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ANALYSING POLYTECHNIC STUDENTS' MOTIVATION TOWARDS THEIR ACADEMIC PERFORMANCE IN DIFFERENTIAL CALCULUS

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Abstract

The concept of differential calculus is used in many areas including applied problems in different disciplines. One of the most important approaches for derivative teaching is to motivate students in solving concepts independently. In the effort to improve students' outcomes in differential calculus, mathematics educators have continued searching for variables that could be manipulated in favour of academic gains. Of all the variables, motivation seems to be leading other variables. It is against this background that this study analyzed polytechnic students' motivation towards their academic performance in differential calculus. A descriptive survey design was used in which all ND2 students offering Calculus for Science (STP 213) constituted this study's population and whereby 200 students were randomly sampled. A self developed close-ended questionnaire was used as the research instrument and was validated by experts. The research instrument was pilot tested and was found to be reliable using Cronbach's alpha ($\alpha = 0.87$). Results were analyzed using descriptive statistics, Pearson's correlation analysis and multiple regressions. The findings revealed that instructional materials and conducive learning environment were found to have influenced students' academic performance in differential calculus. It is recommended among other things that individual differences, background and attitude must be taken into consideration.

Keywords: Motivation, academic performance, differential calculus, polytechnic education.

Introduction

The emergence of polytechnics particularly in Nigeria and across the globe was born out of the need to scale up the production and dissemination of technical education for sustainable economic growth and development (Baba, 2021). It was established to provide quality technical knowledge and skills for the overall development of Nigeria in line with the National Policy on Education (Muhammad, Abdullah & Osman, 2020). Micheal and Iduma (2013) opined that polytechnics are supposed to be the major players in Nigeria's economic diversification and sustainable development. However, its impact had been very insignificant due to inadequate infrastructure, poor funding, negative perception, lack of motivation by organizations on the side of polytechnic graduates through disenchantment and discrimination. Polytechnic education is multifaceted, multi-disciplinary and a pragmatic field, which is aimed at equipping the individuals with requisite vocational and functional technical education that plays a vital and possible role in the development of society (Uwaifo, 2010). No one is in doubt that today's global economy is knowledge driven where by science and technology plays a vital role and to this effect polytechnic occupy the central position in the technological advancement of many modern economies (Baba, 2021).

In making instruction interesting in the learning of differential calculus, there is need to use strategies and materials that will make the learning, active, investigative and adventurous. Such strategies must take into account, learner's differences and attitudes towards topical area (Sani & Mukhtar, 2021). In the effort to improve students' cognition and affective outcomes in differential calculus, researchers have continued to search for variables (personal and environmental) that could be manipulated in favour of academic gains. Of all the variables that have attracted researchers in this area of educational achievement, motivation seems to be gaining more popularity and leading other variables (Awan, Noureen & Naz, 2011; Sani & Garba, 2014). Motivation is considered to be any factor that initiate/direct us to do something or not which can be either *intrinsic* or *extrinsic* in a classroom environment (Bank & Finlapson, 2010; Wormington, Corpus & Anderson, 2011). Sani and Garba (2014) states that students have an intrinsic orientation when learning in the classroom is determined by internal interests such as mastery, curiosity and challenge preference, while students have an extrinsic orientation when learning in the classroom is determined by external interests such as teacher approval and/or grades. Sani and Garba (2014) outlined the following major motivation variables which include self-efficacy, active teaching/learning strategy, active instructional materials, conducive learning environment, behavioural objectives and achievement goal.

The derivative of a function is a fundamental concept for the basis of calculus (Garcia et al., 2011) and is used in many areas including requiring mathematical modelling of several situations in different disciplines such as engineering, physics, economics, etc. This concept was historically constructed as a way to represent rate of change which explains how one quantity changes in relation to another quantity (Weber, Tallman, Byerley, & Thompson, 2012). Differential calculus is a process of finding a derivative $f(x)$ of a variable x (Borji, Alamolhodaei, & Radmehr, 2018; Jones & Watson, 2018). It can be seen as the measure of the rate at which the values of the function f change with respect to the change of variable x (i.e. derivative of f with respect to x). If x&y are real number, and if the graph of f is plot against x, then the derivative is the slope obtained on the graph at each point. The instantaneous rate of change is the result of an approximation producing average rate of change over smaller and smaller intervals. Since this approximation process is related to the concept of limit, quantifying the instantaneous rate of change can be by calculating the limit of average rate of change:

$$\frac{\Delta y}{\Delta x} = \lim_{x \to 0} \frac{f(x_0 + \Delta x) - f(x_0)}{\Delta x}$$

Statement of the Problem

Understanding the derivative requires a wide intuitive base of examples and related perceptions, especially concerning the concept of the rate of change in real-life problems (Weigand, 2014). Researches have shown that most students in Nigerian higher institutions view differential calculus as problematic and abstract; possibly because they have a negative attitude towards it and find it hard to comprehend, assimilate and retain. It is noted that in our tertiary institutions, calculus is one of the most poorly taught and misunderstood subjects that causes students to run away from it, particularly girls. A research undertaken by Ellis (2011) and Firouzian (2013) ascribed the poor performance of students in calculus to the absence of motivation in the classroom, the absence of attractiveness and novelty in the technique of teaching, the bad attitude of learners towards learning and the environmental and gender effects among others. It is against this background that this study tries to analysed polytechnic students' motivation towards their academic performance in differential calculus.

Objectives of the Study

The study intends to achieve the following objectives:

i. To determine the level of students' motivation derived from differential calculus as it regards gender.
ii. To investigate how classroom motivation enhances students' academic performance in differential calculus.

Research Questions

In line with the objectives of the study, the following research questions were raised in this study:

i. What is the level of students' motivation derived from differential calculus as it regards gender?
ii. How does classroom motivation enhance students' academic performance in differential calculus?

Research Hypotheses

In line with the research questions, the following hypotheses were formulated:

$H0_1$: There is no significant difference in the level of students' motivation derived from differential calculus with regards to gender.
$H0_2$: There is no significant difference between polytechnic classroom motivation and students' academic performance in differential calculus.

Methodology

A descriptive survey research design was used for this study. All students of ND 2 offering the course of calculus for science (STP 213) in Waziri Umaru Federal Polytechnic constituted this study's population. In choosing the Department from which the sample size was taken, the researchers embraced a simple random sampling technique. A purposive sampling technique was adopted in selecting the samples of the study. A total of two hundred (200) students (113 ND 2 regular students and 87 ND 2 evening students) filled and returned the questionnaires which were analyzed. The sample comprised of 115 male and 85 female students as shown in Table 1:

Table 1: Samples selected for the study

S/N	Program	Males	Females	Total
1	ND 2 Regular program	64	49	113
2	ND 2 Evening program	51	36	87
	Total	115	85	200

The research instrument used in this research was a self developed close-ended questionnaire named polytechnic students' motivation & academic performance in differential calculus (PSM & APiDC). The PSM & APiDC consist of two sections with 25 items and the research questions served as the controlling variables in preparing the questionnaire. Section A was intended to obtain information on respondents' demographic data while Section B was intended to obtain information on polytechnic students' motivation & academic performance in differential calculus. The instrument was based on four (4) point modified likert scale of strongly agree (SA), agree (A), disagree (D) and strongly disagree (SD). In scoring the items, participants would have a possible 4-1 score that reflects their view on each item. The greater the score, the more the respondent influences the product. The highest score possible is 100, whereas 25 is the lowest score and 75 is the score range. The score in the midpoint is 37.5. The cut-off point is between 62.5 and 100. Thus, participants who obtained scores from 62.5 to 100 were deemed to have positive motivation, while those participants who obtained scores below 62.5 were deemed to have negative motivation towards differential calculus. The instrument was administered by the researchers with the help of two research assistants.

The research instrument was validated by experts and adjustments were made in order to consider it valid. A pilot test was conducted among students who were not part of the study sample but part of the population. The instrument was found to be acceptable and reliable as the reliability coefficient of 0.87 was achieved using internal consistency of Cronbach's alpha reliability value. Thus, any inferences made from the result of this instrument are valid inferences (Chua, 2013; Muhammad et al., 2021; Sani, 2017).

Analysis and Results

The questionnaire was administered to 200 students in which it was filled out and returned by all the participants. Descriptive statistics, Pearson's correlation analysis and multiple regressions were use to analyze polytechnic students' motivation towards their academic performance in differential calculus. Table 2 shows the percentage level of students' motivation.

Table 2: Percentage level of students' motivation derived from differential calculus based on gender

Level of students' motivation	Low		Moderate		High	
	N	%	N	%	N	%
Male	26	22.61	31	26.96	58	50.43
Female	13	15.29	29	34.12	43	50.59
Total	39	37.90	60	61.08	101	101.02
Average %		18.95		30.54		50.51

Table 2 demonstrates that 39 students (18.95%) had a low perception of their level of differential calculus motivation, 60 students (30.54%) had a moderate perception, and 101 students (50.51%) had a high perception. Table 3 shows the mean and SD level of students' motivation.

Table 3: Mean and SD of students' motivation towards their academic performance in differential calculus

Motivation Variables	N	Mean	SD	Remarks
Self-efficacy	200	3.91	0.543	High
Active teaching/learning strategy	200	3.69	0.638	High
Active instructional materials	200	4.43	0.754	High
Conducive learning environment	200	4.87	0.532	High
Behavioural objectives	200	2.99	0.499	Moderate
Achievement goal	200	2.46	0.857	Moderate
Overall	200	3.73	0.637	High

Levels of motivation: Low=1.00-2.33; Moderate=2.34-3.67; High=3.68-5.00 (Sani & Garba, 2014).

Table 3 demonstrates that conducive learning environment $(\text{mean} = 4.87, \text{SD} = 0.532)$ has the highest mean, followed by active instructional materials $(\text{mean} = 4.43, \text{SD} = 0.754)$, self-efficacy $(\text{mean} = 3.91, \text{SD} = 0.543)$, and active teaching/learning strategy $(\text{mean} = 3.69, \text{SD} = 0.638)$. On the other hand, Table 2 revealed both behavioural objectives ($\text{mean} = 2.99$, $\text{SD} = 0.499$) and achievement goal ($\text{mean} = 2.46$, $\text{SD} = 0.857$) to be on moderate mean. Furthermore, the overall mean motivation of students in differential calculus is 3.73 with $\text{SD} = 0.637$, indicating that they were highly driven. In Table 4, Pearson's correlation analysis was utilized to analyze the students' motivation for differential calculus.

Table 4: Students' motivation towards differential calculus and their academic performance

Model	R	Self-efficacy	Active teaching/ learning strategy	Active instructional materials	Conducive learning environment	Behavioural objectives	Achievement goal	Overall
Academic performance	r Sig (2-tailed)	0.249*	0.233*	0.543**	0.471**	0.194	0.157	0.396**

** Significant at 0.01 level (2-tailed)
* Significant at 0.05 level (2-tailed)

Table 4 depicts a Pearson's correlation analysis of the students' academic performance in differential calculus and their overall motivations ($r = 0.396^{**}$, $p = 0.01$), active instructional materials ($r = 0.543^{**}$, $p = 0.01$), conducive learning environment ($r = 0.471^{**}$, $p = 0.01$), self-efficacy ($r = 0.249^{*}$, $p = 0.05$), and active teaching/learning strategy ($r = 0.233^{*}$, $p = 0.05$). However, when it comes to students' academic performance in differential calculus, it demonstrates a relationship with behavioural objectives $(r = 0.194)$ and achievement goals $(r = 0.157)$. Table 5 shows the model summary result for the elements that affect students' academic achievement in learning differential calculus.

Table 5: Model summary result

Model	R	R Square	Adjusted R Square	Std. error of the estimates
Multiple regression	0.689	0.395	0.387	0.3890981

The model summary of the result between the students' performance and motivation is shown in Table 5. It demonstrates a strong relationship between students' differential calculus motivation and their academic achievement (68.9%). It also demonstrates that motivation variables account for only 39.5% of variation in academic performance, whereas 60.5% is accounted for by factors not studied in this research. It also displays an adjusted r^2 of 38.7% with a difference of 0.8%, indicating that this result differs by 0.8% from that obtained using the entire population. Multiple linear regression analysis was conducted in Table 6 to further confirm which of the motivation variables influenced students' academic performance.

Table 6: Multiple linear regression result for academic performance

Model	Unstandardized Co-efficient		Standardized Co-efficient		Sig.
Independent variable	Beta	Std. Error	Beta	T	
Constant	19.537	7.329		3.534	0.023
Self-efficacy	-0.006	3.116	-0.006	-0.083	0.893
Active teaching/learning strategy	-0.153	2.413	-0.019	-0.321	0.679
Active instructional materials	7.396	1.738	0.672	6.327	0.000
Conducive learning environment	3.721	1.827	0.248	2.091	0.030

Table 6 shows the findings of multiple regression, which revealed that active instructional materials $(t = 6.327, p = 0.00)$ and conducive learning environment $(t = 2.091, p = 0.030)$ were the only factors that influenced students' academic performance. Self-efficacy and active teaching/learning strategy, on the other hand, are not academic performance predictors. The model for predicting student motivation in Table 6 is as follows:

$$Y = 19.537 + 0.672\, x_1 + 0.248\, x_2 + \varepsilon$$

Where:

$Y = \text{Students' academic performance}$
$x_1 = \text{Active instructional materials}$
$x_2 = \text{Conducive learning environment}$
$\varepsilon = \text{Error}$

Discussion

Table 3 revealed that respondents enrolled in the STP 213 course valued learning differential calculus as they progressed through the course. Lecturers played a significant role in helping students to be engaged in the teaching and learning of differential calculus through stimulating students' thinking by delivering lectures and tasks. Students also agreed that their enthusiasm to learn was influenced by the differential calculus curriculum, lecturers' instructional methods, and student engagement. This indicates that respondents employed a range of ways to retrieve prior information in order to interpret new experiences and build new understanding. Students with high motivation have advantages, according to Alderman (2004), Sani and Garba (2014), and Sani and Mukhtar (2021), since they have adaptive attitudes and strategies. The result indicates that polytechnic students' academic performance vary significantly in differential calculus as it relates motivation. This is in line with the findings of Awan et al. (2011), Sani and Garba (2014), Wormington et al. (2011). Similarly, Aireand and Tella (2003), Bank and Finlapson (2010) found out that students with high quantity and good quality motivation were equally successful, while Johnson (2006), Skaalvik and Skaalvik (2006) revealed a significant relationship between academic performance and classroom motivation.

Table 4 displays the Pearson's correlation analysis for the six motivation variables, which relates students' academic performance in differential calculus to determine if there was any significant relationship between the variables. The overall motivation had a strong positive relationship with academic performance ($r = 0.396^{**}$, $p = 0.01$) according to the analysis. Furthermore, there were significant positive relationships between active instructional materials ($r = 0.543^{**}$, $p = 0.01$), conducive learning environment ($r = 0.471^{**}$, $p = 0.01$), self-efficacy ($r = 0.249^{*}$, $p = 0.05$), and active teaching/learning strategy ($r = 0.233^{*}$, $p = 0.05$).

In addition, Table 5 shows a multiple regression analysis that was used to predict factors that influence students' academic performance in differential calculus. The four independent variables under research have a strong relationship as seen in Table 5 (active instructional materials, conducive learning environment, self-efficacy and active teaching/learning strategy). Previous research findings by Arbabisarjou et al. (2016), Izuchi and Onyekuru (2017), Korantwi-Barimah, Ofori, Nsiah-Gyabaah and Sekyere (2017), Korantwi-Barimah, Ofori, Nsiah-Gyabaah and Sekyere (2017), and Liu and Hou (2017) is supported by the findings of this study. Table 6 shows that only active instructional materials and conducive learning environment influence students' academic performance in differential calculus, while self-efficacy and an active teaching/learning strategy have no effect. This contradicts the findings of Glynn, Taasoobshirazi, and Brickman (2009), who found that students' self-efficacy had a significant impact on their academic performance.

Conclusion

Two variables, i.e. instructional materials and conducive learning environment, were shown to have influenced students' academic performance in differential calculus among the motivating variables examined in this study, however self-efficacy and active teaching/learning method did not. It was clear that students who were motivated by instructional materials and conducive learning environment were able to perform better in differential calculus and improve their academic performance.

Recommendations

Based on the results of this study, the following recommendations were made:

1. It is necessary to take into account individual differences, background and attitude because the findings revealed that motivation has an important effect with respect to gender.
2. Since highly motivated students perform better than low motivated students, differential calculus teaching should be made interesting by mathematics lecturers.
3. More resourceful methods are needed to ensure that graduates of technical education obtain specific practical knowledge to differentiate them from their peers trained in other similar tertiary institutions.

References

Aire J. E. & Tella, Y. (2003). The impact of motivation on student's school academic performance in Nigeria. *Journal of Personality Study and Group Behaviour;* **23** (1): 107-114.

Alderman, M. K. (2004). *Motivation for Achievement: Possibilities for Teaching and Learning*. London: Lawrence Erlbaum Associates.

Arbabisarjou, A., Zare, S., Shahrakipour, M. & Ghoreishinia, G. (2016). The relationship between academic achievement motivation and academic performance among medical students. *International Journal of Pharmacy and Technology*; **8** (2): 12272-12280.

Baba, T. Y. (2021). Promoting technological and economic innovation in post-COVID 19: The role of the polytechnic education. Keynote speaker at the 8th ASUP annual national conference held at Waziri Umaru Federal Polytechnic Birnin Kebbi, from 16th – 18th November, 2021.

Bank, C. & Finlapson, W. (2010). *Successful motivation of students in academic activities*. McClelland D.C: Appleton century crafts.

Borji, V., Alamolhodaei, H. & Radmehr, F. (2018). Application of the APOS-ACE theory to improve students' graphical understanding of derivative. *EURASIA Journal of Mathematics, Science and Technology Education*, **14** (7): 2947-2967. https://doi.org/10.29333/ejmste/91451

Chua, Y. P. (2013). *Mastering research statistics*. Selangor, Malaysia Sdn. Bhd: McGraw-Hill education.

Ellis, A. B. (2011). Generalizing-promoting actions: How classroom collaborations can support students' mathematical generalizations. *Journal for Research in Mathematics Education*, **42** (4): 308-345. https://doi.org/10.5951/jresematheduc.42.4.0308

Firouzian, S. S. (2013). Students' way of thinking about derivative and its correlation to their ways of solving applied problems. Conference on research in undergraduate Mathematics Education. Denver, Colorado.

Garcia, M., Llinares, S. & Sánchez-Matamoros, G. (2011). Characterizing thematized derivative schema by the underlying emergent structures. *International Journal of Science and Mathematics Education*; **9** (5): 1023-1045. https://doi.org/10.1007/s10763-010-9227-2

Glynn, S. M., Taasoobshirazi, G. & Brickman, P. (2009). Science motivation questionnaire: Construct validation with non-science majors. *Journal of Research in Science Teaching*, **46**: 127-146.

Izuchi, M. R. N., Bruno U. & Onyekuru, B. U. (2017). Relationships among academic selfconcept, academic motivation and academic achievement among college students. *European Journal of Research and Reflection in Educational Sciences*; **5** (2): 93-102.

Johnson, J. O. (2006). *Child psychology*. Calabar, Nigeria: Wusen press limited.

Kamoru, K. (2021). Promoting technological and economic innovation in post-COVID 19: The role of polytechnic education. Lead paper presenter at the 8th ASUP annual national conference held at Waziri Umaru Federal Polytechnic Birnin Kebbi, from 16th – 18th November, 2021.

Korantwi-Barimah, J. S., Ofori, A., Nsiah-Gyabaah, E. & Sekyere, A. M. (2017). Relationship between motivation, academic self-concept and academic achievement amongst students at a Ghanaian Technical University. *International Journal of Human Resource Studies*; **7** (1): 61-73.

Liu, Y. & Hou, S. (2017). Potential reciprocal relationship between motivation and achievement: A longitudinal study. *Social Psychological International*, doi.org/10.1177/0143034317710574.

Micheal, K. O. & Iduma, A. I. (2013). Polytechnic education and human resources development in Nigeria: Challenges and constraints. *Journal of Educational and Social Research*, **5** (1).

Muhammad, S. A., Abdullah, A. H. & Osman, S. (2020). Effect of peer tutoring strategy on students academic performance in a polytechnic linear algebra classroom. *Journal of Advanced Research in Dynamical and Control Systems*; **12** (3): 415-422.

Muhammad, S. A., Abdullah, A. H. & Osman, S. (2021). Improving polytechnic students' high-order-thinking-skills through inquiry-based learning in mathematics classroom. *International Journal of Evaluation and Research in Education*; **10** (3): 976-983. Doi: 10.11591/ijere.v10i3.21771

Sani, M. A. (2017). *Introduction to research methodology and statistics: A guide for students and supervisors*. Ahmadu Bello University press.

Sani, M. A. & Garba, I. M. (2014). The Impact of Motivation on Students' academic Achievement in Kebbi State Junior Secondary School Mathematics. *International Journal of Advance Research*, **2** (12).

Sani, M. A. & Mukhtar, M. S. (2021). Analysing the impact of motivation in enhancing students' mathematics achievement and technical skills among institutions of higher learning. 57th annual national conference of mathematics association of Nigeria (MAN) held at Bayero University Kano, from August 29th – 3rd September, 2021.

Skaalvik, S. & Skaalvik, E. M. (2006). Self-concept and self-efficacy in mathematics: Relation with mathematics motivation and achievement. Proceedings of the international conference on learning sciences, Bloomington, Indiana.

Uwaifo, V. O. (2010). Technical education and its challenges in Nigeria in the 21st century. *International NGO Journal*; **5** (2): 40-44.

Weber, E., Tallman, M., Byerley, C. & Thompson, P. W. (2012). Derivative as a rate of change. *Mathematics Teacher*; **106** (4): 274-278.

Weigand, H. G. (2014). A discrete approach to the concept of derivative. *ZDM*; **46** (4): 603-619. https://doi.org/10.1007/s11858-014-0595-x

Wormington, S. V., Corpus, J. H. & Anderson, K. G. (2011). Running head: Motivation in high school. A person-centred investigation of academic motivation, performance, engagement in a high school setting. Paper presented at the annual meeting of the American educational research association, New Orleans, LA.