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Constructivist-Based Instructional Approach and Senior Secondary School Students' Determination and Understanding of Pi (π) Concept in Imo State Nigeria

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Abstract
This investigation was embarked upon to find out the effect of constructivist-based instructional approach on students' determination and understanding of pi (π) concept. A sample of 100 senior secondary school three students were selected from the population using the random sampling technique. The area of study was Owerri West Local Government Area of Imo State Nigeria. Three objectives guided the investigation. Quasi-experimental research design was employed was employed. The experimental groups were taught the history of pi and how to determine the constant value of pi using three different techniques under the constructivist instructional approach while the control group was taught using the traditional approach without history of pi. The achievement test was the instrument used for data collection. The instrument was validated and has a reliability index of 0.74.The mean, standard deviation and ANCOVA were the statistical tool used for analysis at an alpha level of .05. The result revealed that the students taught using constructivist approach had a higher understanding of pi concept than those taught using traditional approach with a difference that was significant. The second finding revealed that there was no significant difference (F2, 116 = 1.156, p > 0.05) in the relative effectiveness of the three constructivist instructional techniques. The study concluded that the constructivist-based approach was relatively more effective than the traditional approach. It was recommended that teachers should incorporate constructivist teaching using hands-on activities for classroom instruction.

Keywords: ***Constructivist instruction, Pi constant, understanding, determination.***

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I. Introduction

Mathematics as a subject is surrounded by numerous concepts which students utilize during problem solving. This therefore makes it imperative that students should be taught these concepts to demystify the abstractions which are entangled with the concepts. Most of these concepts were discovered long ago and this also demands that students should from time to time be taught the historical positions of some mathematical concepts. Presenting students with the classroom instructional strategies that engage students in hands-on activities make students to understand the nitty gritty or historical background of mathematical concepts. When Mathematics concepts are not well assimilated and accommodated by students, they develop the notion that Mathematics is difficult and abstract. There is need to bridge the gap between mathematical abstraction and concepts. Ertmer and Newby (2013) opined that innovative and activity-based instructional methods should be employed to ensure connection between Mathematics abstraction and the mathematics concepts which they are taught. Braun (2015) posited that active learning is any teaching method which a teacher employs to engage students during classroom instruction. Students can be engaged actively during classroom instruction with discussion or hands-on activities. This might suggest why Frazer (2011) stressed that there is a challenge among scholars when it comes to defining active learning. Succinctly put, active learning is a student-centered instructional method which places less emphasis in the transmission of knowledge from the teacher to the students. Active learning is a teaching method which supports a paradigm shift model of students learning from knowledge acquisition to knowledge.

The constructivist instructional approach comes to mind when the term active learning is mentioned. The constructivist-based instruction is an instructional approach which is anchored on the constructivist learning theory. This theory views learning as a process in which the students actively construct new ideas or concepts by building on their previous knowledge. The constructivist-based instructional approach actively engages students in the learning process rather than receiving knowledge passively. This engagement factor which the constructivist-based approach upholds dissociates students from memorization of mathematical concepts and

associates them with hands-on guided discovery, discussion of thoughts as well as activities which help students demystify Mathematics concepts which they come in contact with. The constructivist classroom guarantees teaching students in relation to the environment. This makes it crucial to employ this approach which engages student in the act of learning while doing and thinking about what they are doing in order to deduce mathematical facts thereby demystifying the abstractions that surrounds the learnt concepts. When students are engaged in hands-on activities that help them to construct new knowledge it makes them to possess autonomy of that which is learnt. This autonomy and application of mathematical knowledge is the ultimate goal of Mathematics education (Corren, Slaughter & Hugo, 2014).

When solving problems in Mathematics, students come in contact with variables (dependent and independent) and constants terms. Outside the variables and constant terms, students also come in contact with mathematical constants which are designated with symbols and numbers with fixed irrational values, for example Pi designated π = 3.141592…; The Golden ratio designated Φ = 1.618 033…; Euler's constant, designated **e** = 2.718 281….; Pythagoras' constant designated $\sqrt{2}$ = 1.414…).Most times these standard mathematical constants, are grantly taken and applied without recourse to how they were originally derived. The mathematical constant Pi otherwise known as Archimedes constant is the most common and widely used in secondary schools. It is used to solve problems that relate to circular measures. Math Open Reference (2011) defined pi as the ratio of the circumference of any circle to its diameter. There are other historical features of pi which the students are expected to know. The knowledge of the historical perspectives of mathematical discoveries increase students zeal and achievement in Mathematics. This may suggest why Kulbir (2006) stated that one of the importance of teaching history of Mathematics in schools is to present the teaching of Mathematics to students in a dynamic and interesting way which is full of human interest and effort. Pi is characterized with features such as: The 16th lower case Greek alphabet, the value gotten when the circumference of a circle is divided by its diameter no matter the size of the circle- it gives the constant value approximately, nobody knows the exact value of pi because its value keeps going unending without repetition, the first calculation of pi was done by one of the greatest mathematicians called Archimedes, the celebration of pi day on MARCH 14 of every year.

The research finding of Sharma and Sharma (2012) showed that the students that learnt mathematics using the constructivist approach had a out performed those that learnt using the traditional approach. It further revealed that the groups were significant. In like manner, the findings of Oludipe and Oludipe (2010), Onwuka (2014) and Chowdhury (2016) revealed that the constructivist learning approach significantly improved the performance, understanding and application abilities of students in Mathematics when compared to the traditional approach. The result of Grady, Watkin and Montaivo (2012) showed that the use of constructive curriculum to teach everyday Mathematics to rural students proved more effective than the traditional curriculum. Xie, Wang and Hu (2018) investigated the effects of constructivists and transmission instructional models on students Mathematics achievement and found out a contrary result which revealed that there was no significant difference in using the two models to teach students Mathematics and that all models had the significant effect of improving students performance. Nwamadi (2017) presented a research finding which showed that all the five strategies under the constructivist approach used to teach students Mathematics improved students achievement and they were not significantly different.

Non of the afore mentioned investigations delved into the area of students' determination and understanding of mathematical constant pi. The most common and widely used mathematical constant in all of Mathematics by secondary school students and yet they lack knowledge of what it actually is. The question that arises is, how do teachers introduce the concept of pi to students? Do they engage students in historical and hands-on activities that can unravel why and how the constant value of pi is 3.142? Do teachers teach students other features of pi or they just tell students that the constant pi value is 3.142 without any form of deduction? Do students know who originated pi constant and who popularized it? Do students know the exact value and the number of digits in pi? This calls for investigation. This study was therefore set to investigate the effect of constructivist-based instructional approach on senior secondary school students' determination and understanding of the constant pi (π) concept in Imo state Nigeria.

Problem Specification

The researchers observed with dismay that there are many concepts which students utilize instrumentally during Mathematics problem solving without having knowledge of such concepts. One of such concept is the widely used constant pi value of 3.142 or $\frac{22}{7}$ when solving circular related problems. The researchers once asked a group of one hundred SS3 students to write what they know concerning the constant pi –value. When the scripts were collated and marked, the answer students wrote was that pi is equal to 3.142 or $\frac{22}{7}$ and that it was used to find the area a circle. The researchers raised eyebrows when one of the student's wrote on his script that it was a mystery to them on how and why the value of constant pi is 3.142 or $\frac{22}{7}$ because no

Mathematics teacher has ever explained this to them. Rather they were just told what the value is and they simply utilize it to solve problems connected to it. When students are taught instrumentally, the result is surface and shallow understanding which cannot be applied but when students are made to construct their own knowledge based on prior experiences and hands-on activities, the knowledge gained becomes self sufficient and applicable. The problem of this study is that Mathematics teachers employ the traditional teaching method to teach almost every topic in Mathematics even when there are innovative teaching methods which could be employed. It is against this backdrop that the researchers sought to investigate the possible effect which the use of constructivist teaching method could have on senior secondary school students' performance and retention in the determination and understanding of the constant value of pi.

Objective 1: Determine the relative effectiveness of the constructivist-based instructional approach over the traditional instructional approach in the understanding gain scores of students in the practical determination of pi.
Objective 2: Ascertain the constructivist instructional technique which is most relatively effective with respect to students' understanding gain scores of students in the practical determination of pi.

Research Question 1: What is the relative effectiveness of the experimental groups taught with constructivist-based instruction over the control group taught with the traditional approach in the understanding gain scores of students in the practical determination of pi?
Research Question 2: Which of the experimental groups taught with constructivist instructional approach is most relatively effective with respect to students' understanding gain scores in the practical determination of pi?

Ho_1: There is no significant difference in the relative effectiveness of the experimental groups taught with constructivist-based instruction over the control group taught with the traditional approach in the understanding gain scores of students in the practical determination of pi.
Ho_2: There is no significant difference in the relative effectiveness of the experimental groups taught constructivist approach with respect to students' understanding gain scores in the practical determination of pi.

II. Materials And Method

Research Design
The intact class quasi experimental design presented three experimental groups and one control group. The first experimental group was tagged GROUP 1, second experimental group was tagged GROUP 2, third experimental group was tagged GROUP 3 while the control group was tagged GROUP 4.
Population of the Study
The population for the study comprised of all thirteen thousand three hundred and twenty one (13,321) senior secondary three (SS3) students in all the public senior secondary schools in Owerri West Local Government Area of Imo State Nigeria.

Sample and Sampling Technique
A sample of one hundred and sixty (160) students of both male and female.were randomly selected from four (4) schools.

Instrument for Data Collection
A researcher developed instrument titled Pi Activity Achievement Test (PAAT) was used to collect data... The test items were derived from the content that was taught on the determination and history of pi. PAAT was made up of twenty (20) multiple choice questions with four options. PAAT was graded in percent. Four different lesson plans for teaching the three (3) experimental groups and one control group were prepared by the researchers.

Instrument Validation
Validation of PAAT was done by two experts in Mathematics education and one expert in test measurement and evaluation before administering to the sample.

Reliability of the Instrument
The reliability of (PAAT) was determined using a test- retest method with a group of thirty (30) SS3 students was not taught the topic before the administration of the instrument. Also, this set of students did not participate in the main study. A pre-achievement test developed from the specific topics was administered to the sample. The students were requested to attempt all the twenty (20) items of the PAAT. The same instrument was

re-administered to the same sample after two (2) weeks. The initial and re-test scores of the sample were correlated using the Pearson Product Moment Correlation. The reliability coefficient yielded 0.74.

Procedure for Data Collection

The regular Mathematics teachers who were trained by the researchers carried out the teaching. The researchers' prepared lesson plans guided the instruction for the 3 groups. A pretest of the PAAT was first administered to all four (4) groups. This was then followed by teaching the topic for four days of double periods each. Table 1 below displayed the hands-on activity for each group. A worksheet for recording students' observation was also developed (Table 2).

Table 1: Hands-on activities for experimental and control groups.

Group	Instructional Approach	Instructional Technique
Experimental Group 1	Activity-based	Measured and recorded the circumference and diameter of different circular objects with the help of ruler and tape. Then finally found the ratio of each recorded observation. History of pi was also discussed.
Experimental Group 2		Drew circles of different sizes on the ground with the help of nail and twine, measured the circumference and diameter of each circle and recorded then finally found the ratio of each circle circumference to its diameter. History of pi was also discussed
Experimental Group 3		Drew circles of different sizes on plain sheets with the help of a pair of compasses, measured the circumference and diameter of each circle and recorded then finally found the ratio of each circle circumference to its diameter. History of pi was also discussed.
Control Group 4	Lecture-based	Told students that the value of pi is 22/7 or 3.142 without discussing the history of pi.

Table 2: Student Hands-on activity worksheet

Circumference	Diameter	Radius	Ratio: $\frac{c}{d}$ or $\frac{c}{2r}$	Note
				The value of $\frac{c}{d}$ or $\frac{c}{2r}$ will cluster around a constant called π

After the teaching, a post-test was given to the four groups. The students' answer scripts were scored in percentages and subjected to analysis

Statistical Analysis

The mean gain and percentage gain were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the null hypotheses at .05 alpha level.

III. Results

Table 3: Gain score of students' pi-activity understanding in experimental and control groups

Group	Group Tag	N	Pre-test Mean	Post-test Mean	Mean Gain	% gain
Experimental	GROUP 1	41	10.63	57.25	46.63	82.89
	GROUP 2	36	13.38	61.75	48.38	86.00
	GROUP 3	43	12.50	64.25	51.75	92.00
Control	GROUP 4	40	9.88	41.75	31.88	56.67

Table 3 presented the difference which exists in the students' understanding of pi concept taught in the three experimental groups using the constructivist-based instructional approach and in the control group. The experimental group 1 had a mean gain of 46.63 with a percentage gain of 82.89, the experimental group 2 had a mean gain of 48.38 with a percentage gain of 86.00, the experimental group 3 had a mean gain of 51.75 with a percentage gain of 92.00 while the control group 4 who were taught with the traditional approach had a mean

gain of 31.88 with a percentage gain of 56.67. The control group which is Group 4 had the least mean gain (31.88, 56.67%). The constructivist instructional approach was more effective than the traditional instructional approach.

Table 4: Gain score of students' pi-activity understanding in the experimental groups

Group	Group Tag	N	Pre-test Mean	Post-test Mean	Gain	% gain
Experimental	GROUP 1	41	10.63	57.25	46.63	82.89
	GROUP 2	36	13.38	61.75	48.38	86.00
	GROUP 3	43	12.50	64.25	51.75	92.00

Table 4 presented the difference which exists in the students' understanding of pi concept taught in the three experimental groups using the constructivist-based instructional approach. It indicated that the mean gain of students in understanding of pi concept was highest in Group 3 (51.75, 92.00%) who were taught with the drawing of different circles on plain sheets using compass and geometrical construction paper. This was followed by Group 2 who were taught with the use of nails and twine to draw circle on the ground (48.38, 86.00%) then Group 1 who were taught with the actual measurement of circular objects (46.63, 82.89%). It indicated that the mean gain in of students was relatively most effective in Group 3 (51.75, 92.00%).

Table 5: Summary of Analysis of Covariance (ANCOVA) on the difference in the relative effectiveness of the experimental groups taught with constructivist-based instruction over the control group taught with the traditional approach in the understanding gain scores of students in the practical determination of pi

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.	Decision at p<.05
Corrected Model	12239.378	4	3059.845	7.358	.000	S
Intercept	194421.228	1	194421.228	467.499	.000	S
Pre-test	19.378	1	19.378	.047	.829	NS
Method	11908.897	3	3969.632	9.545	.000	S
Error	64460.622	155	415.875			
Total	582950.000	160				
Corrected Total	76700.000	159				

S= Significant, NS= Not Significant.

Table 5 showed that there is a significant difference (F3, 155= 9.545, $p < 0.05$) in the relative effectiveness of the experimental groups taught with constructivist-based instruction over the control group taught the traditional approach in the understanding gain scores of students in the practical determination of pi concept Since p-value against approach is less than the alpha level of .05, H_{O1} was therefore rejected.

Table 6: Summary of Analysis of Covariance (ANCOVA) on the difference in the relative effectiveness of the experimental groups taught using constructivist approach with respect to students' understanding gain scores in the practical determination of pi

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.	Decision at p<.05
Corrected Model	1216.758	3	405.586	1.023	.385	NS
Intercept	163622.394	1	163622.394	412.681	.000	S
Pre-test	210.091	1	210.091	.530	.468	NS
Method	917.033	2	458.517	1.156	.318	NS
Error	45992.409	116	396.486			
Total	494950.000	120				
Corrected Total	47209.167	119				

S= Significant, NS= Not Significant.

Table 6 showed that there is no significant difference (F2, 116 = 1.156, $p > 0.05$) in the relative effectiveness of the three instructional techniques used to teach students pi concept in the experimental groups

using the constructivist-based instructional approach.. Since p-value against instructional technique (0.318) is greater than the alpha level of .05, H_{O2} was therefore retained.

IV. Discussion of Findings

Understanding of pi concept by students taught using the constructivist instructional approach and those taught using the traditional approach.

The results of the study have revealed that the students percentage mean gain in the three experimental groups (Group 1: 46.63, 82.89%, Group 2: 48.38, 86.00%, Group 3: 51.75, 92.00%) taught using the constructivist instructional approach were higher than the students in the control group taught using the traditional instructional approach.. This implies that the students in the experimental groups who were taught on how to practically determine the constant value of pi had a higher understanding and thus achieved higher than those who were merely told or informed about the concept of pi. The hands-on activities which students were subjected to had demystified to the experimental group students why the constant value of pi is approximately equal to 3.142. This demystification has unraveled the abstraction which students in the experimental groups had prior participating in the mathematics practical but that of the students in the control group was not unraveled. This implies that the abstraction of the concept of pi which students in the control group had prior the information on the value of pi was not unraveled and thus they had a lower understanding of the concept and achieved less. When put to statistical test, the result revealed that there was a significant difference ($F_{3, 155}$= 9.545, $p < 0.05$) in the relative effectiveness of the three experimental groups over the control group in the gain scores (pretest-posttest) of students in the hands-on determination of pi value. This result is consistent with the studies of Oludipe & Oludipe (2010), Sharma & Sharma (2012), Grady, Watkin & Montaivo (2012), Onwuka (2014) and Chowdhury (2016) who found that students taught using constructive instructional approach outperformed their counterparts who were taught using the conventional teaching method and there was also significant difference in the constructivist approach and the traditional approach groups. This finding is not in agreement with the finding of Xie, Wang and Hu (2018) who investigated the effects of constructivists and transmission instructional models on students Mathematics achievement and found out a contrary result which revealed that there was no significant difference in using the two models to teach students Mathematics and that all models had the significant effect of improving students performance.

Understanding of pi concept by students taught using different hands-on techniques with respect to constructivist instructional approach.

The results of the study have revealed that the students percentage mean gain in the three experimental groups taught with the constructivist instructional approach were high. This implies that the students in the three experimental groups who were taught how to practically determine the constant value of pi had a higher understanding and thus achieved high as a result of the hands-on engagement on the determination of pi. The practical which students were subjected to had demystified to the experimental group students how and why the constant value of pi is approximately equal to 3.142. Though the students in the three experimental groups had high percentage mean gain (Group 1: 46.63, 82.89%, Group 2: 48.38, 86.00%, Group 3: 51.75, 92.00%), it is obvious that the experimental group 3 who were taught the determination of pi with the use of plain sheets and a pair of compasses to draw and measure the circular dimension in addition to history of pi concept yielded the highest achievement amongst the students. When put to statistical test, the result was that hat there was no significant difference ($F_{2, 116}$ = 1.156, $p>0.05$) in the relative effectiveness of the experimental instructional approaches with respect to students' gain scores (pretest-posttest) in the determination of pi. This result is consistent with the studies of Nwamadi (2017) whose result revealed that different hands-on instructional approach to the teaching of Mathematical concepts yield different degrees of achievement in students.

V. Conclusion

This study concluded that the constructivist-based instructional approach was relatively more effect than the traditional instructional approach and thus, improved students understanding of the pi concept which they always use to solve circular related problems.

VI. Recommendations

The following were recommended based on the findings of the study:

1. Mathematics teachers should endeavour to incorporate the constructivist instructional approach in the teaching of some Mathematics concepts for better understanding of mathematical concepts.
2. Mathematics teachers should avail of themselves in the use of different activity-based techniques to teach a named Mathematics concept so as to improve students' performance in the subject.

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