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Engendering Science and Mathematics Education in Nigeria through Constructivist Intervention Strategies.

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Abstract

In recent years, overall student performance in science and mathematics has decreased due to poor method of teaching at the Senior Secondary School level in Nigeria. This study was aimed at devising a gender inclusive pedagogical approach to the teaching of science and mathematics that would enable female students achieve along with their male counterparts.

This study was designed to improve the learning outcomes for students, especially girls, studying science and mathematics by using Constructivist Teaching Strategy (CTS) to work collaboratively in small groups.

A total of 511 students (367 girls and 144 boys) in SSS 1 were exposed to four weeks of teaching on selected concepts in science and mathematics using both CTS and Conventional methods of teaching.

Analysis of student outcomes suggests that this approach to learning has improved students' performance especially in science and mathematics. This is evident in the posttest mean score of female students in science; physics (9.77, 14.16); chemistry (8.61, 9.57); biology (10.6, 15.3) and mathematic (7.82, 10.07) control and experimental groups respectively. That is they perform higher in all subjects after treatment. Females who studied science and mathematics in single sexed schools have better posttest scores than those who had theirs in mixed schools physics (17.5, 9.38); mathematics (10.55, 9.00). The reverse is the case in chemistry (9.0, 10.45); except in biology (15.25, 15.43) where the posttest scores are almost the same. Also, according to treatment and school type there is a significant main effect on the overall means scores of girls in science and mathematics.

It is concluded that this study will increase access, improve participation and better performance of girls in science and mathematics. Based on the findings of this study, it would seem appropriate that teachers are exposed to modern method of teaching like the constructivist teaching strategy.

Keywords: Gender, Science, Mathematics, Constructivist Intervention Strategies.

1. Introduction

The continuing prevalence of educational inequality is a major infringement of the rights of women and girls and it is also an important impediment to social and economic development. In most countries, a fundamental aspect of these disparities is inequality in access to and performance in education, especially science education. These inequalities are deep seated and will require special attention and commitment if they are to be removed within the time - frame envisaged by Education for all (EFA) goals in 2015. The International Community has committed itself, in the Dakar Framework for action in the year 2000 to gender equity, among others, which is one of the Millennium Development Goals (MDGS), (UNESCO, 2003/4.UNESCO (2009). Several factors lead to loss of interest in science and technology by girls. Some of these factors were related to gender differentiation in the society, misconception about the role and ability of women and girls, curriculum design and other educational materials as well as teaching-learning approach (Priscilla et al, 2001). The general notion is that scientific and technological pursuits for the males are not only erroneous but also misleading. This has misled some students and teachers. This attitude coupled with the bias of parents at home against science will not encourage female students to participate in science.

Orukotan and Balogun (2001), while condemning the sex-role discrimination in boys and girls in school learning, suggested that schools should be gender sensitive, give similar attention to girls and boys to participate in science classroom, encourage activities that will not promote gender stereotyping, create conducive atmosphere for boys and girls to express themselves without hindrance and to provide science resources and facilities that are gender sensitive. Everyday classroom practices have been established to be more biased against girls than boys and many other school dynamics have negative consequences for female schooling (Erinosho, 2005). Erinosho (2004) opined that the approach to the learning of science in Nigeria is mainly parroting and regurgitation of facts with virtually no link with the immediate environment of the learner. This has caused low participation and retention in science and technology among the youths. This is an undesirable trend and a challenge to science education in Nigeria

Measures to improve the experience of schooling for both boys and girls require a gender perspective in the design of teaching/learning interventions. Teachers are key actors for this change. The need therefore arises for

teachers to be exposed to the modern methods of teaching science and mathematics. Constructivist teaching strategy is one of such innovative strategies that will foster the learning of science and mathematics among students and especially among girls. This constructivist teaching strategy is a learning process where students construct knowledge based on prior experience and understanding. The teacher merely acts as a facilitator. It is student centred and facilitates student interactions and participation.

This study considered the use of constructivist model which has been found to help students take charge of their learning, availed the girls to speak out during interactive sessions and to cope with the changes in many aspects of life. We need to prepare students with a different set of intellectual skills for everyday classroom practices and interactions they have. In constructivist approach to learning, learning is both interactive as well as constructive. The social setting in which learning can occur must be such that learners can interact among themselves in order to negotiate meanings and arrive at a consensus. The challenge to science teaching is to create a living situation that is non-threatening. A key feature of constructivist-teaching strategy is that students should become aware of their own and other pupils ideas and opinions. In most cases, this involves some form of group work which is central to this method. In the Nigerian setting, researches by Asim (1998), and Omoniyi (2003), Harkirat S. Dhindsa and Shahrizal Haji Emran (2006) found that girls benefited more than the boys when constructivist approach was used to teach science. Also in Ghana, Ampiah et al (1998) in his study found that girls out – performed the boys when Constructivist Strategy was used to teach a concept in chemistry.

It has been observed that educational opportunities were not equally available for boys and girls. The need for this study stem from the fact that the school environment is a constraining factor to female education. It is well documented that schools tend to reinforce and even exaggerate the gender stereotype found in wider society (Stanworth, 1983, Barbara and Denice, 2005). Poor methodological approaches are major factors that account for the gender aversion to school science (Erinosho, 2004, Von, 2002) The most frequent method of teaching science and mathematics is lecture type method (Mulewa, 1997; Onwu, 1998, Charlton, 2006) that assumes a passive individualistic and competitive learning style. While such a style may be acceptable to male learners, female learners, particularly in Africa found it problematic, judging from the socialization process. All these lead to poor performance of girls in science and mathematics. In all studies revealed on the performance of males and females in mathematics there is an overwhelming consensus of better performance of boys in mathematics than girls. This causes girls to eventually miss out on careers that need mathematics and sciences thus narrowing their opportunities in the society. Obodo (1993) and Obioma and Ohuche (1980) have indicated types of school as a factor in girls achievement in mathematics. Ike (1977), found in his study that females in mixed secondary schools performed better in mathematics with a mean score of 3.834 as against 3.650 for single sex schools. Obioma and Ohuche (1980) indicated type of schools as a factor in females achievement in science and found in their study that females in mixed secondary schools performed better with a mean score of 3.834 as against 3.650 for single sex school.

They also come up with differing factors ranging from school type, poor self concept greater apathy for science and teachers qualifications as being responsible for poor achievement in science generally. Salau (2002) found that many females in co-educational schools reject science subjects as soon as students have opportunities to select subjects in secondary schools. This is a disturbing situation. Head (1985) says “females are easily influenced by peers who they sometimes trust more than their teachers” according to both authors, science phobia affects females than males. Factors responsible for this are demands of subjects, abstract nature of the subjects, environmental disturbance which affect females than males; and lack of well trained teachers.

Females view some subjects such as physics, calculus, mathematics and chemistry as masculine and very few show interest in them. This is found to be pronounced in co-educational schools where students in that environment are more likely to acquire a perceived gender role than a single sex schools (Duyilemi, (2005)

Duyilemi (2006) also found that low parental expectation, evaluation and encouragement have discouraged many females excelling in science. Of al the factors that are associated with enrolment and achievement of females in STM, social influence during growth and development and social experiences leading to vocational guidance (whyte, 1983) have been identified to have the greatest influence in steering females away from science related subjects.

The challenge is indeed for educators to design new learning strategies and curriculum that would encourage motivation to learn independently and equip students with thinking and problem-solving skills. Students should not be viewed as empty vessels or blank slates that can be filled with lecturing about science (Gilbert Walls and Osborne, 1982;) rather they must be actively involved in the learning process (Millar & Driver, 1987). The focus of this study is therefore to find out if constructivist teaching technique has any impact on student performance as well as gender influence.

This study was guided by two research questions and two hypotheses respectively: -

2. 1 Research Questions

1. Will the performance in Science and mathematics of girls exposed to constructivist teaching strategy be higher than that of their counterparts exposed to conventional method of teaching.
2. Will girls exposed to the constructivist teaching strategy in single sex and mixed schools perform differently in science and mathematics than their counterpart in single sexed schools?
3. Will there be any significant difference in the mean score of girls in experimental and control groups
4. Will there be any significant difference in mean scores of girls in single-sex schools and mixed schools

2.2 **Research Hypotheses**

1. There will be no significant main effect of constructivist-teaching strategy on the overall girls' achievement in Biology, Chemistry, Physics and Mathematics.
2. There will be no significant main effect of school type on overall girls achievement in biology, Chemistry, Physics and Mathematics
3. There will be no significant difference in the mean score of girls experimental and control groups
4. There will be no significant difference in mean scores of girls in single-sex schools and mixed schools

3.0 **Methodology**

3.1 Design – A pretest, posttest, control group, non-randomized experimental design was used. Treatment was at two levels, constructivist teaching strategy and conventional method. This was crossed with school type in a 2 X 2 factorial matrix.

3. 2 Subjects

The subjects for the study comprised a total of 511 students from seven secondary schools in Akoko and Owo Local government areas of Ondo State, in South Western part of Nigeria. The proportionate stratified random sampling technique was used to select 367 girls and 144 boys that participated in the study. Their ages ranged from 16-18 (mean age = 16). The study was conducted in seven schools.

3.3 Instruments

The nine instruments used for the study were developed and validated by the researcher, four response instruments were constructed for achievement tests on selected concepts in biology, Chemistry, Physics and Mathematics. A panel of experts in Psychometrics and subject specialists from Adekunle Ajasin University ascertained the face and the content validity of the instruments. The reliability measures of the four tests were established using Kuder – Richardson formula 21. The reliability of the instrument obtained was 0.79 for biology, 0.92 for chemistry, 0.87 for physics and 0.83 for Mathematics, four stimulus instruments were constructed for constructivist instructional guide on selected concepts n science and mathematics subjects. These concepts are Pollution in (Biology), Electrolysis in (Chemistry), Heat and Temperature in (Physics) and Pythagoras Theorem in (Mathematics). The main steps involved in constructivist instructional approach was tailored towards the steps designed by Biological science curriculum study, "BSCS" (1993). These include: Introduction, Exploration, Explanation, Evaluation and Taking action. A gender responsive pedagogy was also built into the experimental group.

3.4 Research Procedure

16 teachers participated in the study for four weeks, 8 teachers were trained for one week on how to use the constructivist Instructional Guide and on the gender responsive pedagogy that was built into the study. Students in the experimental group were divided into groups and interacted within and between groups. Activities were supervised by facilitators to the students as they direct instructions and correct misconceptions Practical activities were also enhanced within and outside the classrooms.

8 teachers used the conventional method to teach the selected concepts in science and mathematics. This was teacher-centered ("talk and chalk" method) while students are passive listeners.

3.5 Data Analysis

Descriptive (mean) and inferential statistics (2x2x2 ANOVA) were used to analyze the data collected.

4.0 **Results and Discussion**

4.1 **Result**

The first question was answered using descriptive statistics

Table 1 Posttest Mean Scores of Female Students n Science and Mathematics by Treatment

SUBJECT	CONTROL	EXPERIMENTAL
PHYSICS	9.77	14.6
CHEMISTRY	8.61	9.57
BIOLOGY	10.6	15.3
MATHEMATICS	7.82	10.07

From the mean scores displayed in table 1, it could be observed that girls in the experimental group performed, higher n all the subjects after treatment. But there is marginal difference in the scores in chemistry in which case the experimental group has a mean score of 9.57 as against 8.61 for the control. The reason for this may be as a result of the difficulty in the concepts rather than inability of the treatment to make meaningful impact on the students understanding.

Fig. 1 Posttest Mean score of Female students in Science and Mathematics by Treatment

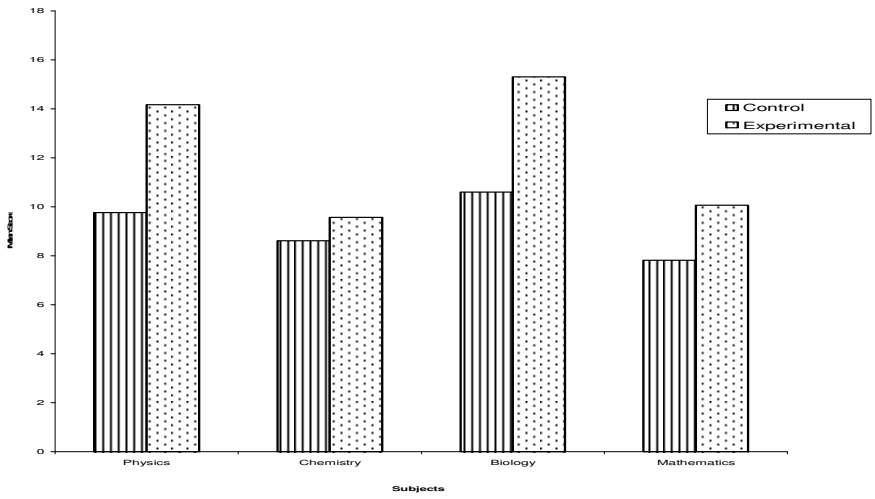

Fig. 1: Posttest Mean Score of Female Students in Science and Mathematics by Treatment

Table 2 Posttest Mean Score of Female Students in Single –Sex and Mixed Schools in Science and Mathematics for the Experimental Group

SUBJECT	SINGLE-SEXED SCHOOL	MIXED SCHOOL
PHYSICS	17.5	9.38
CHEMISTRY	9	10.45
BIOLOGY	15.25	15.43
MATHEMATICS	10.55	9

Fig. 2 Posttest Mean score of Female students in science and Mathematics by School type

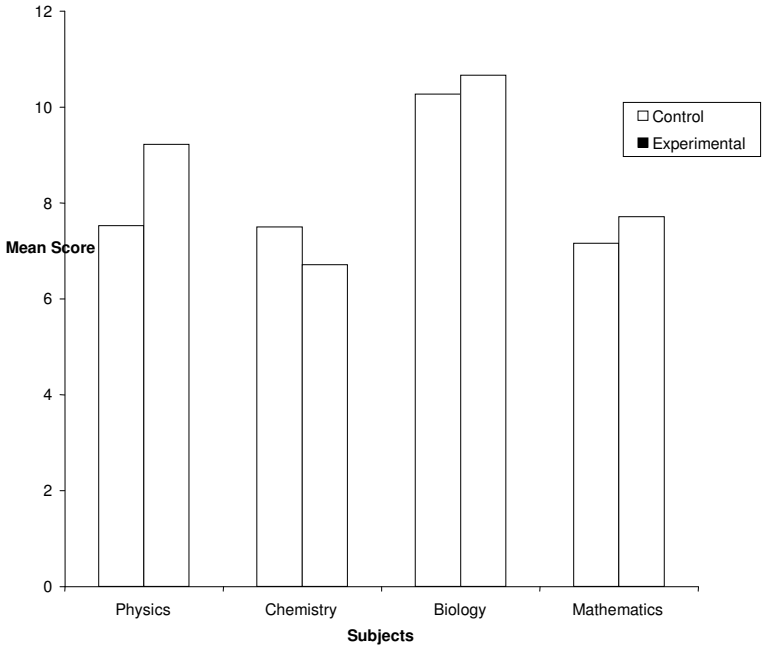

Fig. 2: Pretest Mean Score of Female Students in Science and Mathematics by school type

Table 3: Analysis of covariance of Posttest Overall Achievement scores of Girls in Biology, Chemistry, Physics, and Mathematics according to Treatment and School Type

Source of variation	Sum of squares	Df	Mean square	F	Significant
Covariates	847.426	1	847.426	64.172	.00
Pretest	847.426	1	847.426	64.172	.00
Main Effects	1028.659	2	514.330	38.948	.00
Treat	847.183	1	847.183	64.154	.00*
Sch-Type	185.427	1	185.427	14.042	.00*
2-way interactions	53.366	1	53.366	4.420	.03
Treat Sch-Type	58.366	1	58.366	4.420	.03*
Explained	1934.451	4	483.613	36.622	.00
Residual	4780.383	362	13.205		
Total	6714.834	366	18.347		

Significant at P=0.05

It could be observed that there is significant main effect of treatment on the overall performance of girls n science and mathematics ($F^{(1,366)} = 64.15$;

Table 4: Multiple classification Analysis (MCA) of post-test Overall Achievement Scores of Girls in Biology, Chemistry, Physics and Mathematics according to Treatment

Grand Mean = 10.842

Variance+ category	N	unadjusted dev'n	Eta	Adjusted to independent covariance	Beta
Treatment					
1. Control	173	-1.70		-1.61	
2.	194	1.52	.38	1.44	.36

From the MCA it could be seen that the experimental group had a mean score of 12.23 while the control group had a mean score of 9.23. This shows the efficacy of the treatment group. Hypothesis 3 is there rejected. The $Beta^2$ of 0.1296 indicates that the treatment contributed 12.76% to the variance of the girls' performance in the subjects.

Table 5: Multiple Classification Analysis (MCA) of Post-test overall Achievement Scores of Girls in Biology, Chemistry, Physics and Mathematics according to school Type

Grand Mean = 10.842

Variance+ category	N	unadjusted dev'n	Eta	Adjusted to independent covariance	Beta
1. Girls only	239121	.53		.52	
2. Mixed	28	-1.00	.17 -97	97	.17
Multiple R squard					.279
Multiple R					.529

In order to know the magnitude and direction of the difference, reference was made to Multiple Classification Analysis (MCA) in table 5. Form here it could be seen that girls in single-sex had a mean score of 11.36 as against those in mixed schools with a mean score of 9.87. hypothesis 4 is therefore rejected. The Beta^2 of 0.0279 shows that school type contributed 2.79% to the variance of overall girls' achievement in mathematics and science.

4.2 DISCUSION

From the mean score displayed in table one, it could be observed that girls in the experimental group performed higher in all the subjects after treatment. But there is marginal difference in the scores in chemistry in which case the experimental group has a mean score of 9.57 as against 8.61 for the control. The reason for this may be as a result of the difficulty in the concepts rather than inability of the treatment to make meaningful impact on the students' understanding.

Interestingly, the mean scores of the two sets of students in biology are more or less the same in table two. This shows that irrespective of the type of school, the treatment benefited the female students equally. The situation is different in physics, chemistry and mathematics in which case students in the single sex schools scored higher than those in the mixed schools. The case of physics is unique in the sense that, students in the single sex schools had a much higher mean scores of 17.5 as against 9.38 for those in the mixed schools. It can be concluded that students in the single sex schools concentrated more and thus had better understanding of the physics concepts during the treatment than those in the mixed schools. Obodo (1993) and obioma and ohuche (1980) have indicated types of school as a factor in girls achievement in mathematics. The result as obtained in this study opposed that of Ike (1977), who found in his study that females in mixed secondary schools performed better in mathematics than those in single sex schools. *Th*e fact as revealed in figures one and two supported the findings in tables one and two

In table three, there was significant main effect of treatment on the overall performance of girls in science and mathematics (F = 64.15). This is supported by Asim (1998), and Omoniyi (2003). Harkirat S. Dhindsa and Shahrizal Haji Emran (2006) who found that girls benefited more than the boys when constructivist approach was used to teach science

In tables four and five there was significant difference in the mean scores of girls in single sex schools and mixed schools. This indicates that the treatment contributed 12.76% to the variance of the girls' performance in the subjects. while school type contributed 2.79% to the variance of overall girls' achievement in mathematics and science.

5. **Conclusion**

Conclusively, constructivist teaching strategy is a realistic and deliberate attempt to change students from being recipients of knowledge or passive learners to active participation and performance of girls in science and mathematics. The result is outstanding based on the improvement of girls' performance in physics and mathematics where girls do lag behind the boys in the past. The social interactions among the girls paved way for a kind of social liberation in which case they were able to 'speak out' through interactions among peers.

Based on these findings, the following recommendations are made. More single sex schools should be encouraged in Nigeria as girls in these schools were found to perform better in science and mathematics. A major curriculum reform should be undertaken by policy makers for science and mathematics teachers of science and mathematics should be exposed to constructive teaching strategy and gender responsive pedagogy by the Federal and State Ministries of Education through in-service training and workshops.

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