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Effect of model-based inquiry instructional technique on skill acquisition of pre-service integrated science teachers in Delta State

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Abstract

This study sought to determine the effect of a model-based inquiry instructional technique on critical thinking skill acquisition of pre-service integrated science teachers. Two research questions and three hypotheses that were tested at 0.05 level of significance guided the study. Quasi- experimental design was used for the study because intact classes were used. The population of the study consisted of all the pre-service integrated science teachers in Nigeria Certificate in Education (NCE) in the only Federal College of Education and the two State Colleges of Education in Delta State numbering forty-three (43). The sample of the study consisted of thirty-eight (38) pre-service integrated science teachers in the only Federal College of Education and one of the State Colleges of Education which was selected using purposive sampling technique in order to train more pre-service teachers. The two Colleges of Education (one Federal and one State) were randomly assigned to 5E's model based inquiry instructional technique and demonstration method of instruction using toss of coin. The study was necessitated due to the need to equip pre-service integrated science teachers with appropriate skills as specified in the new minimum standard. Hence, it became necessary to expose the male and female pre-service integrated science teachers toa model-based inquiry instructional technique in order to equip them for the task ahead. The Test of Critical Thinking (TOCT) developed by the researchers and found to be valid and reliable were used for data collection. The groups received pre-test and post-test independently. The research questions were answered using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses. The findings revealed that 5E's model -based inquiry was more efficacious than the demonstration method of instruction in bringing about pre- service integrated science teachers' critical thinking skill acquisition required for the 21st century amongst others. Based on the findings it was recommended amongst others that the National Commission for Colleges of Education (NCCE) should incorporate 5E's model -based inquiry instructional strategy in the Nigeria Certificate of Education (NCE) minimum standard.

Keywords:

Integrated science, 5E's inquiry model, demonstration method, Critical thinking and Pre-service teachers.

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Introduction

Science is a special type of discipline with peculiar characteristics, the prominent among which is the approach through which knowledge is sought. This approach is known as scientific method. Scientific method is a logical, rational and systematic process by which knowledge in science is acquired. The steps involved in scientific method are observation, hypotheses, predictions, experimentations, conclusion and host of others (Ezeh, 2013). Issues challenging the sustainability of man and general wellbeing are evolving. This has necessitated a need to equip current and future citizens in general with the skills to address the rapidly evolving technology needs/challenges of this 21st century (Ezema, 2011). The importance of science in our society and the need to make the citizens to be scientific literate made the Federal Government of Nigeria, through the Federal Ministry of Education to introduce the teaching of Basic Science formerly called Integrated Science at the early stage of secondary education.

At the Nigeria Certificate in Education (NCE) level, Integrated science education is designed to produce competent Basic science teacherswho can demonstrate the intellectual competence and professional skills necessary for the teaching of Basic Science and Technology in primary and junior secondary schools as an inquiry based subject, carry out scientific investigations, emphasizing co-operation, development of appropriate scientific processes and skills as well as the ability and motivation in students to work and think in an independent manner (Nigeria Certificate of Education Minimum Standard, 2020)among others.

Basic Science is an introductory course to the study of the sciences in the senior secondary school. It is a science in which concepts and principles are presented to the learner so as to express the fundamental unity of science and avoid premature or undue stress on the distinction between various scientific fields (UNESCO, 2013). Ukpabi in Omiko (2015) also defined Basic Science as a science in undifferentiated form which stresses the fundamental unity of science. It offers the Basic training in scientific skills required for human survival, sustainable development and societal transformation. These skills go beyond the science process skills among them is the critical thinking skill (Nwosu, 2015). This objective is yet to be achieved in our institutions. Science educators have identified some factors militating against the attainment of this objective to include teachers' methodologies and strategies (Danladi, 2017). Since the government wants its citizens to be scientific literate, there is need to make the citizens to think critically.

Methods and instructional techniques are tools used by the teacher for actualizing the set aims and objectives. If the tools are faulty or inappropriate, the aims and objectives of the teaching and learning will not be achieved. It is clear from the foregoing that the possibility of Basic Science education to provide the needed scientific literate society depends on the ability of the Basic Science teacher to select and maximally utilize appropriate instructional techniques in their lesson delivery. To be successful, teachers should select and use a wide variety of innovative instructional strategies because excellent and effective teaching demands high quality techniques and a host of other devices to achieve critical outcomes. The

ability of basic science teachers to select and utilize the appropriate instructional strategies in the delivery of their lesson is a function of the pre-service and in-service training they received from the teacher training institutions and departments. The quality of teachers is dependent on the preparation for professional role as distinct practitioners (Aina, 2013). There is need to expose prospective Basic science teachers at higher education levels to quality knowledge and skills. Science educators maintain that the task cannot be accomplished without a radical change from the use of teacher centered traditional practices in teacher preparation programs to the use of student centered approaches such as inquiry (Nwosu, 2015).

There is an outcry against below average manpower production characterized by poverty of knowledge and skills from educational system (Pollyn, 2014), substantiating the paucity of innovative instructional strategies in our traditional classrooms (Colman, 2014). At the pre-service training level, student teachers are reduced to mere passive recipients of information through the use of conventional methods of teaching such as the demonstration method among others and the lectures have become one sided and teacher centered. As a result, pre-service teachers produced from such institutions in recent times are seriously limited in intellectual skills especially those of the critical thinking (Nwosu, 2015). This underscores the need for this research.

Learning outcomes in terms of cognitive and intellectual skills that are relevant with wider applicability which pre-service students should imbibe during training is the acquisitions of skills to enable them become useful members of the society (FRN, 2004). The type of curriculum designed, its quality and instructional delivery which accommodates the acquisition of skills is germane for manpower development. This implies that pre-service teachers programs must provide training in the acquisition of skills such as critical thinking skill among the 21st century skills. Hence, there is need to expose the pre-service basic science teachers to a model-based inquiry instructional technique such as the 5E'smodel-based inquiry that involves five (5) stages which are Engagement, Exploration, Explanation, Elaboration and Evaluation that will help to equip the pre-service teachers with the needed 21st century skills for the task ahead. The engagement phase initiates learning, the exploration phase provides students with a common basic experience within which concepts, processes and skills are identified and developed, explanation phase provides opportunities for teachers to introduce concepts, processes or skills amongst others. The elaboration phase challenges and extends the students' conceptual understanding and skills. Lastly, the evaluation phase encourages students to assess their understanding.This underscores the need for this study. Available evidence indicates paucity of research on the use of 5E'smodel-based inquiry instructional technique in science teaching and learning at teacher preparation institutions especially on critical thinkingskill acquisition among basic science pre-service teachers.

Critical thinking is a rational thinking in the pursuit of relevant and reliable knowledge about the material world. It is a purposeful, self-regulatory judgement which results in interpretation, analysis, evaluation and inference as well as explanation of the evidential consideration upon which judgement was made. There is need to investigate the

effect of a model based inquiry technique on pre-service male and female teachers' critical thinking in Basic Science.

Gender involves the biological dimension of being a female or male. This has been a crucial matter to the educationists. Providing quality education and skill acquisition for both males and females ensures sustainable development and this is a factor of the instructional methodology. Hence, the problem of the study posed as a question is: what is the effect of 5E'smodel-based inquiry instructional technique onskill acquisitionof pre-service male and female integrated science teachers.

Statement of the Problem

Prospective science educators at the Colleges of Education need to be exposed to inquiry teaching strategies that will make them to be intellectually competent with the right professional skills they need to exist in a global competitive world against the conventional method of instruction which is predominantly used. It is the duty of the basic science teacher to select and utilize appropriate instructional strategies in lesson delivery and this is a function of the pre-service and in-service training they received from the teacher producing institutions and departments. The quality of teachers is dependent on the preparation for professional role as distinct practitioners (Aina, 2013). This implies that there is need to ensure that a solid foundation is laid for effective and efficient basic science education at the secondary school level using well trained teachers. Hence, the need to expose the pre-service integrated science teachers to an inquiry based method of teaching thus preparing them for the task ahead. Available evidence indicates paucity of research on the use of 5E'smodel-based inquiry instructional technique in science teaching and learning at teacher preparation institutions especially oncritical thinking skill acquisition among male and female integrated science pre-service teachers. Hence, the problem of the study posed as a question is: what is the effect of 5E'smodel-based inquiry instructional techniqueand demonstration method of instruction oncritical thinking skill acquisition of pre-service integrated science teachers.

Goals and Objective

The general objective of this study is to find out the effect of 5E'smodel-based inquiry instructional technique oncritical thinking skill acquisitionof pre-service integrated science teachers in Colleges of Education in Delta State. Specifically, the study hopes to determine the:

1. Relative effectiveness of 5E'smodel-based inquiry instructional technique and the demonstration method on pre-service teachers' critical thinking skill acquisition in integrated science.
2. Influence of gender on pre-service teachers' critical thinking skill acquisition in integrated science.
3. Interaction effect of method and gender on pre-service teachers' mean critical thinking skill in integrated science

Research questions

1. What is the effect of 5E's model-based inquiry instructional technique and the demonstration method on pre-service teachers' critical thinking skills acquisition in integrated science?
2. What is influence of gender on pre-service teachers' critical thinking skills acquisition in integrated science?

Hypotheses

The following hypotheses that were tested at 0.05 level of significance guided the study
Ho_1: There is no significant difference in the mean critical thinking skill acquisitionscores of pre-service teachers' exposed to 5E's model-based inquiry instructional technique and those exposed to demonstration method of instruction.

Ho_2: There is no significant difference in the mean critical thinking skill acquisition scores of male and female pre-service teachers' when exposed to 5E's model-based inquiry instructional technique and those exposed to demonstration method of instruction.

H_{03}: There is no significant interaction effect of methods and gender on pre-service teachers' meancritical thinking skill acquisition scores in integrated science.

Methodology

The study adopted the quasi-experimental design. Specifically, it is non-equivalent control group design because it involved the use of intact classes which ensured that regular class periods are not altered. The intact classes were randomly assigned to experimental and control groups.The study was carried out in Delta State. The choice of the state is based on the emphasis placed on the acquisition of skills by the Government at all levels of education. Hence, the need to train the trainers. The population of this study consisted of all the NCE integrated science students in the only Federal College of Education and the two State Colleges of Education in Delta State numbering forty-three (43) students.The sample of the study consisted of thirty-eight (38) pre-service integrated science teachers in two Colleges of Education comprising the only Federal College of Education and one State College of Education which were selected using purposive sampling technique in order to train more pre-service teachers. The two Colleges of Education were randomly assigned to 5E's model based instructional strategy and the demonstration method using toss of coin.The instrument for this study was the Test of Critical Thinking (TOCT). TOCT developed by the researchers was used to test students' critical thinking. It consisted of ten (10) questions. The Test of Critical Thinking (TOCT) constructed by the researchers was subjected to face and content validity. A test - retest method was used to test for the reliability of the instrument. Ten (10) copies of the questionnaire were administered twice to ten (10) integrated science studentsin College of Education Nsugbe,Anambra State who are not part of the population of the study. Pearson coefficient of correlation was used to analyze the data and a reliability coefficient of 0.81 was got. This shows that the instrument is reliable.Before the experiment, researchers with the help of the research assistants administered the pre-test to the students in the two

groups. After this, the two groups were exposed to the treatments before the post-tests were administered.The scores obtained from the pretest and post-test were analyzed using mea and standard deviation in order to answer the research questions while Analysis c Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

RESULTS

Research Question one: What is the effect of 5E'smodel-based inquiry instructional techniqueand the demonstration method on pre-service teachers' critical thinking skills acquisition in integrated science?

Table 1: Mean and Standard deviation of pretest and posttest rating of the effect of 5E's model-based inquiry instructional technique and the demonstration method on pre-service teachers' critical thinking skills acquisition in integrated *Science*

			Pretest		Posttest		
SN	**Instructional Mode**	**N**	$\bar{X}$	**SD**	$\bar{X}$	**SD**	**Mean Gain**
1	5E'smodel-based inquiry instructional technique	28	8.93	2.07	17.79	2.26	8.86
2	Demonstration method	10	8.40	1.83	11.90	1.19	3.50

According to the results in Table 1, the results show that for each of the groups, the posttest mean scores were higher than the pretest mean scores, with a higher mean gain for the experimental group that was taught using 5E'smodel-based inquiry technique(8.86 > 3.50). This suggests that 5E'smodel-based inquiry instructional techniqueexerted more effects on the critical thinking skills acquisitionof pre-services teachers than the demonstration method.

Hypothesis one

H_{01}: There is no significant difference in the mean critical thinking skill acquisitionscores of pre-service teachers exposed to 5E's model-based inquiry instructional technique and those exposed to demonstration method of instruction.

Table 2: Analysis of Covariance (ANCOVA) of the difference between the mean critical thinking skill acquisition scores of pre-service teachers exposed to 5E's model-based inquiry instructional technique and those exposed to demonstration method of instruction.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Decision
Corrected Model	260.473[a]	4	65.118	14.679	0.00	0.640	
Intercept	386.331	1	386.331	87.086	0.00	0.725	

PrettestCT	.969	1	0.969	0.218	0.64	0.007	
Group	133.332	1	133.332	30.055	0.00	0.477	S
Gender	1.522	1	1.522	0.343	0.56	0.010	NS
Group * Gender	1.509	1	1.509	0.340	0.56	0.010	NS
Error	146.395	33	4.436				
Total	10425.000	38					
Corrected Total	406.868	37					

Note: S = Significant, NS = Not significant, α = 0.05

Table 2 shows that the mean critical thinking skill acquisitionscores of pre-service integrated science teachers' exposed to 5E's model-based inquiry technique and those exposed to demonstration method of instructionwas statistically significant (p = 0.477). Hence, the null hypothesis wasrejected. Inference drawn is that there was significant difference in the mean critical thinking skill acquisition scores ofpre-service teachers' exposed to 5E's model-based inquiry instructional technique and those exposed to demonstration method of instruction in favour of the experimental group.

Research Question Two: What is influence of gender on pre-service basic science teachers' critical thinking skills acquisition when exposed to5E's model-based inquiry instructional technique?

Table 3: Mean and Standard deviation of the influence of gender on pre-service basic science teachers' critical thinking skills acquisition when exposed to 5E's model-based inquiry instructional technique

			Pretest		Posttest		
SN	**Gender**	**N**	***X***	**SD**	**X**	**SD**	**Mean Gain**
1	Male	6	8.67	2.06	14.33	3.20	5.66
2	Female	32	8.81	2.02	16.59	3.26	7.78

Result on Table 3 shows that for the male and female students, the post-test mean critical thinking skills acquisition scores were greater than the pretest mean critical thinking skills acquisitionscores with the female students performing slightly higher than the male pre-service teachers with respect to critical thinking skills acquisition in integrated science (7.78> 5.66).

Hypothesis Two

H_{O2}: There is no significant difference in the mean critical thinking skill acquisition scores of male and female pre-service teachers' when exposed to 5E's model-based inquiry instructional technique.

The result on Table 2 shows thatdifference in the mean critical thinking skill acquisition scores of male and female pre-service teachers' when exposed to 5E's model-based inquiry was not statistically significant (p = 0.01). Thus, inference drawn is that there was no statistically significant difference in the mean critical thinking acquisition skills scores of male and female pre-service teachers' when exposed to 5E's model-based inquiry instructional technique.

Hypothesis Three

H_{O3}: There is no significant interaction effect of methods and gender on pre-service teachers' meancritical thinking skill acquisition scores in integrated science.

The result in Table 2 shows that the result was not statistically significant(p = 0.56). Thus, inference drawn is that the interaction effect of methods and gender on pre-service teachers' meancritical thinking skill acquisition scores in integrated science is not statistically significant.

Discussion of the Findings

Effects of 5E's model-based inquiry instructional strategy and demonstration method of instruction on pre-service teachers' critical thinking skill acquisition in Integrated Science

The result on Table 1 indicate that pre-service teachers taught with5E's model-based inquiry instructional strategyhad a higher mean gain in critical thinking skill acquisition than their counterparts taught with demonstration method of instruction (8.86 > 3.50) and the difference is significant as revealed in hypothesis 1. The pre-service teachers that used the 5E's model-based inquiry strategy displayed higher order thinking skills in answering their questions. Such skills include their ability to analyze situations, evaluate and interpret relationships. Thus, 5E's model-based inquiry strategy offers more opportunity for critical thinking skill acquisition than the demonstration method of instruction. This finding is in line with the study of Yang (2014) who found out a significant improvement on critical thinking skill acquisition through the use of blended digital game-based learning instructional strategy. In the strategy, the researcher incorporated instructor orchestration and scaffolding, provision of learning aids and the use of collaborative learning. Consequently, pre-service teachers in the 5E's model-based inquiry group outperformed those that used the demonstration method having more of the ability to identify central issues and assumptions in an argument, recognize important relationships, make correct inferences from data, deduce conclusions on the basis of the hands-on activities which the 5E's model-based inquiry strategy offered. Critical thinking skills are crucial in this millennium because they enable students to deal effectively with social, scientific and practical problems (Danladi, 2017).

Influence of gender on pre-service teachers' critical thinking skill acquisition in Integrated Science

The result of the findings as shown in Table 3 indicates that the female pre-service teachers performed slightly better than their male counterparts in the acquisition of critical

thinking skills (7.78 > 5.66). However, the test of hypothesis 2 shows that there was no significant difference in the mean critical thinking skill acquisition rating of male and female pre-service teachers when taught with 5E's model-based inquiry instructional strategy.This result indicates that gender is not a significant factor in determining students' critical thinking skills in integrated science. The findings of this study is similar to that of Danladi (2016) who found that no critical thinking skill difference existed between male and female pre-service chemistry teachers. The non - existence of significant gender influence on the acquisition of critical thinking skill as revealed by this study could be because the 5E's model-based inquiry instructional strategy offered unique and equal opportunity devoid of the influences of socio-cognitive and stereotypical orientations for both males and female pre-service teachers to become stimulated/excited in the manipulative activities culminating into the development of these rationality traits. These attributes eventually promote students' cognitive, higher order thinking skill and learning satisfaction. This result supports the position of Piaget, Dewey and Vygotsky in the construction of authentic knowledge. Critical thinking skills are crucial in this millennium because it enable students to deal effectively with social, scientific and practical problems. Hence, the instructional strategy provided the environment where all students irrespective of their gender actively participated in the learning process, since sustainable development is participatory (males and females) and involves equity (Nwosu, 2015).

Interaction effect of treatment and gender on pre-service teachers' critical thinking skill acquisition in Integrated science

The findings of this study as shown in Table 3 showed that there was no significant interaction effect of strategy and gender on pre-service teachers' critical thinking skill in integrated science. This means that the inquiry method used did not have different effects on pre-service teachers' critical thinking skill acquisition in Integrated science. This could be explained by the fact that both male and female pre-service students were provided with equal environment to operate and this environment was gender friendly and all students benefitted from it. Hence, acquisition of more critical thinking skills by the pre-service students using the 5E's model-based inquiry instructional technique was mainly due to the treatment. The absence of interaction effect of method and gender on the students' critical thinking skill acquisition indicated that the strategy benefitted both male and female pre-service teachers equally in enhancing theircritical thinking skill acquisition.

Conclusion

Based on the findings, the following conclusions were made:

From the foregoing discussions based on the findings of the study,5E's model-based inquiry instructional strategy improved Pre-service integrated science teachers' critical thinking skill acquisition and there was no significant difference in the mean critical thinking skill acquisition of male and female pre-service integrated science teachers when taught with 5E's model-based inquiry instructional strategy. Finally, the interaction effect of instructional strategies and gender on pre-service integrated science teachers' mean critical thinking skill acquisition score in integrated science wasnot statistically significant. This means that gender did not interact with the instructional strategies to affect pre-service teachers'critical thinking

skill acquisition. Hence, critical thinking skill acquisition of the concepts under study were due to the specific treatment that was given.

Recommendations

Based on the findings reached in this study, the following recommendations are made:

1. The National Commission for Colleges of Education (NCCE) should incorporate 5E's model-based inquiry instructional strategyin the Nigeria Certificate of Education (NCE) minimum standard as part of the strategies for teaching especially the science courses.
2. The State and Local Government in conjunction with the Federal Ministry of Education should endeavour to organize in-service training in form of workshops, seminars, conferences and symposia regularly for science teachers to enable them update their knowledge, attitudes and skills on the use of innovative teaching strategies.

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