VOL. 05 NO. 8,
AUGUST, 2024
E-ISSN 3026-8893
P-ISSN 3027-1061

African Scholar Publications & Research International
www.africanscholarpub.com

Journal of Education Research and Library Practice (JERLP)

Effects of Dialogic 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 a matter of concern to researchers. Therefore, this study investigated the effects of dialogic discourse on senior school students' performance in differential calculus. Specifically, the study investigated the: (i) effects of the dialogic and teacher-presentation discourses on students' performance in calculus; (ii) influence of gender on the performance of students when taught calculus using dialogic and teacher-presentation discourses; (iii) influence of score levels on the performance of students when taught calculus using dialogic and teacher-presentation discourses. This study adopted the pre-test post-test non-randomized and non-equivalent control group design of the quasi-experimental research design. The pre-test post-test of 2x2x3 was used with experimental levels, that is, discourse patterns, occurring at 2 levels (dialogic and teacher-presentation discourses), gender at 2 levels (male and female) and the students' score levels also at 3 levels (high, medium, and low scoring students). One hundred and six (106) senior secondary school students that were selected from two purposively sampled schools participated in the study. The validated research instrument, Further Mathematics Performance Test on Differential Calculus (FMPT-DC) was used for the study. Findings from the study revealed that there is: (i) a significant difference

in the performance of students taught dialogic discourse and those taught teacher-presentation discourse (ii) no significant difference in the performance of male and female students when taught calculus using dialogic and teacher-presentation discourses, (iii) there is significant difference in the performance of high, medium and low scorers when taught using dialogic discourse. The study concluded that students that were taught calculus using dialogic performed better than those taught using teacher-presentation discourse. The study then recommended that teachers of Further Mathematics should adopt the use of dialogic discourse in teaching calculus and all other concepts in Further Mathematics. Also, teachers should make sure that the medium and low scorers are actively involved by making them group leaders whenever they want to use the dialogic discourse pattern.

Keywords: Discourse, Dialogic Discourse, Teacher-presentation Discourse, Differential Calculus

Introduction

A branch of mathematics known as "further mathematics" covers topics beyond basic algebra, geometry, trigonometry, and arithmetic (Amao, Bakare, & Salman, 2020). Students with the interest or talent for mathematics and related courses, such as engineering, economics, geology, computer technology, chemistry, physics, and so forth, should offer further mathematics (Amao, 2008). According to Harris (2015), the goal of further mathematics is to help students expand on the broad and deep mathematical knowledge and abilities they have already obtained when studying general mathematics. Learners who plan to study mathematics-related courses at the tertiary level of education are studying further mathematics, as opposed to ordinary mathematics. An intermediate course between general mathematics and higher-level mathematics is called further mathematics.

The conceptual and synthetic structures make up the two highly structured com ponents of this subject. Postulates, theorems, defined and undefined ideas and other products of further mathematics are all part of the conceptual structure. Additionally, the syntactic framework includes problem-solving techniques like idealization, induction, and deduction. WAEC (2012).

Differential and integral calculus, elementary statistics, probability, mechanics, vector, operation research, geometry and topology, calculus and analysis, number theory, trigonometry, and logic are among the concepts covered

in further mathematics. Calculus has been identified by students as one of the difficult concepts in further Mathematics out of all of these subjects (Eng, Li & Julaihi, 2013; Craig, 2014; Mokhtar, Tarmizi, Tarmizi & Ayub, 2010).

Calculus is a discipline of mathematics that deals with computing instantaneous rates of change (differential calculus) and summing an infinitely number of small elements (integral calculus) (Berggren, 2024).

A basic understanding of calculus is necessary for further study and the development of confidence in solving real-world engineering problems. Calculus is concerned with two fundamental operations, differentiation and integration, and is a tool used by engineers to determine quantities like rates of change and areas. In fact, calculus is the mathematical "backbone" for dealing with problems where variables change with time or some other reference variable (Fox & Bolton, 2002). In many branches of science, engineering, economics, and other subjects, calculus is an essential tool. Its uses are numerous and crucial to our everyday existence; these include architectural design, weather forecasting, and comprehending the transmission of illnesses (Kishore, 2023). Students continued to view calculus as being difficult despite its significance and the efforts of earlier scholars, which had an impact on how well they performed while solving calculus-related issues. Despite numerous studies being conducted in an attempt to identify a long-term solution, the performance of the students has not improved. Because differential calculus is seen as a tedious and uninteresting concept, students don't seem to be as interested in or like learning it. When students don't appreciate what they are studying, they are more likely to seem unmotivated, not strive for success, and ultimately do poorly or quit out of class. Students' low motivation causes them to perform poorly, and if this issue is not appropriately and effectively resolved, it may result in more serious issues down the road (Ryan, 1995). Teaching is an interactive process that incorporates the teacher, the student, and the environment to assist in promoting learning through classroom activities. Teaching is the process of enabling students to acquire knowledge and skills (Aggarwal, 2002). Several instructional strategies used in the classroom include experimentation, inquiry, reinforcement, and responses to the teacher's lessons (Udeani, 1992). The majority of the teacher-student interactions that take place in the classroom involve different discourses. An essential component of the learning process is student discourse, or the act of students conversing and interacting with their teachers and peers. Students can enhance their comprehension of the subject matter and cultivate critical thinking and communication skills by actively engaging in debates and offering their opinions (Rogers, 2022). Dialogic discourse is one of the various forms of discourse that exist. Since students are given the freedom to openly express their views or opinions on a given subject, the Dialogic Discourse Pattern incorporates the interchange of ideas

(Aggrawal, 2002). Given that it encourages open communication, this discourse style is democratic in character. Dialogic discourse is receptive to various viewpoints, enabling the participants to recognize disparities in viewpoints. Dialogic conversation always makes room for acknowledging and comprehending the viewpoints of others. By means of dialogic discourse, the instructor addresses the perspectives of the students in addition to the school's scientific viewpoint (Mortimer, 2005). When using the dialogic discourse, after teaching the material to the class, the teacher divides them into groups of four or five people each to facilitate discussion. Each group will be assigned a leader who will assist in setting up the conversation. By providing feedback to the students, the teacher guides the actions during the discussion. In addition to welcoming questions and comments from the students, the teacher provides feedback and support for the participants' good efforts. Teacher-presentation discourse involves a straightforward instruction, akin to a mini-lecture, with little to no student interaction. Given their shared traits, this discourse pattern and the lecture style of instruction are related. When a pattern is teacher-centered or teacher-dominated, students are verbally presented with information and concepts.This discourse was used for the control group in this study. Hence, the researcher decided to proffer solution to the pending problem. Therefore, the methods and findings from the study are discussed in the following sub-sections.

Methods

The pre-test-post-test control group design of the quasi-experimental research design was used in this study. Two levels of discourse patterns (dialogic and teacher-presentation discourses), two levels of gender (male and female), and three levels of student score (high, medium, and low) were employed with the pre-test and post-test of the 2x2x3. In this study, the two-level teaching strategies serve as the independent variables, and the students' scores (high, medium, and low) and gender (male and female) serve as the moderating variables. Students in senior school II from two (2) schools were included in the sample; they were chosen on purpose.

Because there are not enough teachers to teach further mathematics, only a few number of schools offer the subject. This is why they were purposefully chosen. Since further mathematics is an elective, few secondary school students choose to take it since they find it dull and challenging due to its abstract and complex subject matter. Since they had not been taught differential calculus and were anticipated to have acquired some calculus knowledge as a prerequisite for learning differential calculus, the senior school II students were deemed suitable. In the study, there were two (2) intact classes. There was one (1) control group and one (1) experimental group.

The two groups were labelled group A and B. While students in group B (the control group) were exposed to teacher-presentation discourse, students in group A were

exposed to dialogic discourse. The researcher chose coeducational schools and further mathematics teachers with at least a B. (Ed.) or B.Sc. with PGDE and five (5) years of teaching experience to ensure that the schools chosen are equal. Fifty-nine (59) students from School A (dialogic discourse group) took part in the study, and their further mathematics teacher has eight years of experience teaching and holds a B. (Ed.) and an N.C.E. in mathematics. In the meantime, the study involved forty-seven (47) students from school B (teacher-presentation group). The Further Mathematics teacher had twelve years of teaching experience and a B.Sc. (Ed) in mathematics.

Schools were sampled into groups using simple random sampling technique, that is, the researcher asked the teachers to pick ballot. The discourse pattern teacher picked from the ballot is what their students were exposed to. The students in each group were later categorized on the basis of score levels after been exposed to pre-test. 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 of four essay item tests which were constructed by the researcher. Each item was awarded five (5) marks making a total of 20 marks. The knowledge, comprehension, and application domains were covered by the Table of Specifications that was created for the test item preparation. The specified study hypotheses guided the analysis of the scores that were obtained. Lesson plans for the two instructional discourses were created once the discrimination index and difficulty index of each item test were determined. The Further Mathematics teacher from school A received direct training from the researcher on how to use dialogic discourse in instruction.

The researcher submitted the essay item test to two (2) mathematics lectures and two (2) mathematics education lecturers for checks and scrutiny in order to validate the FMPT-DC, which the researcher had constructed. To ensure the validity of the test items, the researcher used the test-retest reliability approach. Two (2) coeducational public schools that were not involved in the study were given the test. The same test was re-administered to the same set of students after a period of two (2) weeks. Using Pearson's Product-Moment Correlation, the coefficient of the two (2) sets of scores was found to be 0.87.

In order to obtain permission, the researcher gave consent forms to the parents of the study participants, the further mathematics teacher, and the school administration. The respondents were taught at the designated times for further mathematics to prevent interfering with other class periods, and they were permitted to participate willingly in accordance with study ethics. At no time during the study was the identity of the research assistants, respondents, or participating schools revealed. Additionally, all relevant data were treated with the highest confidentially and were only used to further

the research. Throughout and after the study, there was no risk to the respondents, teachers, or sampled schools.

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

Research questions

1. Is there any difference in the performance of students when taught differential calculus using dialogic 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 dialogic discourse?
3. What is the difference in the performance of male and female students when taught differential calculus using teacher-presentation discourse?
4. What is the difference in the performance of high, medium and low scores when taught calculus using peer discourse?
5. Is there any significant interaction effect among dialogic discourse and gender on the performance of students in differential calculus?

Research hypothesis

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 dialogic discourse 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 dialogic 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.

Ho_4: There is no significant difference in the performance of high, medium and low scorers when taught differential calculus using peer discourse.

$Ho_{5:}$ There will be no significant interaction effect between dialogic discourse and students' gender on the performance of students in differential calculus.

Hypothesis Testing

Table 1 displays the demographic data for the intervening variables (gender and score levels) and the independent variable (dialogic and teacher-presentation discourses) that were provided in this chapter. A sample of 106 pupils (100%) was taken for the study; 59 (55.66%) of the respondents comprised the dialogic discourse group

(experimental group A), while the remaining 47 (44.34%) formed the control group (teacher-presentation discourse group). There are 24 (22.64%) females and 35 (33.02%) males in experimental group A. Finally, there were 19(17.92%) girls and 28(26.42%) males in control group B.

Table 1: *Distribution of Students Sampled Based on Gender*

Groups	Gender	Frequency	Sub-total
Experimental Group A (*Dialogic discourse Group*)	Male	35(33.02%)	59(55.66%)
	Female	24(22.64%)	
Control Group B (*teacher-presentation group*)	Male	28 (26.42%)	47(44.34%)
	Female	19 (17.92%)	
Total			106(100%)

As revealed in Table 2, out of the 59 (55.66%) students that formed the experimental group A, 17 (16.04%) were low scorers; 30 (28.30%) of them were medium scorers while 12 (11.32%) were high scorers. Also, out of the 47 (100%) students that formed the control group B, 13 (12.26%) students were low scorers; 24 (22.64%) of them were medium scorers while 10 (9.43%) of them were high scorers.

Table 2: *Distribution of Students Based on Score Levels*

Groups	Score Level	Frequency	Percentage	Sub-total
Experimental Group A (dialogic discourse group)	Low	17	16.04%	
	Medium	30	28.30%	
	High	12	11.32%	59(55.66%)
Control Group B (teacher-presentation group)	Low	13	12.26%	
	Medium	24	22.64%	
	High	10	9.43%	47(44.34%)
Total				106(100%)

Hypothesis testing

Research Question 1: Is there any difference in the performance of students when taught differential calculus using dialogic discourse and teacher-presentation discourse (conventional method)?

The mean gain score for the 47 respondents who were exposed to teacher-presentation discourse (traditional approach) and the 59 respondents who were exposed to dialogic

discourse are shown in Table 3. The respondent in group A had a mean gain score of 11.64, which is higher than the mean gain score of 6.04 in group B, according to the table. Additionally, the standard deviations for the groups exposed to dialogic and teacher-presentation were 3.58 and 4.07, respectively. Given that the groups' standard deviations were small; this indicates that each student's score in the groups was quite near to the average. Thus, it can be seen that students who were exposed to dialogic discourse outperformed those who were exposed to teacher-presentation discourse (the traditional way).

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

In order to investigate this research hypothesis, students' scores were put to a t-test to determine whether there is a statistically significant difference between students who are exposed to teacher-presentation discourse (the conventional technique) and those who are exposed to dialogic discourse. Table 3 presents the results, which show that the t-value = 6.91 is obtained at a 0.05 alpha level and 46 degrees of freedom, with a p-value of 0.00. The null hypothesis is rejected since the p-value (0.00) is smaller than the alpha threshold (0.05). As a result, there is a notable distinction in the performance of calculus students taught by teacher-presentation discourse (the standard technique) versus dialogic discourse. The outcome, indicated by the dialogic discourse group's higher mean score, is in their advantage.

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

Groups	N	Mean	S.D	*t*	*Df*	Sig. Level	Remark
A	59	11.64	3.578	6.911	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 dialogic discourse?

The difference between the number of male and female respondents in group A and their mean gain score is shown in Table 4. Dialogic discourse was presented to 24 female respondents and 35 male respondents. The average score for each male respondent was 12.09, while the average score for each female respondent was 11.17. Additionally, the standard deviations for the male and female were 3.10 and 4.17, respectively. Given their small standard deviation, this suggests that all of their scores

are extremely near to the mean. As a result, when teaching with dialogic speech, male students outperformed female pupils.

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

To ascertain whether there is a statistically significant difference in the performance of male and female students who were exposed to dialogic speech, the student scores were subjected to t-test analysis. Table 4 shows that the t-value (0.919) is calculated at the 0.05 alpha level and yields a p-value of (0.362). The null hypothesis is not rejected since the p-value (0.362) is higher than the alpha threshold (0.05). Thus, when teaching calculus using dialogic speech, there is no discernible difference in the performance of male and female pupils. Male students outperformed female students in the dialogic discourse group, as seen by the mean scores of male students (12.09) and female students (11.17).

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

Gender	N	Mean	S.D	*t*	*df*	Sig. Level	Remark
Male	35	12.09	4.168				Not significant
				0.919	57	0.362	
Female	24	11.17	3.102				

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 5 shows that teacher-presentation discourse (traditional approach) was presented to 28 male respondents with a mean gain score of 5.54 and 19 female respondents with a mean gain score of 6.79. Every female respondent's average mean score is higher than every male respondent's average mean gain score. Additionally, the standard deviations for the male and female were 3.92 and 4.28, respectively. Given their small standard deviation, this suggests that all of their scores are extremely near to the mean. As a result, female respondents outperformed male 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).

The t-test analysis was used to evaluate the performance of male and female students who were exposed to teacher-presentation discourse in order to ascertain whether there were any statistically significant differences in their responses. Table 5 shows that,

when exposed to teacher-presentation discourse (traditional technique), the mean gain score (6.79) of 19 female students was greater than the mean gain score (5.54) of 28 male students. The table also demonstrates that the t-value (-1.037) is calculated at 45 degrees of freedom and 0.05 alpha level, yielding a p-value of 0.305. The null hypothesis is not rejected since the p-value (0.305) is higher than the alpha threshold (0.05). Therefore, when calculus is taught using the teacher-presentation discourse approach (traditional method), there is no discernible difference in the performance of male and female pupils.

Table 5: 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				Not significant
				-1.037	45	0.305	
Female	19	6.79	4.276				

Research Question 4: Is there any difference in the performance of high, medium and low scorers when taught differential calculus using dialogic discourse?

Table 6 demonstrates that dialogic discourse was presented to 12 high scorers, 30 medium scorers, and 17 low scorers. High scorers, with a mean gain score of 16.08, outperformed the other two categories of score levels, while medium scorers, with a mean gain score of 10.77, and low scorers, with a mean gain score of 10.18, performed about evenly. As seen by their greatest mean score, the outcome benefits the high scorers.

Table 6: *Mean Gain Scores of Students in the Different Score Levels in Group A.*

Score Levels	N	Mean	Std. Deviation
1	12	16.08	1.730
2	30	10.77	3.411
3	17	10.18	3.321
Total	59	11.68	3.812

H_{O4}: There will be no significant difference in the performance of high, medium and low scorers when taught differential calculus using dialogic discourse.

Their scores were examined using Analysis of Covariance to see if there was significant differences between the three scoring levels' mean gain scores. Table 7 illustrates how the p-value of 0.001 at the 0.05 alpha level is used to calculate the F-value (7.404). The null hypothesis is rejected since the p-value is smaller than the alpha threshold (0.05). Therefore, while teaching differential calculus through dialogic

discourse, there is a considerable variation in the performance of high, medium, and poor scores.

Table 7: *ANCOVA Showing the Performance of High, Medium and Low Scorers in Group A.*

Source	Type III Sum of Squares	*df*	Mean Squares	*F*	Sig.
Corrected Model	309.284[a]	3	103.095	10.626	0.000
Intercept	366.728	1	366.728	37.800	0.000
Pre-test A	13.157	1	13.157	1.356	0.249
Score Level A	143.661	2	71.831	7.404	0.001
Error	533.597	55	9.702		
Total	8889.000	59			
Corrected Total	842.881	58			

a. R Squared = 0.367 (Adjusted R Squared=0.332), P<0.05

Research Question 5: Is there any interaction effect among dialogic discourse and gender on the performance of students in differential calculus?

Table 8: *Mean Gain Scores of Male and Female Students in Group A.*

Gender	N	Mean	Std. Deviation
1	35	12.09	4.168
2	24	11.08	3.216
Total	59	11.68	3.812

Table 8 demonstrates that dialogic discourse was encountered by all 24 female respondents (average mean score of 11.08) and all 35 male respondents (average mean score of 12.09). The male respondents' mean gain score is higher than the female respondents' mean gain score. This suggests that the responder who was male outperformed the respondent who was female.

Ho_5: There will be no significant interaction effect between dialogic discourse and students' gender on the performance of students in differential calculus.

Table 9 displays the results of the Analysis of Covariance, which was performed to see whether there was any significant interaction between male and female students exposed to dialogic discourse. The table illustrates how the p-value of (0.412), calculated at the 0.05 alpha level, yields the F-value of (0.684). Given that the p-value exceeds the alpha threshold of 0.05, the null hypothesis remains valid. Thus, there is

no discernible interaction impact between students' gender and dialogic discourse on their differential calculus performance.

Table 9: *ANCOVA Showing the Interaction Effect between Dialogic Discourse and Gender*.

Source	Type III Sum of Squares	*df*	Mean Square	*F*	Sig.
Corrected Model	173.793[a]	2	86.897	7.273	0.002
Intercept	1086.088	1	1086.088	90.901	0.000
Pre-testA	159.488	1	159.488	13.349	0.001
GenderA	8.170	1	8.170	0.684	0.412
Error	669.088	56	11.948		
Total	8889.000	59			
Corrected Total	842.881	58			

a. R Squared = 0.206 (Adjusted R Squared = 0.178), P>0.05

Summary of Major Findings

1. Students taught differential calculus using dialogic discourse pattern performed significantly better than those taught using teacher-presentation discourse pattern.
2. There was no significant difference in the performance of male and female students taught differential calculus using dialogic discourse.
3. There was no significant difference in the performance of students when taught teacher-presentation discourse.
4. High scorers taught differential calculus using dialogic discourse performed significantly better than medium and low scorers in the group, but medium and low scorers performed almost equally.
5. There was no significant interaction effect between dialogic discourse and gender on the performance of students in differential calculus

Conclusion

The goal of this study was to identify long-term fixes for the difficulties that students encounter when learning differential calculus. It has been shown from earlier research that pupils struggle to solve differential calculus problems. Students from Senior Secondary School (SSS) II took part in the study to determine whether teaching differential calculus using discourse patterns would improve student learning outcomes and inspire students to learn the subject. The findings showed that student performance was improved more by dialogic discourse than by teacher-presentation discourse. It is clear that, in comparison to the treatment group, the control group's mean gain score was lower.

This suggests that in order for students to learn in the classroom in a meaningful way, teachers must employ acceptable and suitable instructional tactics that incorporate discourse patterns. The fact that the students exposed to the dialogic discourse patterns outperformed the teacher-presentation (control group) suggests that the dialogic discourse patterns are more effective. The study's findings also showed that, when dialogic discourse patterns are used to instruct pupils, gender has no bearing on their performance. Despite the fact that the descriptive statistics revealed variations between male and female students' performance, these disparities are not statistically significant.

This suggests that if students are taught differential calculus using a dialogic discourse pattern, gender will not be a barrier to their success. Additionally, the study's findings demonstrated that students' performance in differential calculus is unaffected by score levels. For the many levels of scorers participating, the conversation pattern is highly beneficial. While everyone in the dialogic group benefited, high scorers outperformed middle and low scorers by a large margin. The study then proposes that:

1. Teachers of mathematics should employ dialogic discourse when instructing students in differential calculus in the classroom.
2. Students of either gender can be taught using dialogic discourse patterns. They are suitable for both genders because of the gender-friendly discourse structure.
3. When employing the dialogic discourse pattern, teachers should ascertain the students' score levels and choose group leaders from the middle and low scorers to ensure sufficient participation.
4. Teachers of further mathematics should frequently promote student discussion in the classroom since it will aid in the achievement of significant learning objectives.
5. The amount of time instructors spend teaching additional mathematics in a week needs to be extended from two periods in order to allow them to fully investigate the application of the discourse pattern in the classroom. It will take more than two class periods each week to cover all of the differential calculus subtopics utilizing the discourse pattern. Consequently, it will take teachers up to three sessions to cover every differential calculus subtopic in an effective manner using discourse patterns.

Suggestions for Further Studies

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

1. Research might be done to determine how dialogic discourse affects other subjects, such as integral calculus.

2. Research comparing dialogic discourses to other discourses, such as teacher-guided and peer-led discourse, could be conducted.
3. Word and numerical questions which are types of questions can be used by future researchers as another moderating variable in their research.
4. Factors such as the attitude and socioeconomic status of teachers or pupils could be included in mixed research.
5. Research in the future may be conducted in different regions of the world.
6. Studies could be done to determine how the discourse style affects tertiary institution students' performance in differential calculus or other challenging ideas.
7. Retention level of students may be added to their performance as another dependent variable to determine the effects of the discourse pattern on the students' retention.

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