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EFFECT OF PEER DISCOURSE ON SENIOR SCHOOL STUDENTS' PERFORMANCE IN DIFFERENTIAL CALCULUS

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Abstract

Further mathematics is very important to everyday life especially in a society that is technologically increasing. It is being studied by learners who intend to study mathematics related courses at the tertiary level of education. Senior school students' performance in Calculus has not been encouraging and has been concern to researchers. Factors that affect the performance of students include the fact that calculus involves abstract and complex ideas, inadequate understanding, and interest on the part of students and teachers' inability to use innovative and differentiated instructions. Therefore, this study investigated the effects of peer discourse on senior school students' performance in differential calculus based on gender and score levels. This study adopted the pre-test post-test non-randomized non-equivalent control group design of the quasi-experimental research design. The pre-test post-test of 2x2 was used with experimental levels occurring at 2 levels (peer and teacher-presentation discourses), and gender at 2 levels (male and female). 95 students that were selected from two purposively sampled schools participated in the study. The validated research instrument, Further Mathematics Performance Test on Calculus (FMPT-C) was used for the study. The reliability coefficient of the test was 0.87 and it was obtained using Pearson's Product-Moment Correlation. The research hypotheses were tested using the t-test and the Analysis of Co-variance. Findings from the study revealed that there is: (i) a significant difference in the performance of students taught using peer discourse and teacher-presentation discourse, $p< 0.05$; $t=9.86$; (ii) no significant difference in the performance of male and female students when taught calculus using peer discourse, The study concluded that students that were taught calculus using peer discourse performed better than those taught using teacher-presentation discourse. The study then recommended that teachers of further mathematics should adopt the

use of peer discourse in teaching calculus and all other concepts in further mathematics.

Keyword: Discourse, Peer Discourse, teacher-presentation discourse, Calculus

Introduction

The study of mathematics is not limited to the general mathematics, but it also involves the collection of advanced topics which is regarded as Further Mathematics. Further Mathematics is the nomenclature given to a various advanced secondarymathematics concepts. Harris (2015) mentioned that Further Mathematics is designed to develop in students wider and extensive mathematical knowledge and skills acquired when studying general mathematics. In comparism with the general mathematics, it is an advanced mathematics being studied by learners who intends to study mathematics related courses at the tertiary level of education. The aim of introducing Further Mathematics as cited in the National Curriculum of the National Educational Research and Development Council (NERDC) for Senior Secondary schools of the Federal Ministry of Education (2007, p. iv) are to

- help students to develop conceptual and manipulative skills in mathematics so as to prepare them for further studies in mathematics and its application;
- provide an additional intermediate course of study which transmits students from elementary mathematics to higher level mathematics; and
- meet the need of potential engineers, scientists, mathematicians, and other professionals, such as business administrators and architects.

Concepts in Further mathematics include Geometry and topology, Calculus and Analysis, Number theory, Trigonometry and Logic. Among all of these topics, Calculus has been recognized by learners as one of the most difficult concepts in Further Mathematics (Domondon et al, 2022; Craig, 2014;). Calculus is the mathematical study of rate of change, while Geometry is the study of shape and Algebra is the study of operations and the application of these operations in solving equations.

Calculus is very useful in all branches of the physical sciences, such as physics and biology. It is also important in computer science, statistics, engineering, economics, business, and medicine and also in modern developments such as

architecture, aviation, and other technologies (Nipissing University, 2016). Calculus is also useful in day-to-day life in predicting the rates of change of various quantities. If you record the rate of change of a particular quantity, you can predict changes that will occur over a long period of time. For example, after studying the rate of change that occurs in stock prices, you can predict the price of a stock over a specific period. Differential calculus and Integral calculus are the main branches of calculus. Differential calculus focuses on the rate of change and slopes of curve while integral calculus deals with the accumulation of quantities and the area under and between curves. Differentiation is applicable to nearly all quantitative disciplines. For example, in Physics, velocity is differentiation of displacement of a moving body with respect to time, and acceleration is the differentiation of velocity with respect to time. Differential calculus involves description in a precise manner the ways in which related quantities change.Despite the importance of calculus, many students still perceive it difficult, and they display phobia for the subject. Teacher and students factors are factors affecting the performance of students in Calculus. Teacher's lack of support for students and motivational skills (Ahmad et al, 2017). Students' behaviour toward learning mathematics is another factor affecting their performance in calculus (farooq et al, 2008; Peker et al, 2008 & Tarim et al, 2008). Teachers need to use appropriate and adequate instructional strategies in teaching in order to help motivate students in learning calculus easily. Some instructional strategies that can be used in teaching calculus are classroom discourse. According to Forsell, (2023) Classroom discourse is traditionally described as the language used by teachers and students in the classroom which could be both oral and written for the purpose of communication. For the value of discourse to be promoted in classrooms, students and teachers must share responsibility for talking in carefully planned discussion-based lessons. Given privileges or opportunities for purposeful talk in the classroom, student practice developing and revising new concepts by explaining, reflecting, questioning, debating and synthesizing (Forsell, 2023).

Peer Discourse

Teacher teaches the topic to the students. After teaching, the teacher gives assignment and divides the students into groups of 4-5 students per group. Each group will be assigned a leader who has been trained by the teacher for the purpose of leading the member in group discussion. Each group will discuss the

topic being taught and do the assignment given to them cooperatively. Tasks cards will be prepared for each item to be discussed. The group leader ensures the active involvement of all the members of the group. Meanwhile, the teacher coordinates the activities of the entire group to ensure the realization of the objectives of the discussion.

METHOD

This study adopted the pre-test post-test control group design of the quasi-experimental research design. The pre-test post-test of 2x2was used with experimental levels, that is discourse pattern, occurring at 2 levels (peer and teacher-presentation discourses), and gender at 2 levels (male and female). The population for the study involved all the senior school II students. The target population for the study comprised all the students in Senior School II offering Further Mathematics as a subject. The sample comprised senior school II students from two (2) schools that were purposively selected. They were purposively selected because only few schools offer further mathematics as a subject due to insufficient supply of further mathematics teacher. The senior school II students were considered appropriate because they have not been taught differential calculus and at the same time were expected to have learnt some aspect of calculus which served as their entry behaviour for the teaching of differential calculus.

Two (2) intact classes were involved in the study. The schools included one (1) experimental group and one (1) control group. Students in group A were exposed to Peer discourse; while students in group B (control group) were exposed to teacher-presentation discourse. In order to ensure that the schools selected are equivalent the researcher selected schools that are co-educational and also the Further-mathematics teachers hold at least B.(Ed.) or B.Sc. with PGDE and have at least five (5) years teaching experience. Forty-eight (48) students in school A participated in the study and their further mathematics teacher holds a B. (Ed). Mathematics and has been teaching for the past 11 years. Forty-seven (47) students in school B (teacher-presentation group) participated in the study and their further mathematics teacher holds B.Sc. (Ed) Mathematics and has been teaching for the past 12 years.

Schools were sampled into group using simple random sampling technique, that is, the researcher asked the teachers to pick ballot. The discourse pattern each of the teachers picked from the ballot is what their students were exposed to.

The Further Mathematics Performance Test on Differential Calculus (FMPT-DC) was used for this study. The test consisted of two (2) sections. Section I provided information (Age, Name of school, Sex) about the respondents while section II consisted four essay item tests which were constructed by the researcher. Each item was awarded five (5) marks making a total of 20 marks. The Table of Specification for the preparation of the test items covering areas of Knowledge, Comprehension and Application was drawn. The scores obtained were analysed according to the research hypotheses stated. The discrimination index and difficulty index of each item test were obtained and the lesson plans for the four instructional discourses were drawn. The researcher personally trained the Further Mathematics teacher from school A on how to carry out the instruction using peer discourse respectively. FMPT-DC which was constructed by the researcher, the researcher submitted the essay item test to be subjected for check and scrutiny to two (2) experts in the field of Mathematics and two (2) experts in the people who are expert in the field of Mathematics education.

For reliability of the test items, the researcher adopted the test-retest reliability method. The test was administered to two (2) co-educational public schools that did not participate in the research. The same test was re-administered to the same group of students after a period of two (2) weeks. The coefficient of the two (2) sets of scores was 0.87 which was obtained using Pearson's Product-Moment Correlation.

All the research questions were answered using mean and standard deviation while the research hypotheses were tested using the t-test. Meanwhile, analyses of all the results were carried out using SPSS version 20.

Research Questions

1. Is there any difference among the performance of students when taught differential calculus using peer discourse and teacher-presentation discourse (conventional method)?
2. What is the difference in the performance of male and female students when taught differential calculus using peer discourse?
3. What is the difference in the performance of male and female students when taught differential calculus using teacher-presentation (conventional method)?
4. Is there any significant interaction effect between peer discourse and gender on the performance of students in differential calculus?

Research hypotheses

The following research hypotheses were tested in this study:

Ho_1: There will be no significant difference in the performance of senior school students when taught differential calculus using peer discourses and teacher-presentation discourse (conventional method).

Ho_2: There will be no significant difference in the performance of male and female students when taught differential calculus using peer discourse.

Ho_3: There will be no significant difference in the performance of male and female students when taught differential calculus using teacher-presentation discourse (conventional method).

Ho_4: There was no significant interaction effect between peer discourse and gender on the performance of students in differential calculus.

Results: The following table are the representation of the participants based on gender.

Table 1: Distribution of Students Sampled Based on Gender

Groups	Gender	Frequency	Sub-total
Experimental Group (Peer discourse)	Male Female	29(30.53%) 19(20%)	48(50.53%)
Control group (teacher-presentation)	Male Female	28(29.47%) 19(20%)	47(49.47%)
Total			95(100)

Hypothesis testing

The hypotheses postulated for this study were tested using *t*-test and Analysis of Covariance (ANCOVA) at 0.05 alpha level.

Research Question 1: Is there any difference among the performance of students when taught differential calculus using peer discourse and teacher-presentation discourse?

Table 2 reveals that 48 respondents were exposed to the peer discourse and 47 respondents were exposed to teacher-presentation discourse (conventional method). It also reveals that each of the 48 respondents exposed to peer discourse had an average mean score of 13.96 while each of the respondent exposed to the teacher-presentation discourse (conventional method) had an

average mean score of 6.04. Also, the group exposed to peer discourse and teacher-presentation had a standard deviation of 3.93 and 4.07 respectively. This shows that the score of each student in the groups is close to the average score since the groups had a low standard deviation. Therefore, comparing the mean score and standard deviation of students in peer discourse group (13.96) and students in teacher-presentation group (6.04), students in the peer group performed better than students in the control group

Ho_1: There is no significant difference in the performance of students when taught differential calculus using peer discourse and teacher presentation discourse (conventional method).

In order to test if there exist significant difference in the performance of students that were exposed to peer discourse and those that were exposed to teacher-presentation discourse (conventional method), their scores were analysed using *t*-test. It shows in the table 3 that the t-value= 9.86 is obtained with a p-value of 0.00 computed at 46 degree of freedom and 0.05 alpha level. Since p-value (0.00) is less than alpha level (0.05), the null hypothesis is rejected. Therefore, there is significant difference in the performance of students taught calculus using peer discourse and teacher-presentation discourse (conventional method). The result favours peer discourse group as reflected in their higher mean score.

Table 2: t-test Showing the Performance of Students in Group A and D.

Group	N	Mean	S.D	*T*	*df*	Sig Level	Remark
A	48	13.96	3.934	9.858	46	0.000	Significant
B	47	6.04	4.070				

Research Question 2: What is the difference in the performance of male and female students when taught differential calculus using peer discourse?

Table 3 reveals the difference in the number and mean gain score of male and female respondents in group A. 29 male respondents and 19 female respondents were exposed to peer discourse. Each male respondent had an average score of 14.55 and each female respondent had an average score of 13.16. Also, the male and female had a standard deviation of 4.24 and 5.25 respectively. This implies each of their score is very close to the mean since they had a low standard

deviation. Therefore, male students performed better than the female students when taught using peer discourse.

Ho_2: There will be no significant difference in the performance of male and female students when taught differential calculus using peer discourse.

The performance scores of male and female students exposed to peer discourse were analyzed using t-test in order to test if there exist a significant difference in the performance of male and female students that were exposed to peer discourse. Table 6 shows that the t-value (1.216) is obtained with a p-value of (0.230) computed at 0.05 alpha level. Since p-value (0.230) is greater than alpha level (0.05), the null hypothesis is not rejected. Therefore, there is no significant difference in the performance of male and female students when taught calculus using peer discourse. Comparing the mean score of male students (14.55) and female students (13.16) in peer discourse group, male students the group performed better than the female students in the group.

Table 3: t-test Showing the Performance of Male and Female Students in Group A.

Gender	N	Mean	S.D	*t*	*df*	Sig. Level	Remarks
Male	29	14.55	4.239	1.216	46	0.230	Not Significant
Female	19	13.16	5.253				

Research Question 3: What is the difference in the performance of male and female students when taught differential calculus using teacher-presentation (conventional method)?

Table 4 reveals that 28 male respondents with a mean gain score of 5.54 and 19 female respondents with a mean gain score of 6.79 were exposed to teacher-presentation discourse (conventional method). The average mean score of each of the male respondent is greater than the average mean gain score of each of the female respondent. Also, the male and female had a standard deviation of 3.92 and 4.28 respectively. This implies each of their score is very close to the mean since they had a low standard deviation. Therefore male respondent performed better than the female respondents.

Ho_3: There will be no significant difference in the performance of male and female students when taught differential calculus using teacher presentation discourse (conventional method).

To determine if there exist significant difference in the performance of male and female students that were exposed to teacher-presentation discourse, their scores were analyzed using the t-test analysis. Table 9 reveals a higher mean gain score (5.54) of 28 male students against the mean gain score (6.79) of 19 female students that were exposed to teacher-presentation discourse (conventional method). The table also shows that the t-value (-1.037) is obtained with a p-value of (0.305) computed at 45 degree of freedom and 0.05 alpha level. Since p-value (0.305) is greater than alpha level (0.05), the null hypothesis is not rejected. Therefore, there is no significant difference in the performance of male and female students when taught calculus using teacher-presentation discourse (conventional method)

Table 4: *t-test Showing the Performance of Male and Female Students in Group B*

Gender	N	Mean	S.D	*t*	*df*	Sig Level	Remark
Male	28	5.54	3.920	-1.037	45	0.305	Not significant
Female	19	6.79	4.276				

Research Question 4: Is there any interaction effect among peer discourse and gender on the performance of students in differential calculus?

Table 16 shows that each of the 29 male respondents with an average mean score of 14.55 and each of the 19 female respondents with an average mean score of 13.16 were exposed to peer discourse. Hence, the mean gain score of male respondents that were exposed to peer discourse is greater than that of the female respondents in the same group. This indicates that the male respondent performed better than the female respondents.

Table 5: *Mean Gain Scores of Male and Female Students in Group A.*

Gender A	N	Mean	Std. Deviation
1	29	14.55	4.239
2	19	13.16	3.253

Total	48	14.00	3.903

H_{O4}: There will be no significant interaction effect between peer discourse and students gender on the performance of students in differential calculus.

To test for significant interaction between male and female students exposed to peer discourse, Analysis of Covariance was used and the result is presented on table 17. As shown on the table, the F-value (1.189) is obtained with a p-value of (0.281) computed at 0.05 alpha level. Since p-value is greater than the alpha level (0.05), the null hypothesis is not rejected. Therefore, there is no significant interaction effect between peer discourse and students' gender on the performance of students in differential calculus.

Table 6: ANCOVA Showing the Interaction Effect between Peer Discourse and Gender.

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	60.912[a]	2	30.456	2.092	0.135
Intercept	2332.668	1	2332.668	160.238	0.000
Pretest	38.611	1	38.611	2.652	0.110
Gender A	17.303	1	17.303	1.189	0.281
Error	655.088	45	14.558		
Total	10124.000	48			
Corrected Total	716.000	47			

1. R squared = 0.085 (Adjusted R Squared = 0.044), P>0.05

Summary of Major Findings

The major findings of this study based on all the hypotheses tested are summarized below:

- Senior secondary school students taught using peer discourse pattern performed significantly better than those taught using teacher-presentation discourse pattern.
- There was no significant difference in the performance of male and female students taught differential calculus using peer discourse.
- There was no significant difference in the performance of male and female students taught differential calculus using teacher-presentation discourse.

- There was no significant interaction effect between peer discourse and gender on the performance of students in differential calculus.

Conclusion

This study was conducted in order to find lasting solutions to the problems faced by students in learning differential calculus. From previous studies, it was reported that students perform poorly when solving problems in differential calculus. Senior secondary school II students participated in the study to find out if using the discourse patterns to teach will encourage and motivate them to learn differential calculus and enhance their learning outcomes.

The results obtained from the study also revealed peer discourse patterns improve the performance of students in solving differential calculus problems than the teacher-presentation discourse used for the control group. It is obvious that the control group recorded the least mean gain score when compared to the treatment groups. Therefore, this implies that for students to learn meaningfully in the classroom, there is need for teachers to use appropriate and adequate instructional strategies that involve discourse patterns for teaching in the classroom.

The outcome of the study also indicated that gender has no influence on the performance of students when taught using the discourse patterns. Although the descriptive statistics showed differences in the performance of male and female students but the differences are not significant. This implies that gender is not a barrier in the performance of students in differential calculus if they are taught using any of this discourse patterns.

Recommendations

The following recommendations were made based on the findings of this study:

- Further mathematics teachers should use peer discourse in teaching differential calculus to students in the classroom.
- Peer discourse may be used to teach students irrespective of their gender.
- Teachers of further mathematics should often encourage classroom discussion among students as this will help in achieving meaningful learning outcome.

Suggestions for Further Studies

Based on the findings from this study, suggestions were made that further research should be carried out in the following areas.

1. Studies to find out the effects of peer discourses on other topics like integral calculus could be conducted.
2. Studies that compare the effects of peer with other like dialogic discourse and teacher-guided discourse could be carried out
3. Future researchers could include question type (numerical and word problems) as another moderating variable in their study.

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