	0	1	0	1	0	0	1	0	0	0	1	1	0	9
0	0	0	0	1	1	1	1	0	0	1	0	0	0	1	0	0	0	0	1	7
0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	0	0	4
1	1	0	1	0	1	0	1	1	0	1	1	1	0	0	1	0	1	0	0	11
0	1	0	1	1	0	1	0	1	0	0	0	1	1	1	0	1	0	0	1	10
1	0	0	0	1	0	1	0	1	0	0	0	0	1	1	0	1	1	1	0	9
0	0	0	0	1	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	5
0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	4
0	0	1	0	0	1	1	0	1	0	1	0	0	1	0	0	1	1	0	1	9
0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
0	1	1	1	1	0	1	0	1	0	1	0	0	1	0	0	1	1	0	0	10
0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	1	0	0	1	7
1	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	1	1	0	7
1	0	0	1	0	1	0	0	1	0	0	1	0	1	1	0	1	0	0	1	9
1	1	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	0	0	1	6
0	1	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	1	0	0	6
0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	1	0	0	5
1	1	0	1	0	1	1	1	1	0	1	1	1	0	0	1	0	1	1	1	14
1	1	0	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	1	0	8
0	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	4
0	1	0	1	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	0	6
0	0	0	0	1	1	1	1	0	0	1	0	0	0	1	0	0	0	0	1	7
0	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	4
0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2
1	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0	0	1	1	0	7
0	1	1	0	1	1	0	0	1	1	1	1	0	0	1	0	1	0	0	1	11
1	1	0	1	1	1	1	0	0	0	0	0	0	1	1	0	1	1	1	0	11
0	1	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	0	1	5
0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	1	4
0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	1	1	0	0	6
1	1	0	0	1	0	1	1	1	0	1	1	1	0	0	1	0	1	0	1	12
0	1	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	0	0	5
0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	0	5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
0	1	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	6
1	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	5
0	0	0	0	1	1	1	1	0	0	1	0	0	0	1	0	0	0	0	0	6

Printout of test-retest reliability for MAT

CORRELATIONS

/VARIABLES=TOTAL1 TOTAL2

/PRINT=TWOTAIL NOSIG

/MISSING=PAIRWISE.

Correlations

[MAT test-retest reliability analysis for Beyoh Dieudone Nkepah]

Correlations

		TOTAL1	TOTAL2
TOTAL1	Pearson Correlation	1	.783
	Sig. (2-tailed)		.000
	N	40	40
TOTAL2	Pearson Correlation	.783	1
	Sig. (2-tailed)	.000	
	N	40	40

Appendix X
Collected Data on the Cooperative Learning Method / Flipped Learning Method
Cooperative Learning Method

GROUP	GENDER	MATPRETEST	MATPOSTTEST	MINTIVPRETEST	MINTIVPOTTEST
1	4	4	13	60	62
1	4	2	8	52	54
1	5	2	8	41	63
1	5	1	3	39	46
1	5	5	10	51	58
1	5	6	16	56	68
1	4	7	9	62	60
1	5	6	14	58	64
1	4	6	13	59	70
1	5	3	8	51	62
1	5	4	9	52	57
1	4	5	8	50	51
1	5	4	15	65	74
1	5	6	13	47	50
1	4	3	6	32	50
1	5	5	7	51	50
1	4	6	15	60	68
1	4	8	14	67	70
1	5	3	9	48	48
1	5	4	10	49	52
1	4	7	17	69	71
1	5	5	10	49	61
1	4	6	10	47	51
1	5	1	5	29	55
1	5	4	6	40	42
1	5	3	13	51	68
1	5	5	11	49	57
1	5	5	12	52	68
1	4	8	15	64	65
1	4	9	19	75	78
1	5	4	7	43	47
1	4	7	11	47	51
1	4	5	6	47	46
1	5	3	11	50	58
1	5	4	12	52	66
1	4	6	15	57	62
1	5	4	14	65	66
1	4	7	15	63	69
1	4	8	13	58	63
1	5	4	10	48	65

Flipped Learning Method

GROUP	GENDER	MATPRETEST	MATPOSTTEST	MINTIVPRETEST	MINTIVPOSTTEST
2	5	2	7	56	69
2	5	1	3	40	58
2	5	4	11	45	71
2	4	6	17	73	77
2	4	5	12	67	71
2	5	3	10	32	47
2	4	8	17	65	76
2	4	6	12	59	58
2	5	1	5	37	58
2	4	6	16	65	71
2	4	5	7	58	62
2	5	3	9	65	70
2	4	5	13	48	69
2	5	6	16	66	75
2	5	3	11	40	60
2	4	5	12	60	67
2	4	10	20	70	72
2	5	7	16	67	74
2	4	6	11	58	68
2	5	4	12	57	51
2	5	5	16	49	74
2	4	5	10	44	50
2	4	7	14	65	72
2	5	4	14	62	62
2	5	8	13	63	69
2	4	5	8	67	71
2	5	2	10	42	48
2	4	6	8	58	58
2	5	3	15	50	73
2	4	7	13	58	61
2	5	5	16	64	74
2	4	5	7	59	57
2	5	3	15	42	57
2	5	4	14	50	69
2	5	2	9	50	58
2	4	6	10	60	61
2	4	5	15	64	70
2	5	6	10	71	70
2	5	9	18	73	76
2	4	4	5	52	50
2	5	4	6	70	66
2	5	5	13	49	70
2	4	6	10	52	68
2	5	6	17	55	73
2	5	4	16	57	69
2	4	7	15	61	65
2	5	4	13	49	70

Appendix Y

Summary of Variable Characteristics used in the Study

Variable Name	**Item Description**	**Used Codes**
GROUP	Experimental and Control Groups	1=Cooperative Learning Method 2=Flipped Learning Method
METHODS	Teaching-Learning Methods	1=Cooperative Learning Method 2=Flipped Learning Method
GENDER	Sex of Students	4=Males 5=Females
MATPRETEST	Mathematics Achievement Pretest Scores	_____
MATPOSTTEST	Mathematics Achievement Posttest Scores	_____
MINTIVPRETEST	Mathematics Interest Pretest Score	_____
MINTIVPOSTTEST	Mathematics Interest Posttest Scores	_____