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Determining the Effect of Interactive Invention Instructional Strategy and Gender on NCE Pre-Service Teachers' Acquisition of Science Process Skills

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Abstract

Physics is the foundation of science and technology. Students' achievement in this subject at all levels of Education has been consistently poor. In an attempt to seek solutions to this problem, this study determined the effect of interactive invention strategy on NCE pre-service teachers' achievement in physics. The study adopted a quasi experimental research design with 98 females and 94 males from six colleges of education in South Western Nigeria which constituted the sample. A treatment group was exposed to the interactive invention instructional strategy and a control exposed to the conventional lecture method. The treatment was found to have significant effect on pre-service teachers' achievement in physics $F_{(2,185)} = 43.441$, $p < .05$. *Students exposed to interactive invention instructional strategy obtain higher post test score (*$\bar{x}$=38.32*) than those exposed to conventional lecture method (*$\bar{x}$=32.64*). It is concluded that interactive invention strategy improves students' achievement in physics and is therefore recommended for use by lecturers in colleges of education.*

Key Words: Interactive invention, achievement in Physics, Pre-service teachers, conventional, Lecture method

Introduction

Science and technology dominate every area of human endeavour today. The level of advancement in this area determines if a nation is developed or not. Nigeria is classified as a developing nation because of her level of development in science and technology. In her quest for development, the country has been changing from one system of education to another. However, the fact remains that no matter how good an educational system could be, for the aims of that programme to be achieved, the implementation stage of the programme is very important. In line with this, European Commission (2010) noted that the major determinant of any educational system is the quality of its teachers. This is because it is the teacher who will effect the necessary changes and facilitate the expected outcomes of the programme.

In an attempt to improve teacher quality, Nigeria established the National Commission for Colleges of Education (NCCE) with the responsibility of producing teachers with Nigeria Certificate in Education (NCE) to teach at basic education level. Also, for the future generation to have good foundation in science, Physics education is included as part of the N.C.E programme. This is because the science curriculum for basic science contains many physics topics like motion, force, energy, machines, friction, electricity, magnetism and electromagnetism. However, the performance of students in this subject has been reported to be very poor especially at the college level (Adepitan, 2003 and Ukoh, 2012)

This problem of students' underachievement in physics has also engaged the attention of many other scholars over the years (Ivowi and Oludotun, 2001; Ogunleye, 2001; Riess, 2000, Kalijah, 2000). Prominent among the factors which have been identified as contributing to the persistence of poor level of achievement in physics are: Inefficient teaching methods adopted by physics teachers in the field (Adepitan, 2003; Ivowi and Oludotun, 2001; Gbolagade, 2009), poor manipulation of science process skills (Aydogdu and Kesercioglu, 2005; Yesilyurt, Bayraktar and Erdemir, 2004 and Saat, 2004), learner variables such as gender stereotype in physics and lack of confidence by physics students in their approach to tackling physics problems (Ukoh, 2012; Jimoh, 2004, Babosa, 2003 and Riess 2000).

There seems to be a general consensus of opinion among science educators concerning the pivotal role played by the teaching method or instructional strategy adopted as classroom variables affecting students' achievement and attitude to science (Gbolagade, 2009). He emphasized the importance of appropriate teaching method in the development of skills required for making science content relevant to the growth and development of both the individual, the society and to meet the teacher's standards. He called for adequate training of teachers, which should include the introduction of appropriate methods of teaching the subject matter. Based on the forgoing, the use of interactive invention instructional strategy which has been reported to improve students' achievement in mathematics is used in this study.

Interactive invention instructional strategy

The interactive invention strategy (IIS) is a strategy that is widely applied and can be used to teach both concepts and skills (Gbolagade, 2009). It uses teacher's explanation and modelling combined with students' practice, invention and feedback to teach concepts and procedural skills. In an interactive invention instruction lesson, students are active in responding to teachers' questions, analyzing examples and practicing skills to the point where they can be used with little or no mental effort. Rosenshine (1995) reported that interactive invention strategy usually produces better scores on standardized tests of basic skills than other strategies. According to Maccini and Gugnon (2000), interactive invention includes: continuous modelling by teachers, followed by more limited teacher involvement and fading teacher involvement as students begin to master the material.

This strategy has been reported to be good in facilitating cognitive and science process skills development (Yilmaz; 2005 and Millar; 2004). Aydogdu (2009) observed that science process skills form the basis of the ability to conduct scientific research and a means whereby learners construct knowledge on their own and acquire problem solving skills. Also, these skills constitute a general definition of the logical and rational thought that an individual uses throughout his life-time. Duran and Ozdemir (2010) reported that science process skills facilitate the learning in science, make students active, improve students' sense of taking responsibility for their own learning, making learning lasting and equip students with ways and methods of inquiry. Sahin-Pekmez (2001) has shown that the acquisition of science process skills by pre-service teachers is important as a teacher not properly equipped with these skills will experience difficulties to deliver these skills to

his students and will avoid performing experimental activities, thus, physics concepts will be taught theoretically.

Guided practice is a very important part of this approach, during this stage, the students try out the new content as the teacher carefully monitors their progress and provides support and feedback. Teacher and students roles change during this phase. The teacher moves from information provider and model to coach and students move from receiving information to inventing their understanding with examples and problems.

Research indicates that this method provides teacher with access to students thinking, allowing them to understand and "debug" students' error and misconceptions during the lesson (Eggen and Kanchak, 2006). Independent practice stage provides students' opportunity to tryout the new skills and concept on their own, developing automaticity and the ability to transfer their understanding to a new context (Gersten et al 1999) this eventually improves their science process skills. According to Hills (2012), the skills necessary to be successful in accomplishing any science process include the ability to be objective, observant, and consistent in action. Intellectual skills necessary for quality contributions to science include communication, planning, foresight, prediction and critical thinking. More abstract skills, however, can be improved while participating in almost any activity. Aspects of science process skills include fostering curiosity, forming a hypothesis, planning experiments, collecting data, interpreting results and communication of those results. Any activity that forces a person to exercise his or her mental faculties in any of those directions will help improve science process skills. Participating in activities that arouse one's curiosity will help encourage a continuous state of inquiry. Exposing oneself to new information that warrants further questioning often leads to forming a hypothesis. As more information is gained and more questions arise, predictions are naturally made. A participant in good science process skills will often begin an experiment with a hypothesis, stemming from a situation where information was gained and a prediction was made about why things are how they are.

Assessment, monitoring and feedback are also essential part of this model. Interactive invention approach is reported to be effective with students generally but distinctively effective with students from diverse background, Gersten et al (1999).

As pointed out earlier, gender is another factor that has been reported in literature to affect achievement in physics but the actual state of gender

inequality and probable ways of restoring gender balance in various fields of human endeavours has been the concern of many research studies. The quantitative aspect of physics has always been reported to be the cause of gender imbalance in participation in the subject. Babosa (2003) observed in physics world that women are generally greatly underrepresented in physics than all the sciences. Barbosa explains further that many women who take physics end up running away from it and that statistics show that a higher proportion of women than men leave physics at each stage of their career. This could probably be because the learning needs of the female students are not met in the teaching strategies used. However, interactive invention strategies provide opportunities for students to work in small interactive mixed gender groups where the group members help one another and every member of the group is carried along there by enforcing cooperative learning. This is hoped to improve the participation and achievement of both males and females.

Purpose of the study

The purpose of this study was to investigate the effect of interactive invention instructional strategy and gender on pre-service teachers' science process skills acquisition.

Research question

This study will be guided by these research questions:

1. Will acquisition of science process skills be affected by mode of instruction?
2. Will acquisition of science process skills be affected by students' gender?

Hypotheses

This study is designed to provide answers to these hypotheses at $p<0.05$ level of significance.

HO_1: There is no significant main effect of treatment on pre-service teachers' acquisition of science process skills.

HO_2: There is no significant main effect of gender on pre-service teachers' acquisition of science process skills

Significant of the study

This study is considered significant because the findings would provide relevant information on the effects of this instructional strategy on students' acquisition of science process skills. This will provide an opportunity for the pre-service teachers to have an interesting hand –on instructional strategy where they will learn from and most likely implement what they have learnt. The experiment will provide for would be teachers practical and interesting strategy which they will use during their careers so that they can do something different from what other teachers have been doing and this would most likely promote the enrolment and achievement of the learners.

Scope of the study

This study covered three state and three federal Colleges of Education in the South Western Nigeria. All the available NCE III physics students from these Colleges were allowed to take part in the study. Some aspects of Electromagnetism III with course code PHY 321 as contained in the NCCE course outline was taught. A total of one hundred and ninety two (192) students of which ninety four (94) were males and ninety eight (98) females took part in the exercise. Scores of forty item Physics Achievement Test were used to determine the achievement of students in physics.

Methodology

A pretest posttest control- group quasi-experimental research design was adopted for this study. This design is schematically represented as follows:

Experimental group	$O_1\ X_1\ O_2$
Control group	$O_1\ X_2\ O_2$

Where

O_1 represent the pre-test observations for experimental and control groups and

$O_{2,}$ represent the post test observations for experimental group and control groups

X_1 is experimental treatment group; Interactive invention instructional strategy.

X_2 is control; conventional lecture method for group 3.

Selection of participants

The target population for this study comprised all the NCE III pre-service teachers studying physics with other combinations in Colleges of Education in the South Western Nigeria. Three states and three federal Colleges of Education were purposively selected based on their offering physics as NCE course, having physics teachers and functional internet facilities. Three colleges were used as treatment group and the other three for control group. From the selected colleges, all available NCE III students offering physics were used for the study. The lecturers used as instructors in the study were the regular physics lecturers assigned by the H.O.D to handle the course-Electromagnetism III (PHY 321).

Instrumentation

The following research instruments were used in this study:

1. Science Process Skills Worksheets (SPSW)
2. Teachers' Instructional Guide on interactive invention instructional strategy (TIGIIS).
3. Teachers' Instructional Guide on Conventional Lecture Method (TIGCLM).

Science process skills worksheets (SPSW)

The work sheets were developed by the researcher to assess the pre-service teachers' science process skills during every lesson. Each contained eight activities in form of questions assessing ability to observe, identify, classify, measure, formulate hypothesis, gather data, test hypotheses, and making inference based on data collected.

Method of data analysis

The data obtained from the pretest and post test were analyzed, using Analysis of Covariance (ANCOVA) with the pretest scores as covariates. Where the main effects were significant, the multiple classification analysis (MCA) technique was used to find the direction of the difference among the groups.

Result

$H0_1$: *There is no significant main effect of treatment on Science Process Skills acquisition of NCE Pre-Service Teachers'*

Table1: Science Process Skills acquisition

Source	Sum of Squares	DF	Mean Square	F	Sig.	Remark
Main effects Treatment Groups	68933.381 68933.381	2	34466.690	180.108	.000 *	
Explained	68933.381	2	34466.690	180.108	.000*	Sig.
Residual	36168.189	189	191.367			
Total	105101.655	191	550.270			

The above table showed that there was significant difference of treatment on science process skills acquisition of NCE Pre-Service Teachers' ($F(2,189) = 180.108$, $P < .05$). The null hypothesis is therefore rejected.

Table 2: Multiple Classification Analysis (MCA) showing the direction of the effect of treatment on Science Process Skills acquisition of NCE Pre-Service Teachers'

Variable + Category Grand Mean = 53.09	N	Unadjusted variation	Eta	Adjusted for independent + covariates deviation	Beta
Treatment Groups: Experimental I Control	 85 60	 7.73 -27.07	 .81	 7.73 -27.07	 .81
Multiple R-squared Multiple R					.656 .810

In the table, the mean scores of the different two groups were: Experimental I (60.82) and Control (26.03) respectively. This shows that the Experimental I had the higher mean score than Control group.

Table 3: Summary of ANCOVA of Science Process Skills Score by Treatment Groups and Gender

Source	Sum of Squares	DF	Mean Square	F	Sig.	Remark
Main effects Gender	1171.365 1171.365	1	1171.365 1171.365	2.141 2.141	.145 .145	 Sig.
Explained	103930.290	1				
Residual	105101.655	190	547.002			
Total		191	550.270			

Table 3 showed that there was no significant difference (main effect) of gender on pre-post Science Process Skills in Physics Concept

(F (1,191) =2.141, P>.05).

The null hypothesis accepted.

Table 4: Multiple Classification Analysis (MCA) showing the direction of the difference of Gender in Science Process Skills in Physics Concepts

Variable + Category Grand Mean = 53.09	N	Unadjusted variation	Eta	Adjusted for independent + covariates deviation	Beta
Treatment Groups: Experimental I Control	 94 98	 -2.52 2.42	 .11	 -2.52 2.42	 .11
Multiple R-squared Multiple R					.011 .106

In table 4, the mean scores of the age groups were: male respondents (50.57) and the female respondents (55.51) showing that the females had a higher mean score than the males.

Discussion of findings

The major issue addressed in this study was to determine the effect of interactive invention instructional strategy and gender on NCE pre-service teachers' science process skills acquisition. Over the years, the decline in students' achievement in physics has been attributed to the teacher-centred teaching methods with the teacher dominating at the expense of students not being encouraged to construct their own knowledge or take active part in their learning. The problem has also been compounded by the abstract nature of some of the physics concepts coupled with the high quantitative demands of the subject. In this study therefore, interactive invention strategy shifted from the teachers to the students who the strategy sought to empower to take charge of their own learning.

This strategy was found to enhance the acquisition of science process skills of pre-service teachers. This finding is in agreement with the findings of

Aydogdu (2009) and Millar (2004) who reported that interactive invention strategy facilitates the acquisition of science process skills. The forgoing discussion answers research questions one and two: Will NCE students' performance depend on instructional strategy employed? And will acquisition of science process skills be affected by mode of instruction? Since students exposed to interactive invention strategy perform better in acquisition of science process skills than those in the conventional lecture method group it is clear that instructional strategy used determines acquisition of science process skills.

Acquisition of science process skills as evident in the use of the instructional strategy may not be unconnected with the hand-on activities provided by the strategy. This is in line with the observation of Iroegbu (1998) and Albanese and Mitchel (1993) who are of the opinion that learners will be more able to exhibit higher level of cognitive outputs if they are given opportunity to interact with materials and peers.

There is no significant main effect of gender on pre-service teachers' acquisition of science process skills. The data in table 3 shows that there is no significant main effect of gender on pre-service teachers' acquisition of science process skills. ($F(1,191) = 2.141$, $P > .05$).Therefore the null hypothesis is not rejected.

Gender was not found to be a significant variable for influencing the level of acquisition of science process skills. This finding tends to agree with those of (Molinari, Bonfigli, Mignani and Paciello (2003); Raimy and Adeoye, 2002 and Ireogbu, 1998) who have observed that although boys tend to have a slight advantage over girls in physics achievement, such differences have not been significant. It should be noted that the non significance observed in gender differences in achievement might have been caused by the prevailing experimental conditions the students were exposed to. This shows that both males and females could do well in the course if they are exposed to appropriate learning situations. This contradicts the findings of the following researchers: (Murphy and White-legg 2005; Serenade, 2003; Akande, 2002 and Adegoke, 1999) who reported that gender influence academic performance of students. It is worthy to note here that from the findings of this study that girl's enrolment in physics has improved more than the boys in the colleges of education under study contrary to the report of some researchers like Babosa (2003) and Raimy and Adeoye (2002) who reported that girls are underrepresented in physics.

Conclusion

Based on the findings of this study it could be concluded that interactive invention instructional strategy enhances physics students' acquisition of science process skills of NCE students than the conventional lecture method. Also that gender has no significant effect on pre-service teachers' acquisition of science process skills.

Recommendations

On the basis of the findings above and the general experience during this study, the following recommendations are considered necessary.

1. Teacher educators should be discouraged from using teacher centred instructional strategies in training pre-service teachers but learner-centred instructional strategies such as interactive invention instructional strategy should be used. The periodic use of such and other innovative strategies will promote high level learning achievement as well as acquisition of science process skills.
2. The NCE curriculum should be revised to move away from content-based to competent-based because the knowledge in science is dynamic and not static and to cope with these changes the teacher should be equipped on how to access and use this new knowledge.
3. Physics teachers (educators) should be encouraged to use appropriate learning programmes to facilitate hand on practices to prove that physics is not as abstract as many people think.
4 As far as possible, girls should be encouraged to take up the study of physics as there is nothing masculine about the subject as already observed from the data analyzed in the study.

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