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Gender Differences and Achievement of Students in Differential Calculus Using Jigsaw II Cooperative Learning Strategy

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Abstract

This study adopted quasi experimental control group design to investigate gender differences and achievement of students in differential calculus using Jigsaw II cooperative learning strategy compared to the use of traditional lecture method at Federal College of Education (Technical) Gombe, Gombe State, Nigeria. 125 students formed the population of the study; cluster sampling technique was used to select the same 125 students from the study area. The Differential Calculus Achievement Test (DCAT) was administered before and after the treatment. Two research questions and two null hypotheses were developed and tested at 0.05 level of significance. Jigsaw II cooperative learning strategy was used to teach experimental group differential calculus while traditional lecture method was used to teach control group the same topics. The findings indicated no significant difference in achievement between male and female students taught differential calculus using jigsaw II cooperative learning strategy. More so, there is no significant difference in achievement between male and female students taught differential calculus using traditional lecture method. The study recommends that colleges of education authorities should encourage their lecturers to use jigsaw II cooperative learning strategy in their colleges most especially in calculus courses that most students lacked basic background from secondary schools.

Keywords: achievement, calculus, jigsaw cooperative learning, strategy, gender

Introduction

Calculus is a branch of mathematics concerned with the calculation of instantaneous rates of change, known as Differential Calculus, and the summation of infinitely many small factors to determine some whole, known as Integral Calculus (Berggren, 2016). Calculus and Mathematics teaching and learning in Colleges of Education is aimed at achieving two major objectives: the production of qualified and competent teachers who will plan and effectively execute lessons in secondary schools and at the same time prepare students who will demonstrate convincing enthusiasm and intellectual ability for further studies in mathematics at universities. Students' achievement in mathematics at National Certificate in Education (NCE) level therefore, determines the quality of mathematics teachers being produced to teach in schools, which form the foundation for other levels of the educational system.

There is no doubt that mathematics has an extensive application in life and related fields. According to Zuya (2016), Mathematics can be seen from two different points of view: The pure Mathematics point of view (purist) and applied Mathematics (such as engineers, educationist) point of view (utilitarian). Purist sees Mathematics as a study of patterns, relationships and rich interconnected ideas. Utilitarian views Mathematics as a tool for solving problems in a wide range of contexts. So, any definition of Mathematics can be traced from these two views. Michael (2015) sees Mathematics as the science of reasoning and computations. It is the science or study of numbers, quantities or shapes. Michael further defines Mathematics as the language that helps an individual to describe ideas and relationships drawn from the environment.

Carol (2018) notes that every individual needs basic knowledge of Mathematics to function intelligently and efficiently in this world; no matter the field or profession one belongs to, knowledge of Mathematics is relevant. Nigeria as a nation depends solely on mathematics as one of the most important subjects that could help the nation meet her objectives for science and technological advancements. Altbatch (2012) supported this fact that the progress of science could be determined by the extent to which mathematics and calculus knowledge has been included into its methods and contents. In spite of the importance and roles of mathematics and calculus in Nigerians' educational system, science and technology in particular and the aims of teaching mathematics in colleges of education, mathematics students at the colleges of education still register continually low achievement in the Nigeria Certificate in Education in NCE1 level in Math 121, Differential Calculus. The reason for the low achievements, according to the experts in

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the fields of knowledge may vary but this could sometimes be related to the teaching method being used to explain mathematics topics (Chianson et al., 2011).

Iji and Uka (2012) said that no matter how good a course curriculum is, if there are no well trained, qualified and motivated teachers, the desired results/goals may not be achieved. No matter how intelligent the pupils may be, their understanding levels still depend on who is teaching them. Studies have also shown that different approaches should be adopted in teaching and learning of mathematics so that students' interest and academic achievement can be raised (Onah et al., 2015).

In spite of the stated aims of teaching and learning of mathematics in Colleges of Education, available records reveal that the achievement of students of mathematics in NCE 1 Differential Calculus examinations has been low, to the extent that in the years 2012/2013, 2013/2014, 2014/2015, 2015/2016, 2016/2017 and 2017/2018 academic sessions only 36.97%, 29.28%, 35.24%, 40.10%, 27.46% and 56.00% respectively of the students from F.C.E.(T) Gombe got at least a credit, that is grades A-C. While an overwhelming percentage 63.03%, 70.72%, 64.76%, 59.90%, 72.54% and 44.00% respectively obtained ordinary passes and fails.

Studies showed that often poor academic achievement in Calculus is caused by a deficiency in the teacher's content knowledge of the subject (Lam, 2009). Lam studied the content knowledge of calculus of 27 in-service mathematics teachers by using a questionnaire dealing with images and definitions of various calculus concepts. The results reveal a lack of knowledge of various Differential Calculus concepts. An increasing number of investigations have shown that students have difficulties in understanding the concept of Integral Calculus (Zakaria & Salleh, 2015). The analysis of Calculus performance of the students at a university, particularly in Integral Calculus topic was found to be low (Zakaria & Salleh, 2015).

Cooperative learning is an organized and structured way that uses small groups to enhance students' learning and interdependence. Students are given a task, popularly known as assignment, and they work together to accomplish a common goal. Individuals in the group each has a responsibility to play and is held accountable for aiding in the learning process and completion of the assignment; thus, success is ensured through working together. Therefore, to achieve success in learning mathematics, students should be given the opportunity to communicate mathematically, reason mathematically, and develop self-confidence to solve mathematics problems. One of the ways this can be done is through cooperative learning.

In cooperative learning, students study in small groups to achieve the same goals using social skills. Many studies show that cooperative learning can improve performance, long-term memory and positive attitudes towards mathematics, self-concept and social skills (Isah, 2015). More opportunities should be given to discussion, problem solving, creating solutions and working with peers. Several educators in the field of mathematics education conducted studies using cooperative learning and found increase in students' mathematics achievement (Isik & Tarim, 2009).

Cooperative learning can refer to any learning and teaching method which makes students work together in small groups towards achieving common goals. The core element of cooperative learning is the emphasis on students' interaction rather than on learning as a solitary activity. Cooperative learning reduces classroom anxiety created by new and unfamiliar situations faced by students (Slavin et al., 2013). Gillies (2014) found that establishing a strong cooperative learning environment allows for less discipline issues. The positive gains for students who are given opportunity to interact, listen, share ideas and question one another are much higher than traditional "sit and get."

In a traditional classroom, when a teacher calls upon a student, he/she becomes the focus of attention of the entire class. Any mistake or incorrect answer becomes a subject of scrutiny by the whole class (Alemu 2010). In contrast, with cooperative learning situation, when students work in a group, the focus of the attention is diffused among the group. In addition, the group produces a product which its members can review prior to presenting it to the whole class, thus diminishing the prospects of mistakes occurring at all. When a mistake is made, it becomes a teaching tool instead of a public criticism of an individual student. There are different methods of cooperative learning strategy such as: team teaching, Johnson and Johnson, group investigation, Jigsaw I, II, III, IV and V, and so on. For this study Jigsaw II was adopted.

In Jigsaw II, members of the home group are assigned the same material but focus on separate portions of the material. Each member must become an expert on his assigned portion and teach the other members of the home group. Then, when quiz time comes, students' individual scores are averaged within each group to arrive at a group score, which is then compared with other groups.

Stemming from the national need to increase persistence in Science, Technology, Engineering, and Mathematics (STEM), Ellis et al. (2015) conducted a study focused on students' persistence in calculus and investigated factors which may impact the likelihood of a student switching out of a STEM major. They identified a striking relationship

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between gender, switching, and mathematical confidence. Specifically, females were significantly more likely to decrease their intentions to take Calculus II after taking Calculus I. When given a list of potential reasons for not continuing, female students cited that they, "do not believe [they] understand the ideas of Calculus I well enough to take Calculus II," with significantly greater frequency than their male counterparts. These results highlight the role that calculus is playing in students' decisions to leave STEM pursuits, and may help to explain the larger issue of the STEM Gender Gap (Eagan et al., 2013). Educators have long been interested in identifying factors that may contribute to the disparity in gender representation in STEM (Ellis et al., 2015). They claim that "women discontinue pursuing mathematics at a higher rate than men".

Research questions

The following research questions were answered in the study:

1) What is the achievement of male and female students taught Differential Calculus using jigsaw II cooperative learning strategy?
2) What is the achievement of male and female students taught Differential Calculus using lecture method?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance:

Ho1: There is no significant difference in achievement between male and female students taught differential calculus using jigsaw II cooperative learning strategy.

Ho2: There is no significant difference in achievement between male and female students taught differential calculus using traditional lecture method.

Methodology

In this study, the quasi-experimental, non-equivalent control group design was adopted to determine the effects of jigsaw II cooperative learning strategy on achievement of students in differential calculus at Federal College of Education (Technical) Gombe, Gombe state, Nigeria. The quasi-experimental design was adopted because it is difficult to ensure equivalence of experimental and control groups in a school by random assignment of students. Hence, students with their subject combinations are formed as intact groups that may not be dismantled for the purpose of a study, given the length of a treatment, which is capable of altering the regular school programmes. Therefore, in this study, intact classes were used in all the groups without randomization. The design requires two groups, that is, experimental (E) and control (C). This study fitted this description of an experimental design in that, the effects of jigsaw II cooperative learning strategy was

compared with the traditional teaching method at the end of three weeks' treatment whether they have significant effects on the college students' mean achievement score in NCE 1 differential calculus. Both the pre-test and post-test were Differential Calculus Achievement Test (DCAT) which were constructed by the researchers for the purpose of this study.

The population for this study consisted of all 125 mathematics students at Federal College of Education (Technical) Gombe, in the 2018/2019 academic session. Among the population, 107 were males while 18 were females. This implies that the college is a co-educational college. The sample for the study was all 125 NCE1 mathematics students at Federal College of Education (Technical), Gombe.

The instrument used for data collection was the Differential Calculus Achievement Test (DCAT) designed to measure student's achievement for knowledge, comprehension and application levels of cognitive development of the NCE 1 differential calculus course contents for both experimental and control groups. The instrument consists of three sections, viz: Section A, B and C. Section A of the instrument seeks students' personal data, Section B had 20 multiple choice objective questions, while section C consisted of five essay test items in line with the National Commission for Colleges of Education Minimum Standard for Sciences 2012 edition. The choice for essay test items (not only multiple-choice objective questions) was to avoid students using direct differentiation method in differentiating a given function using the first principle and function of a function (chain rule) method.

To determine the reliability of DCAT, a pilot study was carried out using 20 NCE 1 mathematics students in a coeducational college called College of Education Kangere, Bauchi State, which was not part of the study but had all characteristics as the sample for the study. The reliability coefficient of DCAT used was 0.67, using SPSS to estimate their internal consistency at 0.75 level of significance. Before the commencement of the treatment, the instrument (DCAT) was administered on the participants in both experimental and control groups. Treatment started immediately after the administration of the pretest. Descriptive and inferential statistics were employed; the former was used

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Presentation of results

On the basis of decision making, 0.05 alpha level was used at 5% level of significance in order to find out the significant differences before and after the experiment. The t-test was used to analyze the pretest and posttest mean achievement score for the two groups.

Research question 1: What is the post-test mean achievement scores of male and female students taught differential calculus using jigsaw II cooperative learning strategy?

Table 1: Mean, standard deviation and mean difference of post-test mean achievement scores of male and female students taught differential calculus using jigsaw II cooperative learning strategy

Groups	Gender	N	Mean	SD	Mean Difference
Post-test	Male	52	61.65	10.33	3.16
	Female	11	64.81	11.47	

Descriptive statistics in Table 1 shows the mean, standard deviation and mean difference of post-test mean scores based on gender. The post-test mean difference between male and female students in experimental group is 3.16 in favour of female students.

Ho1: There is no significant difference in post-test mean achievement score between male and female students taught differential calculus using jigsaw II cooperative learning strategy

Table 2: t-test analysis of difference in the post-test mean achievement scores between male and female students taught differential calculus using jigsaw II cooperative learning strategy

Groups	Gender	N	Mean	S.D	Df	t-value	p-value	Remarks
Post-test	Male	52	61.65	10.33	61	-0.91	0.37	Not significant
	Female	11	64.82	11.47				

The t- test analysis in Table 2 revealed that there is no significant difference in post-test mean achievement score between male and female students taught differential calculus using jigsaw II cooperative learning strategy [$t_{(61)} = -0.91$, $p>0.05$]. Since the p-value of 0.37 is greater than the chosen significant level of $\alpha=0.05$, the null hypothesis is accepted. Therefore, there is no significant difference in post-test mean achievement score between male and female students taught differential calculus using jigsaw II cooperative learning strategy**.**

Research question 2: What is the post-test mean achievement of male and female students taught differential calculus using lecture method?

Table 3: Mean, standard deviation and mean difference of post-test mean achievement of male and female students taught differential calculus using lecture method

Groups	Gender	N	Mean	Std. Deviation	Mean Difference
Posttest	Male	55	44.49	5.21	2.21
	Female	7	42.29	3.77	

Descriptive statistics in Table 3 shows the mean, standard deviation and mean difference of post-test mean scores based on gender in the control group. The post-test mean difference between male and female students in control is 2.21 in favour of male students.

Ho2: There is no significant difference in post-test mean achievement score between male and female students taught differential calculus using lecture method.

Table 4: t-test analysis of difference in the post-test mean achievement score between male and female students taught differential calculus using lecture method

Groups	Gender	N	mean	S.D	DF	T-value	P.value	Remark
Posttest	Male	55	44.49	5.21	60	1.08	0.28	Not significant
	Female	7	42.29	3.77				

The t-test analysis in Table 4 revealed that there is no significant difference in post-test mean achievement score between male and female students taught differential calculus using lecture method [$t_{(60)} = 1.08$, $p > 0.05$]. Since the p-value of 0.28 is greater than the chosen significant level of $\alpha=0.05$, the null hypothesis is accepted. Therefore, there is no significant difference in post-test mean achievement score between male and female students taught differential calculus using lecture method.

Discussion of the findings

The findings from research question 1 revealed that the post-test mean difference between male and female students in experimental group is 3.16 in favour of female students. This shows that male students exposed to Cooperative Learning Strategy (CLS) performed not better than the female students taught with CLS. The result of Ho1 ($t_{(61)} = -0.91$, $p>0.05$) shows that there was no significant difference in the post-test mean achievement score between male and female students.

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The findings from research question 2 revealed that male students exposed to the traditional lecture method performed better than the female students taught with the same conventional lecture method. The result of Ho2 ($t_{(60)} = 1.08$, $p>0.05$) shows that there was no significant difference in the post-test mean achievement score between male and female students.

Conclusion

The findings of this study support much of the existing knowledge on jigsaw II cooperative learning strategy. Through the study, the researchers were able to find out that girls taught differential calculus with Jigsaw II Cooperative Learning Strategy performed better than boys, though, the mean score was not found to be significant. This simply means that the effectiveness of cooperative learning strategy on students' achievement in differential calculus does not depend on gender. Hence, irrespective of gender, students studying differential calculus will record improved performance in their achievement in differential calculus when jigsaw II cooperative learning strategy is used for teaching.

Recommendations

The following points are recommended:

i) Colleges of education authorities should encourage their lecturers to use jigsaw II cooperative learning strategy in their colleges most especially in calculus courses that most students lacked basic background from secondary schools.

ii) Curriculum planners should incorporate jigsaw II cooperative learning strategy in their curriculum design and implementation to simplify the identified difficulties in teaching and learning of mathematics at all levels.

iii) Mathematical Association of Nigeria (MAN), Science Teachers Association of Nigeria (STAN) and Nigerian Mathematics Society (NMS) should organize workshop on cooperative learning strategy as their members met annually to update their knowledge about the problems in teaching and learning of mathematics.

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