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EFFECT OF DIFFERENTIATED INSTRUCTION IN TEACHING ANTI-DERIVATIVE FUNCTIONS CONCEPT ON POLYTECHNIC STUDENTS' ACADEMIC PERFORMANCE

[1]Muhammad Sani Abdurrahman, PhD; [2]Mukhtar Muhammad Sani and [3]Bayaro Aliyu

[1]Department of Mathematics, Waziri Umaru Federal Polytechnic Birnin Kebbi
e-mail: abdurrahman@wufpbk.edu.ng

Abstract

The concept of anti-derivative function is used in many areas including applied problems in different disciplines. One of the most important approaches for anti-derivative teaching is differentiated instruction (DI) because it makes teachers to proactively modify curricula, teaching methods, resources, and learning activities in order to maximize the learning opportunities as well as address student diversity. A quasi-experimental design was used in which all ND II students offering Calculus for Science (STP 213) constituted this study's population with 100 students randomly sampled. A self-developed pre-test and post-test were used as the research instrument which are validated by experts. The instruments were pilot tested and were found reliable using Cronbach's alpha ($\alpha = 0.69$). Mean, SD, and t-test were used to statistically analyze the results. The findings revealed that polytechnic students' understanding of the concepts of anti-derivative functions can be improved through differentiated instruction. Furthermore, gender was discovered to have a significant impact on polytechnic students regarding their post-test scores. It is recommended among other things that teachers should explore the use of differentiated instruction frequently.

Keywords: Anti-derivative functions, differentiated instruction, polytechnic students

Introduction

The polytechnic was designed to institute the promotion of industrial technology, technological development and transformation to serve as a change agent for both technical system and societal changes. Putting the nature of the polytechnic system in mind, it is designed to catalyze economic transformation and can be used to address the challenges of the rising unemployment and societal crises. This can be actualized by expanding the horizon of employment opportunities activities, especially where the potentials remain large and greatly unexploited (Kamoru, 2021; Muhammad, Mukhtar, Abdullahi & Hassan, 2022). It is very obvious that without a proper policy on polytechnic or technical education and training there cannot be sustainable economic development in Nigeria. Government should ensure increased productivity and output, economic diversification, value addition and self-sustenance which are needed by the polytechnics (Baba, 2021). The output of the education acquired in polytechnics is visible to such an extent that uneducated could see if a failure occur. Polytechnic graduates are supposed to solve social and economic problems sustainably. In order to do this, they need to be sufficiently equipped and informed in technical education concepts and the application of its theoretical principles in solving practical problems (Muhammad, Abdullah, Osman, Ali, Abu-Samah, Jumaat, Ashari & Umar, 2020). In order to promote technology in Nigeria, there is the need to upgrade the standard of educational practice in all the polytechnics because the needs of the industrial sector are on the increase (Kamoru,

2021). Manpower supply is one of the greatest assets a country could have in order to develop and reviewing the curriculum to meet this need becomes paramount as the level of technical demand had greatly increased with time.

The derivative of a function is a fundamental concept for the basis of calculus (Garcia, Llinares & Sánchez-Matamoros, 2011; Muhammad et al. 2022) and is used in many areas including mathematical modelling of several situations in different disciplines such as engineering, physics, economics, etc. Anti-derivative functions is a branch of calculus that is referred to as *anti-derivative* (i.e. a function whose derivative is the given function) which serves as fundamental, essential operation of calculus, and also as a tool to solve problems in mathematics and physics involving the area of an arbitrary shape, the length of a curve, and the volume of a solid, among others (Borji, Alamolhodaei & Radmehr, 2018; Jones & Watson, 2018; Muhammad et al., 2022). Integrals are the values of the function found by the process of integration. The process of getting $f(x)$ from $f'(x)$ is called integration. Integrals assign numbers to functions in a way that describe displacement and motion problems, area and volume problems, and so on that arise by combining all the small data (Weber, Tallman, Byerley & Thompson, 2012). According to Stroud (2007), $\int f(x)\,dx$ denoted the integral of $f(x)$ with respect to the variable x; the symbol $\int$ is the integral sign, $f(x)$ is the expression to be integrated, and dx is the differential that assist in evaluating of certain integrals.

Understanding how things relate to and work in relation to other things is aided by conceptual definitions. To express abstract concepts with descriptive terms such as differentiated instruction (DI), definitions must be carefully constructed and understood rather than relying on common sense, which results in imprecise representations (Prast, Van de Weijer-Bergsma, Kroesbergen & Van Luit, 2018). Because DI is not a single arena, but a combination of both conceptual orientation and practical application, it is important for teachers to have a thorough understanding of the concept with its specific strategies in order to apply differentiation into professional practice (Prast et al., 2018). Many experts recommend DI to instructors as it is a successful method. It is known as student-aware teaching because it recognizes and teaches learners differently (Garba & Muhammad, 2015). DI is described in this study as a method of teaching that allows students to learn while taking into account their individual differences and needs. Despite its usefulness, DI implementation is sometimes found to be difficult and impractical in most circumstances (Tomlinson, 2014). This is because DI methods appear promising due to its indistinctness of the concept and in what form differentiation is successful for all ability levels (Garba & Muhammad, 2015). As a result, many educational settings have infrequent and inconsistent approaches (Alice, 2011).

The model of DI, as described by Tomlinson (2014) and Tomlinson and Imbeau (2010), provides a synthesised framework to promote the standards of inclusion and customized learning. Differentiation of instructional strategies can be grouped into four components: content, process, product, and learning environments. The content refers to what the instructor wants his/her students to learn as well as the materials or procedures through which they will learn it. Products are the means by which students demonstrate what they have learned in the lesson. Process describes learning activities designed to ensure that students use key skills required to make sense of essential ideas and information. Finally, the environment is one in which the instructor and students continue to grow in mutual respect and care while establishing a true conducive learning atmosphere (Tomlinson, 2014; Tomlinson & Imbeau, 2010). Teachers' knowledge of students' levels of readiness,

interests, and learning profiles is essential to support successful and appropriate differentiation of the above factors (Garba & Muhammad, 2015). It necessitates teachers getting to know each of their students on a personal basis and must understand how each child receives classroom activities and tailor the experiences to his or her specific needs so that understanding takes place. In other words, teachers must be well aware of who and what they are teaching (Garba & Muhammad, 2015). As a result, teachers must engage students in education by using a diversity of modalities and different forms of instruction with varying degrees of complexity.

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 Anti-derivative functions 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 (Muhammad et al., 2022). The differential scholastic achievements of students in Nigeria have been and are still a source of concern and research interest to educators, government and parents. This is so because of the great importance that education has on the national development of the country. All over the country, there is a consensus of opinion about the fallen standard of education in Nigeria (Muhammad & Madugu, 2014). Parents and government are in total agreement that their huge investment on education is not yielding the desired dividend. It is against this background that this study tries to see the effect of differentiated instruction in understanding the concepts of anti-derivative functions among polytechnic students.

Objectives of the Study

The study intends to achieve the following objectives:

i. Determine the effect of differentiated instruction (DI) in understanding the concepts of anti-derivative functions among polytechnic students.
ii. Investigate the effect of DI on gender in understanding the concepts of anti-derivative functions among polytechnic students.

Research Questions

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

i. Does DI affect polytechnic students' academic performance in understanding the concepts of anti-derivative functions?
ii. How does DI affect both male and female students in understanding the concepts of anti-derivative functions?

Research Hypotheses

From the research questions, the following null hypotheses were formulated and tested at 0.05 level of significance.

Ho_1: There is no significant difference between the academic performance of students taught anti-derivative functions using DI and those taught using conventional approach.

Ho_2: There is no significant difference between the mean scores of male and female students in anti-derivative functions using DI.

Methodology

A quasi-experimental design was used to test the effectiveness of the differentiated instruction (DI) using two groups (experimental and control) as the research samples were randomly distributed (Muhammad et al., 2021; White & McBurney, 2010). In this type of design, the groups were observed and analysed before and after being exposed to a treatment (Sani, 2017). This study took place in a polytechnic, targeting all National Diploma II (ND II) students offering the course of calculus for science (STP 213). Using simple balloting methods, two ND II classes were randomly selected as the study samples from the three collages of the institution. In addition, a hat-draw sampling technique was used to assign experimental and control groups to the selected classes. The total number of students involved in this study was 100 (56 and 44 for both experimental and control groups respectively). This number of students is adequate for the collection and analysis of quantitative and qualitative data (Nieuwenhuis, 2013; Seabi, 2012). Table 1 shows the samples that are selected for the study.

Table 1: Samples selected for the study

S/N	Group	Program	Males	Females	Total
1	Experimental	ND 2 Regular program	31	25	56
2	Control	ND 2 Evening program	24	20	44
		Total	55	45	100

The research instrument used in this research was a self-developed test (pretest & posttest). This is to determine the level of homogeneity and understanding in the subject area. The two groups were given a pre-test before administering the treatment. The groups were separately instructed, meeting once a week for a minimum of two hours over a period of seven weeks and were given the same post-test. The research instruments were validated by experts and adjustments were made in order to consider the instruments valid. Pilot tests of the instruments were 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 0.69 was achieved using internal consistency of Cronbach's alpha reliability value. Thus, any inferences made from the result of this instrument are valid inferences (Muhammad *et al*., 2021; Sani, 2017).

Results and Analysis

Data in this study were collected through pre-test and post-test and also analysis of the students' scores were measured by comparing the results of the pre-test and post-test. The result of the tests were analyzed statistically using mean, SD and independent t-test in order to determine the effectiveness of differentiated instruction among polytechnic students in anti-derivative functions.

Pre-Test

Both groups were given the same pre-test prior to the intervention process in order to determine their level of homogeneity. Independent sampled t-test statistic was used to confirm whether or not the mean pre-test scores were statistically significant as shown in Table 2.

Table 2: T-test comparison for both experimental and control groups on pre-test

Group	N	$\bar{X}$	SD	SE_M	df	t-val.	p-value	Remark
Experimental	56	33.21	3.26	0.69	98	0.196	0.641	Not Sig.
Control	44	32.75	3.09	0.51				

Table 2 shows the independent sample t-test statistic of both experimental and control groups on their pre-test, a significance level of alpha=0.05 was used in comparing the pre-test scores of both experimental (M=33.21, SD=3.26) and control (M=32.75, SD=3.09) groups with a difference in mean of 0.46. This difference was found to be statistically non-significant at t(98)=0.196 and p>0.001. For this test, Cohen's d was 0.039, which can be described as a very small effect size in the mean difference (Cohen, Manion & Morrison, 2017).

Post-Test

After the intervention process, the groups were given the same post-test to see the effect of the intervention. Independent sampled t-test statistic is used to confirm whether or not the mean post-test scores are statistically significant as shown in Table 3.

Table 3: T-test comparison for both experimental and control groups on post-test

Group	N	$\bar{X}$	SD	SE_M	df	t-val.	p-value	Remark
Experimental	56	50.89	4.51	0.85	98	13.546	0.000	Sig.
Control	44	37.62	4.93	0.91				

Table 3 shows the independent sample t-test statistic of both experimental and control groups on their post-test, a significance level of alpha=0.05 was used in comparing the post-test scores of both experimental (M=50.89, SD=4.51) and control (M=37.62, SD=4.93) groups with a difference in mean of 13.27. This difference was found to be statistically significant at t(98)=13.546 and p<0.001. For this test, Cohen's d was 3.74, which can be described as a large effect size in the mean difference (Cohen et al., 2017).

Table 4: T-test comparison for gender in anti-derivative functions scores on post-test

Gender	N	$\bar{X}$	SD	SE_M	df	t-val.	p-value	Remark
Male	55	52.16	3.99	0.95	98	12.874	0.000	Sig.
Female	45	43.72	3.67	0.89				

Table 4 shows the independent sample t-test statistic of both gender on their post-test, a significance level of alpha=0.05 was used in comparing the post-test scores of both male (M=52.16, SD=3.99) and female (M=43.72, SD=3.67) gender with a difference in mean of 8.44. This difference was found to be statistically significant at t(98)=12.874 and

$p<0.001$. For this test, Cohen's d was 2.31, which can be described as a large effect size in the mean difference (Cohen et al., 2017).

Discussion

The differentiated instruction (DI) was found to have a significant effect on students' understanding of the concepts of anti-derivative functions among polytechnic students based on the findings of the independent sampled t-test in Table 3. The result indicates that the performance of the experimental group whom are taught with DI method is greater than the control group who were taught with conventional method. The result showed that learning via DI significantly improves students' performance because teachers proactively modify curricula, teaching methods, resources, learning activities and it also address the diverse needs of students either in small groups or individually within the classroom. Though in the use of the DI, it was discovered that polytechnic students have been able to demonstrate differential effects on productive disposition, conceptual understanding, strategic competence and adaptive reasoning. Students' cognitive skills can as well be motivated in DI since they are encouraged to develop their knowledge and explore beyond what the teacher provided. This finding is in agreement with the findings of Abdurrahman and Garba (2014), Beecher and Sweeny (2008), Castle, Deniz and Tortora (2005), Garba and Muhammad (2015), who asserted that new approach to mathematics teaching will provide opportunity for better achievement.

Based on the findings of independent sampled t-test statistic from Table 4, gender was discovered to have a significant impact on polytechnic students regarding their post-test scores. The result indicates that male students performed better than their female counterparts in anti-derivative functions with a mean difference of 8.44 in their post-test scores. This is because, after learning through DI, students can grasp and apply basic anti-derivative functions principles in a variety of situations. According to Castle, Deniz and Tortora (2005), Garba and Muhammad (2015), DI allows students to actively participate in observations, identifying trends and drawing conclusions based on the collected information. On one hand, the study's finding agreed to the findings of Abdurrahman and Garba (2014), Beecher and Sweeny (2008), Castle et al. (2005), Garba and Muhammad (2015), whereas on the other hand it contradicts that of Preckel and Brull (2008) who found no difference among gender using DI.

Conclusion

Polytechnic students' understanding in the concepts of anti-derivative functions can be improved through differentiated instruction (DI) according to the findings of this study. The results show that through DI, the performance of the experimental group is greater than that of the control group (i.e. learning via DI significantly improves students' performance). Nevertheless, previous studies have shown that it is difficult for students to understand certain anti-derivative functions units because the concept appeared a bit abstract. This can be tackled by applying DI as it proves to be effective in understanding the concepts of anti-derivative functions. Furthermore, gender was discovered to have a significant impact on polytechnic students regarding their post-test scores. This is to say that male students performed better than their female counterparts in anti-derivative functions.

Recommendations

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

i. Teachers should explore the use of differentiated instruction (DI) frequently as the findings revealed that the concepts of anti-derivative functions can be improved when differentiated instruction is adequately utilized.
ii. Polytechnic students should be given proper orientation about the course of anti-derivative functions as the findings reveal that gender has significant impact on the performance of male students.

Suggestions for Further Studies

The following suggestions were made for further studies:

i. The findings of this research show the need for more research on the use of DI in teaching anti-derivative functions concept on polytechnic students' academic performance. This study was conducted with 100 ND II students (56 and 44 for both experimental and control groups respectively) for a period of 7 weeks in only one polytechnic. It would be of great interest and provide deeper insight if several polytechnics and a wider range of participants from the same program level is used over a longer period of time. This may lead to the achievement of a more robust result with regards to teaching anti-derivative functions concept.
ii. The main purpose of polytechnic education is to train students in technical and vocational fields to provide middle-level workers with the required manpower in a country's industrial and technological growth. It would be of great opportunity to achieve this if a closer alliance is made with regards to the application of anti-derivative functions concept to real life situation (like traffic flow, electrical network, and stress analysis of a truss). This indicates that more research needs to be done to help bridge this gap between the anti-derivative functions taught in our polytechnic classrooms and the real-life scenario.
iii. Results from the research have shown that DI has the potential to develop students' thinking skills in anti-derivative functions concept. Therefore, more research should be conducted on the use of other students' centred leaning approach in order to respond to the learning environment of the 21st century.

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