

EFFECTS OF EDUCATIONAL ROBOTICS ON STUDENTS' ACHIEVEMENT IN BASIC SCIENCE AND TECHNOLOGY AMONG JUNIOR SECONDARY SCHOOL STUDENTS IN NIGER STATE

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Abstract

The study investigated the effect of educational robotics method on students' achievement and interest in Basic Science and Technology. Three research questions and three null hypotheses guided the study. Quasi-experimental design was adopted for the study. The study was carried out in Bida Educational Zone of Niger State. The sample for the study comprised of 80 JSS II students from two intact classes in two secondary schools in Bida Education Zone of Niger State, drawn using multi stage sampling techniques. The experimental group were taught using educational robotics method, while the control group was taught using conventional lecture method. The treatments lasted for four weeks. Two instruments were used for data collection in the study namely; Basic Science and Technology Achievement Test (BSTAT) and Basic Science and technology Interest Inventory Scale (BSTIIS). Data collected were analyzed using mean, standard deviation and Analysis of Covariance (ANCOVA). The results revealed that educational robotics instructional method was superior to conventional instructional method in facilitating students' achievement and interest in Basic Science and Technology. There was no significant difference in the mean scores of male and female students in Basic Science and Technology after the treatment, although male students performed slightly better than their female counterpart. Educational robotics method was more effective than the conventional method. Based on the findings of the study, the educational implications of the findings were highlighted and the following recommendations were proffered among others: that Basic Science and Technology teachers should adopt educational robotics instructional method when teaching in order to enhance students' achievement and interest in Basic Science and Technology.

Keywords: Educational robotics, Basic Science and Technology, Achievement and Interest.

Introduction

Teaching methods are ways used by teachers to create learning environment and to specify the nature of the activity in which the teacher and the learner will be involved during instructional delivery process. It is primarily a description of learning objective-oriented activities and the flow of information between the teacher and the learner(s), O' Banon (2002) categorized teaching method into two approaches; namely; student centered approach and teacher centered-approach. Teacher-centered approaches are grounded in behaviorism and include all the teaching methods that see the teacher as possessor of knowledge. These methods include lecture /expository, demonstration, discussion, recitation etc. while student centered approaches are grounded in constructivism and includes all the instructional methods that underscores teachers as decision makers and problem solvers but rather as a guide in the learning process.

The teacher's role in a student-centered learning environment is, he/she remains the facilitator and guide. The students are in control of their own learning and the power and responsibility are the students' concern. Learning may be independent, collaborative, cooperative and competitive. The utilization and processing of information is more important than the basic content. Learning takes place in relative contexts and students are engaged in constructing their own knowledge (Theroux, 2001). The teacher who utilizes the student-centered method effectively is constantly on the move. The teacher may be engaged with the students as a classroom collective, individually or in groups. Their involvement would include questioning, disciplining, guiding, validating, monitoring, motivating, encouraging, suggesting, modeling and clarifying (McKenzie, 2005). This student-centered method is in line with the National Policy on Education.

In order to improve students' understanding on the nature of science, various Science and Technology courses have been introduced in the curriculum of high schools with expectations to provide skills such as information and communication technologies. Besides computers, in parallel with developments in robotics in recent years, use of robots in teaching and learning environments can be seen. Educational Robotics methods of learning is considered to be an approach that matches constructivism and especially constructionist approaches. Constructionism is a learning and instructional theory which emphasizes the learner's active role and technology is used to create a context that enables "learning by making" and "learning by design". Harel and Papert (2012) argued that knowledge should not just be transmitted from teacher to pupil, but rather constructed in the mind of the students in form of active learning. Hence, students should learn with technology and be actively involved in the learning process rather than learn from technology with traditional practices. Therefore, there are different approaches by which robotics can be used in educational settings. As far as it concerns the use of robotics in educational settings. It can be used as a cognitive tool in a particular lesson, as a teaching technique, or as a subject area itself. Mubin *et al.* (2013) pointed out the various roles of robot in education – as tutor, tool, or peer. In that way educational robots are categorized as: learning materials, learning companions and teaching assistants.

Papert (2003) conducted a study on robotics as a cognitive tool in which he believed that the computer was a tool that could allow children to explore mathematics and other curricular subjects. Bellou & Mikropoulos (2013) suggest educational robotics as mind tools in Physics and Computer Science education through meaningful learning activities. Educators have started to generate ideas and develop activities to incorporate robotics into the teaching of diverse subjects. Science, Technology, Engineering and Mathematics (STEM) are the subjects that use robotics activities more frequently since concepts in Physics and Technology are relevant to the benefits of educational robotics (Barak & Zadok, 2009). Papert (2008) used Logo programming to teach geometry concepts with the movements of a turtle on the computer screen. That approach has evolved to the visual, drag-and-drop programming languages.

Model robots are beneficial especially in teaching such concepts and processes as computer programs, electronic vision, hearing, feeling, and decision-making that students perceive as too abstract or have difficulty in perceiving. As well, robots can be effective in instilling higher-order thinking skills including critical thinking, quantitative thinking, and creativity. In the literature, studies that employ programmable LEGO and Mindstorm robot family can often be encountered. For example, in a study conducted by Sartatzemi (2005), high school students were given training in basic programming using these robots and it was concluded that robots support learning. Harbor (2002) expressed that high school students like to build and program robots and that the students in the experimental group were significantly better than the control group at comprehending embedded systems. The fact that the use of model robots in teaching programming increases student motivation and helps create a learning environment that is more fun was revealed by research performed (Pásztor *et al.*, 2010).

Lecture method is concerned with the teacher being the controller of the learning environment. Power and responsibilities are held by the teacher and they play the role of instructor (in the form of lectures) and decision makers (in regards to curriculum content and specific outcome) They regard students as having knowledge holes that needs to be filled with information. The traditional teacher view is that the teacher causes learning to occur, (Novac, 1998). According to Awodi (2001), the lecture method is mainly teacher- centered, with students being constantly passive and contents are constantly taught as absolute knowledge irrespective of the above comments on lecture method of teaching. Lecture method is mostly employed by most science teachers because of some of its advantages which include the fact that it can be used to cover a large content area at a time and students are given the same content at the same time.

Another major advantage is that it can be used to teach a large class which is a prominent feature in most Nigerian secondary schools. It has been observed that effective teaching may facilitate learning and make it more meaningful. In line with this Sander (2001) stated that effective teaching helps the learner to learn better, while poor teaching would naturally lead to poor learning and consequently poor achievement. Achievement according to Adeyemi (2008) is the scholastic standing of a student at a given moment. It has to do with the successful accomplishment of goal(s). The purpose of testing an achievement is to help the teacher and the students evaluate and estimate the degree of success attained in learning a given concept. Interest on the other hand is an important variable in learning because when one is interested in an activity, one is likely to perform positively.

Chukwu (2001) stated that interest can be expressed through simple statement made by individuals of their like and dislikes. Lack of interest according to Chukwu may be caused by uninteresting teaching methods. Also, Obodo (2002) described interest as the attraction which forces or compels a child to respond to a particular stimulus. This point that a child develops interest if a particular stimulus is attractive and arousing or stimulating. This shows that interest comes as a result of eagerness to learn not by force. The development of interest in basic science and technology as an objective of the basic science and technology teaching, may likely promote achievement in the course. The realization of the goals of education in Nigeria and the gain from its contribution to the National economy, Government shall take necessary measure to ensure among others that educational activities shall be learner centered for maximum self-development and self-fulfilment, (FGN,2013).

It is therefore required by teachers to provide that guidance to learners to be able to learn with little or no assistance. Another issue of contention in Nigeria today is the issue of gender in our educational system. In recent times educators have expressed diverse views about gender and achievement especially in science and technology. While some are of the view that males do better than females, others disagree with this view, arguing that achievement is a factor dependent on several factors such as socio-economic background, teaching method among others. In view of the issues on the use of educational robotics and lecture teaching method on students' achievement and interest in sciences in senior secondary schools. The researchers wish to investigate the effects of educational robotics and conventional lecture methods of teaching on students' achievement and interest in Basic Science and Technology in junior secondary schools in Bida Educational Zone of Niger State.

Purpose of the Study

The main purpose of this study is to find out the effect of educational robotics and lecture methods of teaching on students' achievement and interest in basic science and technology. Specifically, the study determined:

1. The effects of gender on students' achievement in Basic Science and Technology when taught using educational robotics and lecture method.
2. The effects of educational robotics and lecture method on students' achievement in Basic Science and Technology.
3. The effects of educational robotics and lecture method on students' interest in Basic Science and Technology.

Hypotheses

The following null hypotheses (H_0) were formulated and tested at 0.05% level of significance:

H_{0_1} : There is no significant difference in the mean achievement scores of students taught Basic Science and Technology using the two methods.

H_{0_2} : There is no significant difference in the mean interest scores of male and female students taught Basic Science and Technology using the two methods.

H_{0_3} : There is no significant interaction effect of the treatment given to students and their gender as regards their mean interest score in Basic Science and Technology.

Methodology

The design for the study is quasi-experimental design. Like a true experiment, a quasi-experimental design aims to establish a cause-and-effect relationship between an independent and dependent variable. However, unlike a true experiment, a quasi-experiment does not rely on random assignment. Instead, subjects are assigned to groups based on non-random criteria. Specifically, the study applied the non-equivalent control group design, (Janice 2003). Quasi-experimental design is considered appropriate for the study because intact classes was used to avoid disruption of normal class lessons and to control extraneous variables. The area of the study is Bida Education Zone of Niger State. The study was conducted in Bida Educational Zone of Niger State. Bida Educational Zone consisted of Three Local Government areas namely; Bida, Edati and Lavun Local Government areas.

The choice of the zone is borne out of the fact that researches have shown that students in the zone have a lot of problems in Basic Science and Technology (BST). A total of 4,592 respondents comprising of 2,865 males and 1727 females JSS II students offering BST was used as the total population for the study. A

purposive sampling technique was used to select two schools each from the Local Government areas that constituted the population of the study. Therefore, the sampled population was 42 males and 38 females from the six schools. Simple random sampling techniques was used to assign to the 3 schools for experiment group A and hence for control group B. Two instruments: Basic science and Technology Achievement Test (BSTAT) and Basic science and technology Interest Inventory Scale (BSTIIS) were developed by the researcher to collect data for the study. The BSTAT consists of 30 multiple choice items with four options, A, B, C, and D. Each of the items in the BSTAT carries one mark. The Second Instrument is Basic Science and Technology Interest Inventory Scale (BSTIIS) which was designed to assess students' interest in BST on four-point Likert type rating scale thus: strongly agree (SA) = 4, Agree (A) = 3 Disagree (D) = 2 and Strongly disagree (SD) = 1.

The research instruments (Basic Science and Technology Achievement Test and Basic Science and Technology Interest Inventory Scale) were face validated by three experts from the Department Industrial and Technology Education Federal University of Technology Minna. The experts validated the instrument and vetted the lesson plans. These experts validated the items in terms of Clarity of language, Appropriateness and adequacy of the items in measuring what they are supposed to measure. Content validation were done using table of specification. The advice of the experts helped to delete, modify and select the set of test items for the study.

The reliability of the BSTAT was determined using Kuderson formula The internal consistency of Basic Science and Technology Interest Inventory Scale was determined from the response of 20 JSS students from Suleja Educational Zone of Niger State. A reliability coefficient of 0.78 was determined for the instrument using Cronbach alpha (α) formula. The test was administered to 20 secondary school students by their class teacher. An internal consistency of 0.091 was obtained. One-week Training programme was organized for the Basic Science and Technology teachers in the sampled schools to assist in the study. These basic science and technology teachers were trained on how to teach using educational robotics approach.

Basic science and technology teachers in the sampled schools helped the researchers in the collection of data. The teachers collected the data before and after the experiment, after which the researchers collected and organize the data accordingly for data analysis. The scores obtained from the pre and posttest were analyzed using mean and standard deviation for research questions and Analysis of Covariance (ANCOVA) for testing the hypotheses at 0.05 level of significance. ANCOVA was used to test the hypotheses because the experiment involved pretesting of the subjects. ANCOVA was used to remove the effect of the covariate or pretest. The decision on the hypothesis was based on the 0.05 level of significance. Hence any item with a value less than the 0.05 will be accepted and vice-versa.

Results

Research Question 1

What is the influence of gender on the mean interest scores of students taught Basic science and technology using educational robotics and conventional lecture method?

Table 1: Mean (X) and Standard Deviation (SD) of influence of gender on students' mean interest scores in Basic science and technology

Gender	N	Pre Test		Post Test		Mean Gain Score
		\bar{x}_1	SD ₁	\bar{x}_2	SD ₂	
Male	42	1.96	0.66	2.96	0.61	1.05
Female	38	1.11	0.14	1.84	0.51	0.73

Note: N= number of students, SD₁= standard deviation for pretest, SD₂= standard deviation for posttest, \bar{x} = mean.

Table 1 revealed a mean interest of score of 2.96 with standard deviation of 0.61 for male students, while their female counterparts had mean interest score of 1.11 with standard deviation of 0.15. Male students therefore, had higher mean interest in basic science and technology than their female counterparts. Male students had mean gain score of 1.05 while their female counterparts had mean gain score of 0.73. Therefore, male students were superior to their female counterparts.

Research Question 2

What is the interaction effect of method and gender on students' mean achievement scores in basic science and technology?

Table 2: Means (X) and Standard Deviation (SD) on Interaction Effect of Method and Gender on the Mean Achievement Scores of Students in Basic science and technology

Teaching Method	Pre-test			Post-Test			Mean gain score
	N	X ₁	SD ₁	N	X ₂	SD ₂	
Educational robotics							
Male	24	39.74	11.94	24	68.04	18.59	28.30
Female	23	38.21	11.53	23	63.50	14.56	25.29
Conventional method							
Male	15	43.13	10.56	15	60.60	7.88	17.47
Female	18	40.67	11.81	18	55.61	12.04	14.94

The results in Table 2 revealed a higher mean gain score of 28.3 for male students taught basic science and technology using educational robotics method, while their female counterparts had a mean gain score of 25.29. Male students who were taught basic science and technology with conventional lecture method had a mean gain score of 17.47 while their female counterpart had a mean gain score of 14.94. The results do not suggest ordinal interaction effect between method of instruction and genders on students' mean achievement scores in basic science and technology. This was because at all levels of gender, the gain scores were higher for students taught basic science and technology using educational robotics method and the difference in the gain scores of male and female students in each group was tangible. The result showed that there is no interaction effect of gender and methods on students' mean achievement scores in Basic science and technology.

Research Question 3

What is the interaction effect of method and gender on students' mean interest scores in basic science and technology?

Table 3: Means (X) and Standard Deviation (SD) on Interaction Effect of Method and Gender on the Mean Interest Scores of Students in Basic science and technology

Teaching Method	Pre-test			Post-Test			Mean gain score
	N	X ₁	SD ₁	N	X ₂	SD ₂	
Educational robotics							
Male	24	1.94	0.69	23	2.97	0.65	1.03
Female	23	1.13	0.14	24	2.14	0.32	1.01
Conventional method							
Male	18	1.87	0.65	18	2.95	0.58	1.08
Female	15	1.08	0.14	15	1.38	0.95	0.3

The results in Table 3 indicated that male students taught Basic science and technology using educational robotics methods had a mean gain score of 1.03 and their female counterparts had a mean gain score of 1.01. Also, male students taught Basic science and technology using lecture method had a mean gain score of 1.08 while their female counterparts had a mean gain score of 0.3. This indicates that the males in both groups had slightly higher mean gain interest score than their female counterparts. This showed that there is interaction effect of gender and method on students' interest in Basic science and technology.

Hypotheses Testing

Hypothesis 1: There is no significant difference in the interest scores of students taught basic science and technology using the two methods.

Table 4: Analysis of Covariance of Students' Mean Interest Scores in Basic science and technology

Sources of Variation	Sum of Squares	df	Mean Square	F	Sig
Corrected model	30.339	3	10.113	38.304	.000
Intercept	430.050	1	430.050	1628.871	.000
Method	2.875	1	2.875	10.888	.001
Gender	27.852	1	27.852	105.493	.000
Method x gender	2.585	1	2.585	9.789	.002
Total	522.504	80			
Corrected total	50.404	79			

Data in Table 4 showed that there is a significant mean effect for mode of instruction on students' interest in basic science and technology $f(1, 80), p < .001$. The null hypothesis therefore was rejected, indicating that there was significance difference in the mean interest score of students taught basic science and technology using educational robotics method and those taught using conventional instructional method.

H_{O_2} : There is no significant difference in the mean interest scores of male and female students taught basic science and technology using the two methods.

Table 4 above revealed no significant mean effect of gender on student's interest in basic science and technology $f(1, 80) p > .001$. The null hypothesis was not rejected, indicating that there was no significant difference in the mean interest scores of male and female students taught basic science and technology using educational robotics method.

H_{O_3} : There is no significant interaction effect of teaching method and gender on student's mean interest scores in basic science and technology.

Data in table 4 indicated non-significant interaction effect of method and gender on student's interest in basic science and technology $f(1, 80), p > .002$. The null hypothesis was not rejected. The interaction effect of method and gender on students mean interest scores in basic science and technology was, therefore, not statistically significant.

Findings of the Study

From the results obtained in the study on the effects of educational robotics method on student achievement in basic science and technology, it was found out that;

1. Gender did not significantly influence students' interest in basic science and technology although the males scored higher mean interest score.
2. There was significant ordinal interaction between mode of instruction and gender on students' achievement in basic science and technology.
3. There was significant interaction between mode of instruction and gender on students' interest in basic science and technology when taught using educational robotics method.

Discussion of Findings

The gender differences in student's interest could be as a result of the steps involved during the treatment process, given that male students had higher interest than their female counterparts, It could be traced to the fact that female students flourish more in speech, verbal abilities and presentation. They might have found it difficult to do practical activities unlike their male counterparts, female have greater writing capabilities and can memorize words with greater proficiency, while concrete and visual teaching are enjoyed by boys who are effective with toys; such as movable wheels, clocks, motor toys etc. These may have increased the interest of boys in learning basic science and technology using educational robotics method than their female counterparts. The result of the study revealed that male students had higher

mean interest score in basic science and technology than their female counterparts. The finding is in line with the views of Ezeudu (2015) that male student had higher mean interest score in biology than their female counterparts. The finding of the result is that gender was a significant factor in maintaining student's interest in science subjects in schools.

Results of test of interaction indicated significant ordinal interaction effect between mode of instruction and gender on students' achievement in biology. Educational robotics method was superior to the conventional method of instruction on students' achievement in basic science and technology. However, the educational robotics method proved to be most effective than that the conventional method. The students participated more actively in instructions based on educational robotics method of instruction and performed best in the posttest.

Therefore, the interaction of mode of instruction and gender represents a case of ordinal interaction in which the regression lines do not cross each other indicating the superiority of the educational robotics method over the conventional method. The finding of this study with respect to method of instruction agreed with the previous findings of Ibe (2004) who found no significant interaction effect between gender and treatment. In addition, Ibe and Nwosu (2015) found no interaction effect of gender and instructional treatment. Contrary to the finding of this study, Nwagbo(2009) reports a significant interaction effect between gender and instructional treatment (cognitive conflict strategy) on students' conceptual change in physics using cognitive conflict instructional model. This showed that instructional method is not gender biased.

However, the results of the interaction effect of teaching method and gender indicated no significant interaction effect between mode of instruction and gender on student's mean interest scores in basic science and technology. The male students scored higher interest than the female students irrespective of the mode of instruction. The differences in the mean scores however were not significant at 0.05 level of confidence. This is an indication that both male and female students show interest in basic science and technology irrespective of the method used for teaching. This finding may be attributed to the fact that basic science and technology is unified in nature and students at junior secondary school level perceive science as a whole not segmented. This broader picture of science gives them a better and clearer view of the world thereby stimulating their interest.

Conclusion

The study investigated the effects of educational robotics on students' achievement in basic science and technology among junior secondary school students in Niger state. Educational technologists have tried to evolve innovative ways of improving instructional presentation. Consequently, researchers focused on comparison between technology-mediated instructional and non-mediated instruction (conventional method). Hence, possible solutions were put forward. While it is true that robotics has enormous potential to offer in education, perhaps it must be stated that the benefits thereof can only be guaranteed and fully harnessed when the curriculum is combined with an enabling, conducive learning environment and a holistic educational philosophy. The only thing that remains constant in life is change. As the world keep changing in this direction, the government of the day must rise to the occasion in other to actualize it vision to be among the top twenty industrialized country in the next ten years. Taking such steps will definitely provide us with the platform to taking a rightful place in the committee of developed nations.

Recommendations

Based on the findings of this study, and their implications, the following recommendations are made.

1. The Ministries of Education should ensure that textbook authors incorporate educational robotics methods in the instructional methods for secondary schools.
2. Teachers of Basic Science and Technology should make teaching and learning of science gender unbiased.
3. Ministry of Education should ensure that their teachers are trained regularly on the use of innovative instructional approaches eg. educational robotics method.
4. The curriculum planners should ensure that they incorporate educational robotics methods in basic science and technology curriculum, as it will help to promote students' achievement and interest in the subject.

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