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EFFECT OF PROCESS-BASED INSTRUCTION AND DISCUSSION METHOD ON SECONDARY SCHOOLS STUDENTS' PERFORMANCE IN HEAT ENERGY IN SOKOTO STATE, NIGERIA

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ABSTRACT

This study investigated the effect of Process-Based Instruction and Discussion method on Secondary School Students' Performance in Heat Energy in Sokoto state, Nigeria. The study employed quasi- experimental research design involving pretest and posttests. Ten (10) schools with a total of 2264 SS II Students formed the population of the study, out of which 965 were sampled using purposive sampling techniques across gender. Four intact classes were selected from the four participating schools. The instrument titled Heat Energy Performance Test (HEPT) was used for data collection. The instrument was validated by experts and reliability coefficient of 0.89 (using KR 20) was established. Research questions were answered using means and standard deviation while research hypotheses were tested at 0.05 level of significance using t-test. The findings revealed that there was significant difference in the performance of students in experimental and control groups. No significant difference among gender in students' performance was observed. It was recommended that stake holders in education should organize seminars and conferences for science teachers and emphasize the implementation of Process Based Instruction in the teaching of secondary school physics.

Keywords: Process-based Instruction, Discussion method, Heat energy and Physics

INTRODUCTION

Teaching methods can produce the desired goal of making students learn with understanding especially constructivist ones, empowers learners with skills of independent thinking and problem-solving. According to Palmer (2005), classroom practice is highly likely to be more effective when informed by an understanding of how students learn and this calls for science teachers to apply effective teaching method such as process-based teaching method in the classrooms, which is a key to the development of cognitive processes within the learner. This approach affords students the opportunity to experiment and make sense of the world around them.

Consistently, different teaching methods and strategies have been adopted by science teachers in order to assist students in the process of learning, understanding and to improve their academic performance in Physics. Unfortunately, students still perform poorly in Physics at the West African School Certificate Examinations probably because many of them are yet to acquire the basic concepts and skills necessary for the learning and understanding the subject (Isaac and Daniel, 2014). Studies (Sunday and Veronica, 2014) reveal that the performance of Nigerian students in ordinary level Physics was generally and consistently poor over the years, which they say could be attributed to many factors

among which teacher's strategy itself was considered as an important factor. Omiko (2013) and Nweke (2015) found that poor performance in practical work is the result of poor method of acquisition of science process skills. This poor and discouraging achievement may not be unconnected with abstract nature of physics. Amadalo, Ochalla and Memba (2012) reported that many students consider physics as difficult, abstract and theoretical hence is considered devoid of applications in the day to day life. The methods and strategies included but not limited to problem-based method, flipped classroom, etc. It should be noted however, that all the cited work above on students' performance in Physics at ordinary level are independent of gender.

Apart from teaching methods, gender is also implicated in students' achievement in science. This study is necessary because of gender disparity in science enrolment and also in job placement in Nigeria. Kola and Taiwo, (2013) believed that gender discrimination in employment is one of the factors contributing to gender inequality in pursuit of science, technology and mathematics education. He said many employers of labour, sometimes including female employers prefer employing men to women. Okafor and Okoye (2004) observed that there are more men in civil and other technological courses than women. Some people even believed that male performed better than female in any course that deal with calculation as observed by Awoniyi (2000) that male candidates performed better, relative to female in subjects requiring quantitative ability. He said male show superiority in science, statistics and accounting.

Mustafa and Umar (2007) investigated the differential effects of two modes of instructional program and gender difference on students' understanding of heat and temperature concepts, and their attitudes toward science as a school subject. The subjects of this study consisted of 72 seventh grade students from two General Science Classes taking the course from the same teacher. Each teaching method was randomly assigned to one class. The experimental group received reinforcement via the conceptual change texts while the control group utilized traditionally designed science texts over a period of four weeks. Analysis of co-variance was used. Logical thinking ability was taken as a co-variate. The results showed that the conceptual change oriented instruction produced significantly greater achievement in understanding of heat and temperature concepts. The result for science attitudes as a school subject showed no significant difference between the experimental and control groups.

Heat energy or thermal energy is an important concept in physics which is defined as a form of energy which transfers among particles in a substance (or system) by means of kinetic energy of those particles. The energy associated with temperature is defined as heat (Nitin 2009). Olumuwiya and Okunola (2008) see heat as energy in the process of transfer from one place to another as a result of temperature difference between them. Heat is the state or condition of a body in reference to the kinetic energy of the particles of which a body is composed (Culler, 2009). On the other hand, heat is preconceived as a sensory function of "hot" or "cold" for most people, especially children. Thus, the perception of heat as temperature felt by the human body conflicts greatly with the scientific concept of heat which is considered an abstract quantity (Yesmin, 2014). The concepts of heat and temperature are theoretical and abstract

hence require effective teaching methods and strategies that would encourage students' participation and interaction and improve their understanding and performance across gender.

Akinbobola and Ikitde (2008) investigated the facilitating effect of models, realia and charts on students' attitude in teaching the concept of heat energy in Nigerian senior secondary school Physics. A total of 183 senior secondary two (SS2) Physics students constituted the sample. This study adopted quasi-experimental design in 4 co-educational secondary schools in Ife South Local Government Area of Osun State, Nigeria. Physics Attitude Scale (PAS) was used to collect the data and the coefficient of internal consistency for PAS was 0.85 using Cronbach alpha. The data collected were analyzed using Analysis of Covariance. The results showed that models were the most effective in facilitating students' attitude towards leaning Physics. This was then followed by realia while charts were found to be the least effective in facilitating students' attitude towards Physics learning.

Ogunleye and Babajide (2011) investigated the effect of students' commitment to science and gender on their achievement and practical skills in Physics. An *expost-facto* research design which is causal-comparative was used. 330 SSII science students from twelve senior secondary schools were purposively selected for the study. The schools were selected from Oyo Township in Oyo State, Nigeria. One intact class of SSII students offering science subjects was then randomly selected from each of the selected schools. All students in the selected classes participated in the study. Three instruments were developed and used for the study. These include Students Commitment to Science Questionnaire (SCOSQ) Physics Achievement Test (PAT) and Practical Skills Test (PST) The reliability coefficient of 0.88 for SCOSQ using Cronbach method, KR-20 value of 0.86 for PAT and a split half reliability index of 0.87 for PST were obtained. Data were analyzed using the inferential statistic of independent samples t-test. Findings showed a significant effect of commitment to science on both students' achievement and practical skills. In each case, students with high commitment to science performed better than those with low commitment to science. However, there was no significant effect of gender on both dependent variables.

Bello and Famakinwa, (2014) stated that the issue of gender is an important one in science education especially with increasing emphasis on ways of boosting manpower for technological development as well as increasing the population of females in science and technology fields. The issue of gender and gender stereotyping affects every aspect of human endeavor. Okeke (2007) observed that the consequences of gender stereotyping cut across social, economic, political and educational development, especially in the areas of science and technology. Many researchers (Njoku; 2000; and Okeke 2000) cited in Giginna, (2013) provided reports that there are no longer distinguishing differences in the achievements of students in chemistry in respect of gender. However, Croxford (2002) and Kolawole, (2007) in their studies found that male students performed better than female students in the cognitive, affective and psychomotor skill achievements. There is a strong association between gender and response to science education. In this study the researchers 'interest is to compare between the process-based instruction and discussion method on Science Process Skills acquisition and performance in physics

among secondary school student in Sokoto State.

Science Process-Based Instruction (PBI) is a strategy that simplifies learning of science, it develops student' sense of responsibility to learn by themselves and this promotes permanent learning (Samuel, 2015). The Process Approach method of teaching science is meant to foster inquiry and manipulative skills in students and discourage rote learning. This embraces other teaching strategies and is mainly activity based preferable to those that are teacher- centered (Akinyemi and Folashade, 2010). The student-centered active learning process within which the teacher is merely a guide is the focal point of contemporary education systems. Different studies have been conducted on the effects of Process-Based Instruction on performance of students in science among which are: Shaibu and Mari (2003) who conducted a research on the effects of process-based instructional strategy on secondary school students 'Formal Reasoning Ability in Nigeria against traditional lecture method. A total of 76 students obtained from two schools located in Zaria metropolis Kaduna state of Nigeria made up the sample. The design of the study was pre-test post-test matched groups design. The groups were assigned to concrete and formal operators based on their scores in the Group Assessment of Logical Thinking Test (GALT). The experimental group was exposed to process-based instruction that lasted for six weeks and for three hours per week. The post-test scores of both experimental and control groups were analyzed using the t-test statistics. The result showed that the experimental group exposed to process-based instructional approach performed significantly better than the control group exposed to the traditional instructional approach.

Gumel (2007) determined the effectiveness of Science Process Approach on remedial science students 'performance in Jigawa State with a sample 78 students (52 male and 26 female) drawn from two tertiary institutions using a purposive sampling technique. A pre-test post-test matched group experimental design was used. A pretest was administered to the two groups as pretest using Teacher Made Test (TMT) and TCOA and Test of Science Process Skill (TOSPS) was administered as post-test to the two groups. The data obtained were analyzed and the hypothesis were tested using t-test statistic at 0.05 level of significance. Findings of the study revealed that process based approach does not seem to be more effective than lecture method in enhancing academic performance in science. And there was no significant difference in the level of acquisition of SPS between male and female students taught chemistry using the process approach.

Keil, Haney and Zoffel, (2009) conducted another study to examine students' achievement and science process skills using environmental health science problem-based learning curricula. Participating students were in classes taught by teachers that have undergone professional development though Project Environmental Health Science (EHS) Exploration through Cross-disciplinary and Investigation Team Experiences (EXCITE) in Bowling Green State University. Students' scientific process skills were evaluated using the 21 question Performance of Process Skills test (POPS). The POPS was previously tested for validity and had a total test reliability of 0.75 using the Kuder Richardson formula 20 for this study. Data were analyzed using one tailed test and one-way ANOVA Analyses of proficiency and performance scores indicate positive effects for both measures, offering educators further

support for the use of integrative problem-based environmental health science curricula.

Discussion is one of the most widely used and valuable method in the teaching of social studies and sciences. It represents a type of teamwork, based on the principle that the knowledge, ideas, and feelings of several members have great merit than those of a single individual (Fazalu, Jaddi and Nabi, 2011). He added that in a discussion class the students are actively involved in processing information and ideas. The discussion class is intended to be a free give and take between teacher and students and among students on the current topic of concern in the course. It is characterized by probing questions from the teacher designed to elicit student interpretations, opinions, and questions. Stephen and Preskill (2005) observed that children learn to deal with facts through discussion method. Discussion is the thought of taking a problem and investigating all options with an ultimate objective to reach a mutual understanding of the problem. Teaching by discussion can be an effective mean of helping students apply abstract ideas and think critically about what they are learning. Fazalu, Jaddi and Nabi, (2011) also described the following objectives of discussion: thinking critically, democratic skills, complex cognitive objectives, speaking ability, ability to participate and attitude change. Frequent questions, whether asked by the teacher or by the students, provide a means of measuring learning and exploring in-depth the key concepts of the course. The Basic Education curriculum emphasized on skills acquisition through the use of different teaching methods particularly in the teaching of physics in senior secondary schools which seems to be one of the most abstract and difficult subjects as perceived by most of the science students in Sokoto. Similarly, there is general apathy by many researchers (Akanbi, 2003); (Aina and Akintola, 2013) in terms of students' performance in physics in Sokoto, especially in the concept of heat energy. Hence, there is need to investigate the appropriate teaching method that improves the performance of students in physics which this study seeks to address. The present study employed process-based instruction that is expected to be one of the best teaching strategies that enables students of different reasoning abilities to participate actively during lessons. Therefore, the study investigates the performance of students in heat energy as a branch of physics when process-based instruction was used compared to the students' performance in discussion teaching method used by teachers.

Research Questions

The study is therefore designed to seek answers to the following questions:

1. Do students performance in Heat energy depends on Process Based Instruction or Discussion method?
2. Is learning of heat energy using process based instruction dependent on gender?
3. Is learning of heat energy using discussion method dependent on gender?

Null Hypotheses

The null hypotheses developed for the study includes:

1. There is no significant difference in students learning of heat energy when taught using process based instruction or discussion methods.

2. There is no significant gender difference in learning heat energy when taught using process based instruction.

3. There is no significant gender difference in learning heat energy when taught using discussion method.

MATERIALS AND METHODS

This study adopted quasi experimental research design involving pre-test post-test. This involves two groups experimental and control groups, both groups were assigned to pre-test before the treatment to determine the homogeneity of the two groups or equivalence in their ability in physics content areas selected. The experimental group received experimental treatment (Process-Based Approach), while the control group was taught using discussion method. At the end of four weeks' treatment, a posttest was given to both groups to determine their post academic performance in physics.

The population of the study was 2264 male and female SS 11 physics students, drawn from the ten (10) secondary Schools under the ministry of science and technology Sokoto State. Of the ten (10) schools from this ministry, only 2 are female schools. Hence, purposive sampling technique was used to select four (4) schools: 2 male and 2 female schools, from the study population, which have a total of 965 students. This is to enable the researcher obtain homogeneity in gender. The sample size for each school was intact classes of not less than thirty (30) subjects. The two intact classes formed the experimental and control groups respectively.

The main research instrument employed in the study was Heat Energy Performance Test (HEPT) and lesson plans.

Heat Energy Performance Test (HEPT)

This instrument was designed by the researcher following test development model (TDM I) by Cyril (2016). It consists of twenty eight multiple choice questions followed by four (4) options letter A to D. The instrument (HEPT) was validated by the experts, subsequently subjected to pilot testing and the Kuder Richardson (K-R 20) reliability coefficient(r) of 0.89 was obtained. Lesson plans were developed on different sub-topics in heat energy. The researcher used the different lesson plans to teach both the experimental and control groups. After the four week's treatment, data were collected and analyzed by descriptive statistics mean score standard deviation and percentage and inferential statistics of t-test using statistical package for social science (SPSS) version 20.

RESULTS

Research Question One: Do students' performance in Heat energy depends on Process Based Instruction or Discussion method?

Table 1: Mean and Standard Deviation between Process-Based and Discussion Groups.

Variables	N	Mean	SD	Mean Difference
Process-Based	90	22.9	5.21	
				2.79
Discussion	98	20.1	6.40	

The data presented in Table 1 shows there is difference in the experimental group who were taught Heat Energy using Process-Based Instruction and the control group taught the same concepts using discussion method. From the table, the Process-Based group had a mean score of 22.9 and standard deviation of 5.21, while the Discussion

group had a mean score of 20.1 and standard deviation of 6.40. The mean difference is 2.79 in favor of Process-Based group.

Research Question Two: Is learning of heat energy using process based instruction dependent on gender?

Table 2 showed that there is difference between the performance of male and female taught heat energy using process-based Instruction. It shows that Male in the experimental group had mean score of 22.2 and standard deviation 6.47 while their female counterparts had mean score of 19.9 and standard deviation of 6.92. The difference in their mean achievement scores is 2.3 in favour of female group.

Table 2: Mean and Standard Deviation of Male and Female Students taught Heat Energy using Process-Based Instruction.

Variables	N	Mean	SD	Mean Difference
Males	45	22.2	6.47	2.32
Females	48	19.9	6.92	

Research Question Three: Is learning of heat energy using discussion method dependent on gender?

Table 3 shows the performance of male and female students taught heat energy using discussion method. From the table, Male in the control group had mean score of 20.6 and standard deviation 6.47 while their female counterparts had mean score of 19.8 and standard deviation of 6.39 the mean difference is 0.80 in favour of male group.

Table 3: Mean and Standard Deviation of Male and Female Students taught Heat Energy using Discussion method.

Variables	N	Mean	SD	Mean Difference
Male	45	20.6	6.47	0.80
Female	53	19.8	6.39	

Null Hypotheses testing

Ho_1: There is no significant difference in students learning of heat energy when taught using process based instruction or discussion methods.

Table 4: t-test analysis of the Students' Performance in Process-Based Instruction and Discussion Method.

Variables	N	Mean	Df	t-cal.	P-value	Decision
Process-Based	90	22.9	186	3.26	0.00	Rejected
Discussion	98	20.1				

$\alpha = 0.05$

The result in table 4 shows the t-test analysis of performance of experimental group (process-based instruction) and control group (discussion method) in heat energy. From the table, p-value of 0.00 obtained is less than the alpha value of 0.05. This indicates that there is significant difference in the performance of students taught Process-Based Instruction and discussion method in favour of experimental group (process-based). Thus, the null hypothesis is rejected.

Ho_2: There is no significant gender difference in learning heat energy when taught using process based instruction.

Table 5: t-test analysis of Male and Female in Experimental Group (Process-Based)

Variables	N	Mean	Df	t-cal.	P-Value	Decision
Male	45	22.2				
			91	1.67	0.98	Retained
Female	48	19.8				

α =0.05

The result in table 5 shows the t-test analysis of performance of male and female in experimental group (process-based instruction) in heat energy. From the table, p-value of 0.98 obtained is greater than the alpha value of 0.05. This indicates that there is no significant difference in the performance of male and female students taught heat energy using Process-Based Instruction. Thus, the null hypothesis is therefore retained.

HO_3: There is no significant gender difference in learning heat energy when taught using discussion method.

Table 6: t-test Analysis Comparing Male and Female in Control Group (Discussion).

Variables	N	Mean	Df	t-cal.	P-Value	Decision
Male	45	20.6				
			96	0.62	0.54	Retained
Female	53	19.8				

α =0.05

The result in table 6 shows the t-test analysis of performance of male and female in control group (Discussion method) in heat energy. From the table, p-value of 0.54 obtained is greater than the alpha value of 0.05. This indicates that there is no significant difference in the performance of male and female students taught heat energy using discussion method. Thus, the null hypothesis is therefore retained.

DISCUSSION

The study came up with the following findings which were discussed. The findings are: Process- Based Instruction significantly improves the academic performance of physics students taught heat energy than those taught with Discussion method. The higher performance suggests that Process-based Instruction was more effective than the discussion method of instruction. This finding is in conformity with the findings of Mari (2003); Bilgin (2006); Keil, Haney and Zoffel, (2009); and Samuel, (2015). Their findings revealed that there was significant difference in the understanding of science concepts as expressed by students' performance in the experimental and control groups respectively. Similarly, the finding is in line with Keil, Haney and Zoffel who reported that lower performing students benefit more from the PBI than other methods such as discussion. The reason why the experimental group performed better than the control group could be attributed to nature of the instruction which is less teacher –centered, but more learners centered, and thus, provided variety of activities for the students to control their own action in the process of learning. The relative performance of the students in control group is an indication that the discussion method adopted in teaching science is not quite effective.

Other finding of this study revealed that the use of process-based instruction has no significant effect on the academic performance of both male and female students taught Heat energy. This finding agrees with the research work of Mustapha

and Umar, (2007); and Ogunleye and Babajide, (2011) who reported that there was no significant difference in gender when teaching science concepts and their attitudes toward science. They further added that the era of male dominance and supremacy in science learning is fast winding up. Although, research conducted by Iyang and Ekpeyong, (2000), Njoku, (2002); and Ogunneye and Lasisi (2008) contradict the outcome of this study and concluded that more ladies are found in Biology and Chemistry than in Physics Departments of higher learning. This accounted for females' low contribution in the areas of Engineering, Medicine, and Technology. The study contradicts the earlier report by Shuaibu and Ameh (2001), who reported that male performed better in science than female.

CONCLUSION

On the basis of the findings, the instructional strategies adopted by the teachers greatly affect the students' learning of concepts. This is reflected in their achievement in the use of Process-Based instructional strategy. PBI enhanced students' achievement in Heat energy when compared with discussion method. PBI and Discussion methods enhanced improvement on both male and female students.

Recommendations

The following recommendations were made based on the findings of the study;

1. Since Process Based Instruction (PBI) is effective in the improvement of student performance. In-service training, workshops, and seminars should be organized by government ministries of education and professional bodies to encourage science teachers in the use of PBI. The use of PBI should be popularized by curriculum planners by incorporating it into Physics curriculum for implementation by science teachers at secondary schools.
2. The use of discussion method should be encouraged by stake holders in education in teaching scientific concepts that do not involves abstraction.
3. Both male and female students benefitted equally when taught heat energy using PBI. Based on this finding, the female and male students should be encouraged to vigorously pursue most of the physics based courses like engineering, medicine and so on.

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