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Effects of Flipped Learning Method on Students' Achievements in Numerical Functions in Technical High Schools in Mezam Division - Cameroon

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Abstract: ***The purpose of the study was to investigate the effects of the flipped learning method in enhancing students' achievements in numerical analysis. It was carried out in Mezam Division of the North West Region of Cameroon and involved all final year students in technical high schools. The study adopted the pretest-posttest non-equivalent control group design. Ninety students drawn from a population of 536 students and grouped into one experimental of 41 students and one control group of 49 students, constituted the sample of this study. Data was collected using a Numerical Functions Achievement Test (NFAT). The Kudder-Richardson 20 (K-R 20) reliability of the NFAT was found to be 0.83. Mean was used to answer the research questions while ANCOVA was used to test the hypotheses. The findings showed that the flipped learning method was effective in enhancing students' achievements in numerical functions. In relation to gender, the flipped learning method was more effective in enhancing the mean achievement score of female students than that of male students. Based on the findings, it was recommended among other things that technical school mathematics teachers in Cameroon should adopt the use of the flipped learning method in teaching numerical functions.***

Keywords: flipped learning, students' achievement, mathematical learning, technical schools, numerical functions

1. Introduction

Many structural changes have taken place in mathematics over the years. These changes have always been necessitated by the realization of the role which mathematics plays in the nation's scientific and technological development as well as responses to societal needs and demands. 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 human life. Its role is such that there is hardly any discipline of study in which mathematics is not involved.

Seasoned 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 is in line with Ukeje as cited by Orji and Uche (2010), who observed 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. Thus mathematics is a sine qua non in the scientific and technological development of any nation.

Unfortunately, despite the importance and benefits of mathematics to our day-to-day activities and its role as an agent of national development and wealth creation, students' achievements in the learning of mathematics have been pitiable. There has been consistent poor performance and failure of students in mathematics examinations in Cameroon (Akoko, 2010).

Many writers have tried to explain why achievement rates in this very important subject are consistently low. Anyagh and Ok'wu (2010) did identify many variables as responsible for students' poor performances in mathematics. They include: curriculum, mathematics pedagogy, examination bodies, teachers, students, environment and textbooks. Also, 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 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 technical schools in Cameroon. 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 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 very often, they have limited resources to help them accomplish such task. Thus students are expected to handle the elements of the lower level (remembering, understanding and to some extent applying) of the revised Bloom's taxonomy (Anderson & Krathwohl, 2001) with the teacher in class, while the higher levels (analyzing, evaluating and creating) are handled by the students at home, in the course of working on their assignments.

There is an outcry by researchers, parents and other education stakeholders in Cameroon, 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 Baccalaureate Examinations; the last certificate for students in technical schools after completing seven years of study. The mathematics paper in this examination is usually divided into four sections. The last section being that on numerical functions always carries 50% of the total marks in mathematics. Unfortunately, most students face a lot of difficulties managing this section. Consequently they end up failing the entire paper. This further affects their entire results negatively.

The foregoing suggests that to enhance the understanding of numerical functions, technical school students must be more active in the classroom and must creatively acquire knowledge, especially in understanding and solving numerical functions problems. In this technological age, both mathematics 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. Among the alternative teaching-learning methods for the delivery of numerical functions lessons which can possibly keep learners active and allow them to interact creatively with technology is the flipped learning method.

Flipped learning is a relatively new and less widely researched teaching-learning method which is an embodiment of technology and active learning (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 teaching-learning 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. Thus students are expected to handle the elements of the lower level (remembering, understanding and to some extent applying) of the revised Bloom's taxonomy at home, while the higher levels (analyzing, evaluating and creating) are handled by the teacher in class. 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.

According to Brame (2013) , 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. 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). 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. Thus all students have sufficient time to go through the material as many times as possible before class time.

Another area of interest in this study is the effect of gender on the achievements of technical school students in numerical functions within the flipped learning method. 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 (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. 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. It is therefore necessary to establish the current state of gender inequality in the achievement of students especially in numerical functions in technical schools, given that many studies carried out have yielded varied findings

Beyoh (2018) carried out a study to compare the effectiveness of flipped learning and cooperative learning methods in enhancing students' interests and achievements in mathematics. The study was carried out in Mezam Division of the North West Region of Cameroon and involved all Form Three students in English-speaking public secondary schools. The study adopted the quasi experimental design. 141 students constituted the sample of the study. Two instruments, Mathematics Achievement Test (MAT) and Mathematics Interest Inventory (MINTIV), were used in collecting data for the study. Mean was used to answer the research questions while the Analysis of Covariance (ANCOVA) was used to test the hypotheses. The findings of the study showed that both the cooperative and the flipped learning models of teaching mathematics were better enhancers of students' achievements and interests, than the lecture method. In relation to gender, a significant difference was noticed only in the achievements of males and females in the flipped model, in favour of females.

Martins-Umeh (2012) also 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.

The literature reviewed suggests that no known experimental study (to the researcher) on flipped learning in numerical functions has been carried out in Cameroon. Furthermore, according to FLN (2014), quantitative research on flipped learning is limited. These are gaps the present study intends to fill.

1.1 Purpose of the Study

The purpose of this study was to investigate the effectiveness of the flipped learning method in enhancing students' achievements in numerical functions in Technical High Schools in Mezam Division of North West Region-Cameroon. Specifically, the study set out to:

1) Compare the effectiveness of the flipped learning method in enhancing technical school students' achievements in numerical functions, with that of the conventional learning method.
2) Compare the mean achievement scores of male and female students taught numerical functions using the flipped learning method.

1.2 Research Questions

1) How effective is the flipped learning method in enhancing students' achievements in numerical functions when compared with the conventional learning method?
2) What are the mean achievement scores of male and female students taught numerical functions using the flipped learning method?

1.3 Hypotheses

The following hypotheses were posited and 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 conventional learning method in enhancing students' achievements in numerical functions.
2) There is no significant difference in the mean achievement scores of male and female students taught numerical functions using the flipped learning method.

2. Methodology

The study adopted a quasi experimental research design. Specifically, the design used was a pretest-posttest non-equivalent control group design. Gad (2015) opined that this design is appropriate when independent variables are to be manipulated in an experiment, and their effects on the dependent variable observed, while checking on extraneous variables. The population of the study was made up of all the 536 Upper sixth students in three functional Government Technical High schools in Mezam Division. Ninety upper sixth students with 64 males and 26 females constituted the sample of the study. The sample was arrived at through a combination of simply random and purposive sampling techniques. Firstly, three Government Technical Schools were purposively selected on the baseis that these were the only functional schools in Mezam Division. Through simple random sampling technique two schools were selected from among the three. Through simple random sampling technique again, the two groups (flipped and control groups) were allocated to the selected schools; Flipped learning group to Government Technical High School (GTHS) Nkwen and the Control group to GTHS Mendankwe. The industrial classes of these two schools made up of 41 and 49 students respective, were used to conduct the study.

A 20-itemised Numerical Functions Achievement Test (NFAT), made up of objective test questions, was developed and used to collect relevant data. The NFAT was face and content validated by two experts in mathematics and a specialist in measurement and evaluation. After trial testing, the psychometric (difficulty and discrimination) indices of the instrument were determined. Using Kudder-Richardson 20 (K-R 20) method, the reliability of the NFAT was established as 0.83. The NFAT was administered as a pretest in the first week and also as a posttest in the sixth week, with the items reshuffled and paper colour changed during the posttest.

Sixteen lesson plans (eight for each group) developed by the researcher from video lessons on numerical functions and validated by two mathematics teacher trainers and a Regional Inspector of mathematics, were used as instructional tools in both groups. The study was delimited to numerical functions, a section which carries 50% of the marks in mathematics in the baccalaureate examinations. The study was conducted according to the normal time table of the sampled classes, with two lessons of 100 minutes each weekly, giving a total of eight lessons taught within the four weeks of the experimental period in each group. Before the start of the experiment, the class teacher for the experimental group was trained by the researcher on how to implement the flipped learning method. The researcher equally had contacts with the control group teacher to acquaint him with the objectives and contents of the lesson plans. This was to ensure that the same objectives were attained in both groups, after each lesson. Thus the teacher variable and experimental bias were systematically checked. Prior to the start of the experiment, the NFAT (pretest) was administered to both groups.

During the experiment, students in the flipped learning group 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. On the other hand, the control group used the conventional or traditional methods of instruction, that is, lecture, discussion and problem solving. The class teacher for this group merely kept the students learning the way they are used to. However, to ensure that students in all the three classes involved in this study were exposed to the same material, the class teacher for this group also administered the same quizzes after presentation of the concepts of each lesson.

After the experiment which lasted for four weeks, the NFAT (posttest) was again administered to both groups during the sixth week. Each correctly answered NFAT item was scored one mark, giving a maximum of 20 marks that could be scored by each respondent. The bench-mark for the NFAT was thus taken to be 10. Hence any teaching-learning method with a mean numerical functions achievement score from 10 and above was considered to be effective. After scoring, mean was used to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance, and also to check the non-randomization effect in the two intact classes. Other extraneous variables such as: Hawthorne effect, pre-test/ post-test sensitization and contamination effect were also systematically checked.

3. Findings

Research Question 1: *How effective is the flipped learning method in enhancing students' achievements in numerical functions when compared with the conventional learning method?*

Table 1: Mean Numerical Functions Achievement Scores of Students in the Flipped Learning Method and Conventional Learning Method Groups.

Group	N	Pretest Mean	Posttest Mean	Mean Gain
Flipped Learning Method	41	5.27	12.61	7.34
Conventional Learning Method	49	5.22	9.83	4.61

Table 1 indicates that the pretest mean numerical functions achievement score for students taught using the flipped learning method was 5.27. Their posttest mean was 12.61. This gave a mean gain of 7.34. With regard to those taught numerical functions using the conventional learning method, they had a pretest mean of 5.22 and a posttest mean of 9.83, giving a mean gain of 4.61. This shows that the flipped learning method was effective in enhancing students' achievements in numerical functions. Going further, the mean gains indicate that the flipped learning method was more effective when compared with the conventional learning method.

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

Table 2: Mean Achievement Scores of Male and Female Students Taught Numerical Functions using the Flipped Learning Method

Gender	N	Pretest Mean	Posttest Mean	Mean Gain
Males	30	5.07	11.82	6.75
Females	11	5.21	12.86	7.65

Table 2 suggests that for students taught numerical functions using the flipped learning method, the males had a pretest mean achievement score of 5.07 and a posttest mean achievement score of 11.82, giving a mean difference of 6.75. On the other hand, the pretest mean numerical functions achievement score for the females was 5.21 and their posttest mean was 12.86, giving a higher mean difference of 7.65. This shows that the flipped learning method was more effective in enhancing the mean achievement score of female students than that of male students.

Hypothesis 1: *There is no significant difference between the effectiveness of the flipped learning method and that of the conventional learning method in enhancing students' achievements in numerical functions.*

Table 3: Summary of ANCOVA Comparing Students' Achievement Scores in Numerical Analysis in the Flipped Learning Method and the Conventional Learning Method.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	480.424	2	240.212	22.125	.000
Intercept	274.386	1	274.386	25.273	.000
MFATPRETEST	282.579	1	282.579	26.027	.000
GROUP	**172.002**	**1**	**172.002**	**15.842**	**.000**
Error	944.565	87	10.857		
Total	12293.000	90			
Corrected Total	1424.989	89			

Table 3 shows that the F-ratio for the test was 15.842, giving a p-value of 0.000 ($p < 0.05$). Thus, the F-ratio is significant (S) at the 0.05 level of significance. Consequently, null hypothesis 1 was rejected. Therefore, there is a significant difference between the effectiveness of the flipped learning method and that of the conventional learning method, in enhancing students' achievements in numerical functions. This significant difference is in favour of the flipped learning method (Table 1).

Hypothesis 2: *There is no significant difference in the mean achievement scores of male and female students taught numerical functions using the flipped learning method.*

Table 4: Summary of ANCOVA Comparing Male and Female Students' Achievement Scores in Numerical Analysis in the Flipped Learning Method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	151.243	2	75.621	8.198	.001
Intercept	250.979	1	250.979	27.209	.000
MFATPRETEST	104.999	1	104.999	11.383	.002
GENDER	**68.702**	**1**	**68.702**	**7.461**	**.025**
Error	350.513	38	9.224		
Total	7021.000	41			
Corrected Total	501.756	40			

Table 4 indicates that the F-ratio for the test was 7.461. This gave a p-value of 0.025. Thus the F-ratio was significant at the 0.05 level of significance. For this reason, null hypothesis 2 was rejected. Hence, there is a significant difference in the mean achievement scores of male and female students taught numerical functions 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 2).

4. Discussion of Findings

The findings of the study show that the flipped learning method was effective in enhancing students' achievements in numerical functions numerical functions. Going further, the mean gains indicate that the flipped learning method was more effective when compared with the conventional learning method. Evidence of consonance between the findings of this study and those of earlier studies abound in the work of Beyoh (2018) who established that the flipped learning method produced higher learning gains than the traditional learning method. The possibility of students taught with the flipped learning method to achieve higher, is certainly not unconnected with the active involvement of students in the activities embedded in the method. This finding suggests that the present day Cameroonian students are good digital natives who seem to relate better with videos and pictures than with textbooks. Thus they turn to relate well with technology. This may account for why the use of video lessons within the flipped method had a significantly positive effect on students' achievements in numerical functions.

The findings of the study also indicate that for students taught numerical functions 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; 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.

5. Recommendations

Technical school mathematics teachers in Cameroon should adopt the flipped learning method as an alternative method of teaching numerical functions, and should use this method more frequently than the conventional method of teaching numerical functions. This pedagogical shift will 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 and in particular numerical functions.

Government, Non Governmental Organisations, Parent-Teacher Associations and other stake holders in education who do not only expect better achievements in technical school mathematics, but who are also concerned about the achievement of female students 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 the females) within the flipped learning method.

The ministry of secondary education should organize compulsory training seminars on flipped learning for in-service mathematics teachers in technical schools. This will go a long way to update in-service mathematics teachers on how to use the flipped learning method in teaching mathematics and especially numerical functions in technical schools.

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