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EFFECTS OF TEACHING METHODS ON BASIC SCIENCE ACHIEVEMENT AND SPATIAL ABILITY OF BASIC NINE BOYS AND GIRLS IN KOGI STATE, NIGERIA

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ABSTRACT

The study investigated the effects of process-oriented instructional strategies on the spatial abilities of basic science students in Kogi state. Spatial ability contributes immensely to the understanding of science. 702 basic nine students, made up of 316 boys and 386 girls were used for the study. While the experimental group was taught topics in basic science using process-oriented instructional strategies, the control group was taught with lecture method. Variables such as gender and teaching strategies informed the direction of the investigation. Four null hypotheses were formulated and tested at the 0.05 level. Three research instruments; Spatial Ability Test (SAT), reliability 0.81, Basic Science Achievement Test I (BSAT I), reliability 0.87, and Basic Science Achievement Test II (BSAT II) with a reliability of 0.85 were used. Data analysis utilized percentages, frequencies, means, and t-test for independent samples. The results showed that no significant differences in basic science achievement between boys and girls taught by lecture method and those of process-oriented instructional strategies were found. Significant differences were found between the spatial abilities of girls taught by lecture and those taught by process-oriented instructional strategies and between boys taught by lecture and those taught by process-oriented instructional strategies. It was recommended that boys and girls could be taught together; thus solving the problem of space and materials/resources often expensive and relatively scarce in many Nigerian schools. Teachers should emphasize the process-oriented instructional strategies in science teaching

Contribution/Originality: The study found no significant gender difference in basic science achievement between the control and experimental groups. Boys and girls taught by process-oriented strategies performed better in spatial abilities than those of lecture. So, process-oriented instructional strategies should be encouraged among both sexes hence improving their participation in national development.

1. INTRODUCTION

Without controversy, science and its ally, technology, hold the key to national development. Overwhelming evidence abound to show that the developed nations and communities of the world are those with sound education and reliable and sustainable breakthrough in science and technology. Such education has been able to solve human problems like hunger, malnutrition, disease, poor shelter, and so on. On the other hand and sadly too, nations that pay lip service to functional education suffer from the malaise of hunger, disease, malnutrition, and perpetual dependence on industrialized nations for survival, progress and in fact, domination. To realize these objectives, sound pedagogy anchored on delivering the goals of science education cannot be given second place. Process-oriented instructional strategies emanated from the period after 1957 when Russia launched the sputnik into space. Process skills are activity-packed; they are observing, measuring, experimenting, predicting, hypothesizing, etc. As Stohr-Hunt (1996) puts it, there was a paradigm shift from the way science was taught to emphasizing the process criteria that is rooted in hands-on experiences or students' active engagement with the materials and resources of science teaching and learning through the laboratory method. This position is supported by Edsys (2018) who discussed 50 innovative science teaching methods. Some of the methods discussed are hands-on-learning, science games, use of museums and so on. These exploratory approaches are believed to help students learn science well. This awakening affected other nations of the world like a tidal wave, America, Britain, Germany, Africa (including Nigeria), and the reverberations spread all around the world.

Spatial abilities, according to WiseGeek (2012), King (2006), Gage and Berliner (1990) and Kali and Orion (1996) are categories of reasoning skills about the capacity to think about objects in three dimensions and being able to draw conclusions about those objects from limited information. Piburn (1993), Keig and Rubba (1993) and Smith *et al.* (1983) are of the view that this kind of ability is a veritable asset to science teaching and learning. Hoffman *et al.* (2011) said that gender gap in underrepresentation of women in science, engineering and technology workforce is due partly to their relative poor performance in spatial ability tasks. They blamed gender differences in spatial ability on cultural differences. They reported that women from matrilineal cultures performed as good as men but those in patrilineal cultures performed worse on spatial tasks than men. The implication of this finding is that where equal educational opportunities and improved treatment are made available to women, gender differences in spatial ability will be erased. Pappas (2011) stated that gender difference in spatial ability between men and women is due to cultural differences, not innate intelligence. She noted that the way society treats women, that is to say, a particular society's culture, affect their response to spatial tasks. Pushing this discussion further, Oakwood (2016) noted that gender differences in performance in spatial tasks can be eliminated by the framework the task is presented. A more socially friendly frame will elicit better female performance than a typical spatially loaded environment. Curry (2016) argued that gender gaps in spatial cognition are real but are not fixed. Tasks like mental rotation or way finding, orienting oneself in physical spaces are areas men dominate women in performance. Toivainen *et al.* (2018) however, added another dimension to the gender debate in spatial abilities. They said that spatial ability is the most consistent gender difference in which males on the average outperform females. From their twin design studies, even though females with male co-twins had better performance on spatial tasks than female co-twin with females; there was no indication that prenatally transferred testosterones from males to a female twin influences sex differences in spatial ability.

Lecture, otherwise known as expository method, according to Chiappetta and Koballa (2002) is a traditional teacher-centered method that involves the didactic presentation of facts and information. Students are mainly passive listeners where lecture is the prevalent teaching strategy.

In a nutshell, the study investigated the effects of process-oriented instructional strategies on the spatial abilities of basic science students, gender differences and the effect of lecture method on basic science achievement. Four null hypotheses were formulated and tested, the results were presented, discussed and recommendations were made.

2. THEORETICAL FRAMEWORK

Genetic epistemology, propounded by Jean Piaget, is the theoretical framework used to undergird this study. Piaget's main pre-occupation was to discover the origin (genesis) of intelligence or knowledge (epistemology) among children. McArthur and Wellner (1996) reported that Piaget's interest was to study the embryology of the child's concept of space namely topologic, projective and Euclidean spaces. Piaget believes that spatial ability has a genetic linkage and is influenced by the child's active involvement with the environment. Piaget found that children pass from sensorimotor intelligence (0-2 years), to pre-operational (2-7 years), to concrete operational (7-11 years) and formal operational (11 years plus) stages in the same order but not at the same time. Children make sense of their environment by the use of cognitive structures like assimilation, accommodation and equilibration. These progressive adjustments enable the child make sense of his environment, which is learning. The child as a result, grows from egocentric frame, that is, child's immediate environment, to allocentric frame, which is the environment outside his immediate influence. This is the same way that topologic, projective and Euclidean spaces operate; topologic is more primitive, projective is less primitive, while Euclidean is the most advanced form of spatial ability. It presupposes a movement from mere sense appreciation of things to abstract construction even when actual materials may not be present. Teaching emphasis in science must reflect these virtues that encourage active engagement of the children in their own learning. This promotes the development of spatial abilities among children. Males' popularly believed superiority in spatial ability over women as an innate factor has no popular support in literature. The pattern of this development can be explicated by the picture of this skill among basic science students and thus provide a useful index for an intervention.

3. HYPOTHESES

The following hypotheses were formulated to guide the study:

1. There is no significant mean difference in the basic science achievement scores between boys and girls taught by lecture method.
2. There is no significant mean difference in the basic science achievement scores between boys and girls taught by the process-oriented instructional strategies.
3. There is no significant mean difference in spatial ability scores between girls exposed to the lecture method and those exposed to the process-oriented instructional strategies.
4. There is no significant mean difference in the spatial ability scores of boys exposed to lecture method and those exposed to the process-oriented instructional strategies.

4. STATEMENT OF THE PROBLEM

Science teaching and learning in Nigeria is riddled with problems; this often results in poor and declining performances of candidates. It is strongly believed that sound teaching can help to reverse this trend and lead to improved performance in schools. Reviewed the report of an international study on pupil's achievement and reported that Nigerian pupils performed lowest in primary science and last but one in secondary science (Okebukola, 1985) reviewed some research findings and reported that the quality of science teaching in our schools is poor, ineffective and leads to poor achievement. Akpan (1992) reported that students who received laboratory instruction (a kind of process-promoting approach) were superior in science achievement to those who received no laboratory instruction. This worrisome picture coupled with a sizeable number of science teachers using lecture method oblivious of the effects of their action on learning outcomes necessitated this investigation. Again, the nature of the effects of process-oriented instructional strategies on spatial abilities and that of spatial abilities on science achievement between boys and girls is not quite understood, hence the need for this investigation.

5. RESEARCH METHODOLOGY

The research is a quasi-experimental design that employed non-randomized pretest-posttest control group design. All basic nine students of Kogi state of Nigeria constitute the population. The sample of 702, made up of 316 boys and 386 girls was used. The research instruments are Spatial Ability Test (SAT) with a calculated reliability of 0.81, Basic Science Achievement Test I (BSAT I) with a reliability of 0.87, and Basic Science Achievement Test II (BSAT II) with a reliability of 0.85. SAT, a 29-item test was used to determine the spatial ability level of the students. BSAT I was used to classify the students into ability levels, while BSAT II was employed to measure the basic science achievement levels of the students. All the instruments were validated by experts. The schools were surveyed prior to the test to obtain the consent of school administrators and to find out relevant information about the schools and respondents. Schools used are those that have enough human and material resources for the teaching and learning of basic science and must have presented students for the basic science nine certificate examinations previously. Resident basic science teachers were trained for two weeks to serve as research assistants. Intact classes in eight schools were randomly selected and assigned to control and experimental conditions. SAT, BSAT I, and BSAT II were administered as pretest. This was followed by the ten-week treatment. The experimental group was taught topics in basic science while the control group was equally taught for ten weeks through lecture method. Thereafter, SAT and BSAT II were administered as posttest to both groups, the results formed the raw data for the subsequent analysis.

5.1. Research Methodology in Brief

Being a quasi-experimental pretest and posttest non-randomized study, the experimental and control groups were pretested using SAT, ISAT I, and ISAT II. After 10 weeks, of treatment, posttest was administered. These data was analyzed in response to the hypotheses posed for the study.

6. DATA ANALYSIS METHOD

T-test for independent sample was used for the analysis aside from simple descriptive statistics like means, frequencies, and percentages. An alpha value of 0.05 was used to test for significance. However, for the fact that the design of the study is quasi-experimental, the students in control and experimental groups could not be assumed to be equivalent. They were therefore administered pretest before treatment. The pretest scores were subjected to t-test and found not to be statistically significant. Arising from this development, post test scores only were used for the analysis.

7. RESULTS

The pretest and posttest means for spatial ability and basic science achievement for the group taught by process approach, that is, the experimental group and the group taught using the lecture approach, that is, the control groups were not significant:

Data for hypotheses 1 to 4 are presented in Tables 1 to 4:

Table-1. Basic science achievement scores of boys and girls taught by lecture method.

Gender	N	Mean	S.D	Df	t-test	Sig.(2-tailed)
Boys	165	-.497	6.53753	355	1.354	.177
Girls	192	-1.479	7.07992			

Key:
N = Sample size
S.D = Standard deviation
df = Degree of freedom
From Table 1, the mean difference in basic science achievement scores between boys and girls taught by lecture method was not significant.

Table-2. Basic Science achievement scores of boys and girls taught by process-oriented instructional strategies.

Gender	N	Mean	S.D	Df	t-test	Sig.(2-tailed)
Boys	151	1.960	9.21729	343	.106	.915
Girls	194	1.851	9.73181			

Key:
N = Sample size
S.D = Standard deviation
df = Degree of freedom
Data in Table 2 shows that the mean difference between boys and girls taught by process-oriented instructional strategies was not significant.

Table-3. Spatial ability scores of girls taught by lecture method and those taught by process-oriented instructional strategies.

Methods	N	Mean	S.D	Df	t-test	Sig.(2-tailed)
Process	194	4.418	4.61198	384	4.472	.000
Lecture	192	2.202	5.10573			

Key:
N = Sample size
S.D = Standard deviation df = Degree of freedom

Results on Table 3 show that the spatial ability of girls taught by lecture and those taught by process-oriented instructional strategies was significant.

Table-4: Spatial ability scores of boys exposed to lecture method and those exposed to process-oriented instructional strategies.

Methods	N	Mean	S.D	Df	t-test	Sig.(2-tailed)
Process	151	2.874	5.12680	314	2.441	.015
Lecture	165	1.370	5.76916			

Key:
N = Sample size
S.D = Standard deviation df = Degree of freedom

From data on Table 4, the spatial ability of boys taught by lecture and those taught by process-oriented instructional strategies was significant.

Hypothesis 1 was tested using the data in Table 1. Result showed that the mean difference in basic science achievement scores between boys and girls taught by lecture method was not significant. So, the hypothesis could not be rejected.

Hypothesis 2 was tested using the data in Table 2. Result showed that the mean difference in basic science achievement scores between boys and girls taught by process-oriented instructional strategies was not significant. So, the hypothesis could not be rejected.

Hypothesis 3 was tested using the data in Table 3. Result showed that the mean difference in spatial ability between girls taught by lecture method and those with process-oriented instructional strategies was significant. This being the case, the hypothesis was rejected.

Data in Table 4 was used to test hypothesis 4. Result showed that the mean difference in spatial ability between boys taught by lecture method and those by process-oriented instructional strategies was significant. So, the hypothesis was rejected.

8. FINDINGS

The study came up with the following findings:

1. There was no significant mean difference in the basic science achievement scores between boys and girls taught by lecture method.
2. There was no significant mean difference in the basic science achievement scores between boys and girls taught by process-oriented instructional strategies.
3. There was a significant mean difference in spatial ability between girls taught by lecture method and those by process-oriented instructional strategies.
4. There was a significant mean difference in spatial ability between boys taught by lecture method and those taught by process-oriented instructional strategies.

9. DISCUSSION OF FINDINGS

No significant mean difference in the basic science achievement between boys and girls taught by lecture method and those of process-oriented instructional strategies was found. However, boys recorded higher mean gains in basic science achievement than girls even though the differences were not statistically significant. So, neither lecture nor process-oriented instructional strategies is gender sensitive. Erickson and Erickson (1984) argued that biological interpretation on sex related differences in science achievement can be explained by biological factors. This being the case, the plausible reason for the observed differences in science achievement must be due to spatial abilities. There was a significant difference in spatial ability between girls taught by lecture method and those by process-oriented instructional strategies in favour of the latter (that is, the experimental group). The findings of McArthur and Wellner (1996), Kali and Orion (1996) , Hoffman *et al.* (2011), Pappas (2011) and Curry (2016) on the effect of relevant experience and education (which process-oriented instructional strategies emphasize) lend strong support to this finding.

The mean difference in spatial ability between boys taught by lecture and those taught by process-oriented instructional strategies was significant in favour of the latter, hence the influence of practice and education on spatial abilities. Overall, there was no significant difference in basic science achievement scores between boys and girls taught by lecture method and those taught by process-oriented instructional strategies. The mean differences in spatial ability between girls taught by lecture method and those of process-oriented instructional strategies and between boys taught by lecture method and process-oriented instructional strategies were significant in favour of the experimental group. So, it can be concluded that teaching method, as against gender, is a factor responsible for differences in spatial ability among the group studied.

10. RECOMMENDATIONS

The study recommends the following for improving field practice:

1. Since the mean differences in basic science achievement between boys and girls taught by lecture method and those taught by process-oriented instructional strategies were not significant, boys and girls can be taught together in the same classroom. This will save space and resources which are often scarce and expensive to provide in science teaching and learning.
2. Since the mean differences in spatial ability between girls taught by lecture method and those by process-oriented instructional strategies and those of boys taught by lecture and process-oriented instructional strategies were significant in favour of the experimental group, teachers of basic science should sustain their efforts in the use of process-oriented instructional strategies in teaching. The implication is that hands-on-experiences, science game environment and those that predispose children to exploring their environments are better at developing their spatial intelligence. This will improve the spatial ability of the students and hence basic science achievement.

11. CONCLUSION

From the study, the mean differences in basic science achievement between boys and girls taught by lecture method and those taught by process-oriented instructional strategies were not significant. The study established significant differences in spatial ability between control girls (that is, those taught by lecture method) and experimental girls (that is, those taught by process-oriented instructional strategies); this same finding applied to the control boys and experimental boys.

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Foot Note

1. References cited within the abstract have been deleted; the abstract was modified to reduce the number of words to 250 as required.
2. Structure of the study. Refer to the last paragraph of the introduction