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Research article

The Gender Difference In Student's Acquisition of Formal Reasoning Ability In Kaduna State, Nigeria

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Abstract

The study was carried out to determine the gender difference in students' acquisition of formal reasoning ability. The population of the study consisted of 280 senior secondary school class three (SS III) Biology students from five private schools with adequate facilities in Sabon Gari Local Government Area, Kaduna State, Nigeria. Out of the five schools, one school was randomly selected as a study school, 41 subjects (21 males and 20 females) were randomly selected from the population of the study school and were pre and post tested using Group Assessment of Logical Thinking (GALT). GALT was used to measure the reasoning ability of the subjects. The group was taught genetic concepts using learning cycle teaching strategy. The data collected were analyzed using t-test statistics at 0.05 level of significance. Two hypotheses were tested and the following findings were obtained; reasoning ability was found to be gender friendly before treatment; there was no significant difference between male and female in their mean reasoning ability after treatment. There was no significant difference between male and female subjects in their proportional, acquisition of combinatorial and probabilistic reasoning abilities after exposure to learning cycle teaching strategy. However, there was significant difference between male and female subjects in their acquisition of conservational, control of variables and correlational reasoning abilities.

Key words: Gender, difference, acquisition, formal reasoning ability

Introduction

Formal reasoning has been observed by Lawson (1995) to be the key to the understanding of science concepts, students' achievement and interest in science. Mari (2001), has also found out that the understanding of science concepts and the ability to solve science problems have several inter-relationship with formal reasoning ability. This means that the acquisition of formal reasoning ability by both male and female science students is very essential especially at Senior Secondary School level.

Sexism, according to Action Health International (AHI, 2003) is the conscious or unconscious assumption that members of one sex (male or female) are superior to members of the other sex by virtue of their biology. For example, AHI (2003) observed that, it is generally assumed that males are superior and more capable in science and applied Science subjects than females. On the other hand, females are more superior in the Arts and Social Science subjects than males. Generally, humans are born as either male or female, this is biologically determined. The male or female child biological functions do not change over time or with cultures. However, Male and female children are born into various societies or cultures. It means that the reasoning of males and females students may be affected by cultures as each culture has different roles for boys and girls (AHI, 2003). This may account for gender related differences in learning and performance in science. For example, Mari (2001) conducted a study to find out the effects of process skills instruction on the reasoning ability of male and female senior secondary school students. He found out that science process skills instruction was found to be more effective in promoting the acquisition of science process skills in female than their male counterpart.

On the other hand, James (2000) combined reflective writing and concept mapping instructional strategies to find out the attitudes and achievement of pre-service male and female NCE teachers in Biology. He found out that there was no significant difference in the performance of male and female pre-service teachers in terms of achievement and attitude to Biology. Similarly, Usman (2000) conducted a study to find out the relationship between male and female students' performance in practical activities and their academic achievement in integrated science using Nigeria Integrated Science Teacher Education Project (NISTEP) mode of teaching. He found out that there was no significant difference between male and female in their performance in practical activity and academic achievement.

Similarly, Lovoie (1993) & Musheno & Lawson (1999) have found out that there was no significant difference between male and female performance in genetics when taught genetics using learning cycle teaching strategy. As there are many indications from research findings (James, 2000; Usman, 2000; Mari, 2001, Musheno & Lawson 1999) that some instructional methods are gender friendly while others are not and literature reviewed have shown that there is little or no studies conducted in Nigeria to find out the relationship between gender and the acquisition of formal reasoning ability using learning cycle teaching strategy among secondary school students. This study therefore, is intended to establish if there is any relationship between gender and the acquisition of formal reasoning ability among secondary school students in Nigeria using learning cycle teaching strategy.

Objectives of the Study

The objectives of the study are to determine the effect of Learning Cycle teaching strategy on male and female acquisition of formal reasoning ability.

Research Questions

1. What is the difference in the acquisition of formal reasonning ability between male and female students when taught using learning cycle teaching strategy?
2. When taught using learning cycle teaching strategy, what is the difference between male and female students' academic achievement in the following formal reasoning skills?
    a) conservation
    b) proportional reasoning
    c) control of variables.
    d) correlational reasoning
    e) combinatorial reasoning
    f) probabilistic reasoning

Hypothesis

H0:1 There is no significant difference between male and female students in their mean acquisition of formal reasoning ability when taught using learning cycle teaching strategy.

H0:2 There is no significant difference in the pre and post test mean scores of students' taught using learning cycle teaching strategy in the following reasoning skills.

a) conservation
b) proportional reasoning
c) control of variables
d) correlational reasoning
e) combinatorial reasoning
f) probabilistic reasoning.

Research Design and Methodology

This study adopted Ex-post factor research design involving pre and posttest. The study subjects (male and female) were pre-tested to determine the level of formal reasoning ability using Group Assessment of Logical Thinking (GALT). The pre tests were administered to determine if the two groups were equivalent in their formal reasoning ability before the commencement of instruction. After the administration of the pre test, the study subjects were taught genetic concepts as obtainable in Nigerian Senior Secondary Three (SSIII) curriculum using learning cycle teaching strategies for thirteen weeks. At the end of the instruction the study subjects (male and female) were post-

tested using the same instrument. The posttest was used to determine the effect of the treatment given (learning cycle teaching) to the study subjects.

Population for the Study

The population of the study consisted of all the senior secondary class three (SSIII) biology students in the five coeducational private secondary schools with adequate facilities in Sabon Gari Local Government Area, Kaduna State, Nigeria. The total students' population was 280 which comprised 187 boys, 93 girls distributed among five secondary schools in the category. Both private and public secondary schools in Nigeria use the same curriculum for teaching and learning. They equally sit for the same public examinations. The population for the study is presented in table 1.

Table I: Private Schools with Adequate facilities in Sabon Gari LGEA

S/N	Names of School	Boys	Girls	Total
1.	Therbow School, GRA Zaria	49	45	94
2.	Great Hallmark, GRA Zaria	40	62	102
3.	Premier Secondary School, GRA Zaria	12	10	22
4.	Abuhurayrah College, GRA QRTS Zaria	29	38	67
5.	Demonstration Secondary School, A.B.U. Zaria	187	93	280

Source: Sabon Gari LGEA (2009)

Sample and Sampling Procedure

The private secondary schools in Sabon Gari Local Government Area were divided into three categories based on their exclusive similarities. Those schools that have adequate infrastructures, instructional facilities, qualitative teachers and student's enrolment effective selective mechanism were categorized into category 'A'. Those with fairly adequate facilities were categorized into 'B' while those with inadequate facilities were categorized into 'C'. The category 'A' schools, was purposely chosen for the study. This is because the schools in this category have adequate infrastructure, instructional facilities, qualitative teachers and good students' selective mechanism. These qualities make it reasonable to assume that students in this category might have some reasonable number of students functioning at the formal reasoning abilities. One school (Therbow) from category 'A' was randomly selected as a study school. Therbow school had only two classes (A and B) of SSII Biology students. In order to get one class that will constitute the study group, SS III 'A' was randomly selected as a study group.

In order to control other variables that might influence the formal reasoning ability along the period of the study of the participants, a survey of the teaching methods used by teachers in teaching subjects in the study group was carried out. It was found that teachers used lecture/explaining methods in teaching their subjects. In the case of science subjects, the lecturing/explaining method is sometimes followed by practical sessions in which studests are expected to follow a given instruction to arrive at already established facts. This method of teaching has been found not to promote formal reasoning ability (Karplus, 1979). This finding made the researcher to seek the cooperation of the teachers teaching the study group not to change their methods of teaching for the entire period of the study. Which they did. The distribution of subjects used for the study is given in table 2:

Table 2: Distribution of Subjects in the study group.

Name of school	Type of school	No of students Male	Female	Total	Group
Therbow Secondary School Zaria	Co-educational	21	20	41	Experimental

Instrumentation

Group Assessment of Logical Thinking (GALT) was used for the study.

This instrument was used to measure the six reasoning abilities of the study subjects. It was adopted as it was used in 1993 from Roadranka, Yeany & Padilla (1983). It's reliability was re-established with a calculated (r) of 0.79.

The instrument consists of 12 questions testing six reasoning abilities or schemata namely;

a) Conservation
b) Proportional reasoning
c) Controlling variables
d) Probabilistic reasoning
e) Correlational reasoning
f) Combinatorial reasoning.

Items 1 and 2 deals with conservational ability, 3 and 4 test proportional reasoning, 5 and 6 test controlling variables, 7 and 8 test Probabilistic reasoning 9 and 10 test correlational reasoning and lastly 11 and 12 test combinational ability.

In question 1- 10, subjects were required to give reasons for their responses. This is to avoid guess work and to ensure that subjects make judgment based on reasons. Every item was followed with three alternative answers and four reasons for the subjects to choose the most suitable answer and reason. As these reasons could only be abstracted, subjects who make right responses with suitable reasons might have acquired formal reasoning. For items 11 and 12, questions were posed and subjects were required to give possible combinations.

GALT was scored adopting the mode of scoring by Siegel (1989) in which a correct responses and reasons are tied to score. When there is a correct response with wrong reason or vice versa, the item was not scored. However, item 11 and 12 were scored differently. For item 11, marks were given to responses which show a pattern and not more than one error. While item 12 was scored if there is a pattern and not more than two errors or omissions. This is because the number of arrangements required to produce a pattern are more in question 12. This mode was adopted based on the observation by Siegel (1989) that formal thinkers always seek reasons on which to base their judgement and actions. A correct response and reason earns one mark. Correct pattern with one error or two errors earns a mark for question 11 and 12 respectively. A respondent can score a maximum of 12 marks and a minimum of zero mark for a test.

Administration of Treatment

The study group was taught basic genetic concepts as obtainable in West African Examination Council (WAEC) and National Examination Council (NECO) syllabus using Learning Cycle instructional strategy by the researcher. Thirteen lessons, each lasting 40 minutes were conducted over a period of thirteen weeks for the group.

The stages involved in learning cycle teaching strategies used in this study are illustrated below:

Step I: Concept Exploration phase (Development of concept)

The teacher engages the students in the following concept exploration phase activities;

a) presentation of initial physical and or mental tasks which students are not accustomed to; cannot use their existing reasoning patterns in tackling the tasks, consequently, creating initial difficulties in trying to handle the tasks.

b) Involvement of students in active physical/mental activities where they create and debate their results and reflect upon implications and explanations.

c) Involvement of students in group activities where they freely compare and contrast activities, results, explanations etc.

d) Involvement of students in activities that provides a wide variety of scientific investigation approaches.

e) Presentation of tasks and challenges to students where unexpected events will occur and questions will be raised that cannot be answered by looking in textbooks or laboratory manuals.

The Primary purpose of the exploration phase is to allow the students experience, create and discover the concept(s) to be learned by exposing the students to both physical and mental activities related to the concepts without naming or telling them about the concept.

Step II: Concept Introduction phase

The teacher name and explains the students' identified concept(s) using a variety of teaching methods based on the experiences gained by the students in the exploration phase. The teacher establishes a discussion environment where he or she asks students to report and interpret their findings and encourage them to formulate statements on the concept (s) or main idea in their own words.

Step III: Concept application phase

The teacher provides variety of different activities from those of exploration phase in which the students apply the new concept(S) or reasoning pattern to additional examples in order to extend the range of applicability of the new concept (s). The purpose of the application activities is to provide students with experience that help them organize the concepts they have constructed and /learned with other ideas that relate to the concept (s).

Results

The results obtained are presented in tables 3 to 12

Table 3: Distribution of Scores on the Reasoning Ability Test Among the Subjects in the Study Group Before Treatment (N = 41).

Reasoning ability group	Number of subject each reasoning level		Total
	Male	Female	
Concrete level (scores 0-5)	17	18	35
Formal level (scores 6-12)	4	2	6
Total	**21**	**20**	**41**

Using the results in table 3 shows that 17 male students and 18 female students were functioning at concrete operational level and only 4 male and 2 females were functioning at formal operational stage in the study group before treatment.

Table 4: Distribution of Scores on Reasoning Ability Test in Study Group After Treatment (N=41)

Reasoning ability group	Number of subject each reasoning level		Total
	Male	Female	
Concrete level (Scores 0-5)	8	10	18
Formal level (Scores 6-12)	13	10	23
Total	**21**	**20**	**41**

Table 4 shows that 8 males and 10 females were operating at the concrete level and 13 males and 10 females were operating at formal operational stage after treatment. Nine (9) males and six (6) females have moved from concrete to formal operational level because of the treatment.

Hypothesis Testing

There is no significant difference between male and female in their acquisition of formal reasoning ability when taught using learning cycle teaching strategy.

To test the hypothesis, the pre-and post test reasoning ability mean scores of male and female subjects in the study group were compared using t-test statistics. The results are shown in tables 5 – 6 .

Table 5: t-test Analysis of Pre-test Mean Scores in Reasoning Ability of Male and Female Subjects in the Study Group before Treatment

Group	N	$\bar{x}$	SD	SE	DF	t-cal	t-crit	P-value
Male	21	2.67	2.03	0.44	39	0.31	2.02	0.76*
Female	20	2.85	1.06	0.39				

not significant at P $\leq$ 0.05

From table 5 the calculated t-value of 0.31 is less than the t-value critical of 2.02and and P value of 0.76 is greater than 0.05 level of significant acceptance of hypothesis. This means that there is no significant difference in the mean scores of boys and girls in their reasoning ability before treatment. This tends to show that reasoning ability is gender friendly at least before treatment.

Table 6: t-test Analysis of Post-test Mean Scores in Reasoning Ability of Male and Female Subjects in the Study Group after Treatment

Group	N	$\bar{X}$I	SD	SE	DF	t-cal	t-crit	P-value
Male	21	3.52	2.50	0.38	39	0.14	2.02	0.89*
Female	20	3.45	2.20	0.34				

not significant at P $\leq$ 0.05

From table 6 the calculated value of 0.14 is less than the critical value of 2.02 and P value of 0.89 is greater 0.05. This means that there is no significant difference between the mean scores of male and female subjects in the study group after treatment. This also show that both male and female subjects benefited equally from the treatment.

The results of the analysis in tables 3 – 6 shows that there is no significant difference in the mean scores of boys and girls in their reasoning ability before and after exposure to learning cycle teaching strategy. The results suggest that learning cycle teaching strategy is gender friendly. The finding is in disagreement with the general believe that males are superior to females on science reasoning ability. The findings support the observation of Thomas (2004) and Zember & Blume (2009) that the gap between and male and female in science is shrinking. The gender related difference in science reasoning ability often reported by researchers may be due to role expectations and varied motivations of male and female in a society. In this study, the subjects in the study school are children of mostly enlighten parents. It is therefore reasonable to assume that both the male and female children of these parents could have received the same motivations towards science. This could be the reason for the lack of significant difference in the mean scores of boys and girls in their reasoning ability before and after treatment.

H0:2 There is no significant difference in the post test mean scores of male and female students' taught using learning cycle teaching strategy in the following reasoning skills;

- Conservation
- Proportional reasoning
- Control of variables
- Correlational reasoning
- Combinatorial
- Probabilistic reasoning

To test H0:2, the post test means scores of male and female subjects in the study group were compared in the following skills.

Table 7: t-test Analysis of Post-Test Mean Scores of Male and Female Subjects in Study Group in Conservational Reasoning Skill after Treatment

Group	N	XI	SD	SE	DF	t-cal	t-crit	P-value
Male	21	0.52	0.55	0.12				
					39	2.00	2.02	0.05*
Female	20	0.30	0.56	0.11				

significant at P ≤ 0.05

The results in Table 7 show that there is significant difference between the mean scores of male and female subjects after treatment. The null hypothesis is rejected. This shows that the male subjects achieved better than the female subjects in conservational reasoning ability after treatment.

Table 8: t-test Analysis of Post-Test Mean Scores of Male and Female Subjects in Control of Variables Reasoning Skill after Treatment in the Study Group.

Group	N	XI	SD	SE	DF	t-cal	t-crit	P-value
Male	21	0.76	0.90	0.18				
					39	1.04	2.02	0.30*
Female	20	0.58	0.75	0.17				

not significant at P ≤ 0.05

The results in Table 8 show that there is no significant difference in the achievement of male and female subjects in control of variables reasoning ability after treatment. The null hypothesis is accepted. Both the male and female subjects achieved better after they were exposed to learning cycle teaching strategy.

Table 9: t-test Analysis of Post-test Mean Scores of Male and Female Subjects in Proportional Reasoning Skill after Treatment in the Study Group.

Group	N	XI	SD	SE	DF	t-cal	t-crit	P-value
Male	21	0.88	0.81	0.19				
					39	0.87	2.02	0.04*
Female	20	0.73	0.82	0.19				

significant at P ≤ 0.05

The results in Table 9 shows that there is significant difference in the achievement of male and female subjects in proportional reasoning ability after they were exposed to learning cycle teaching strategy.

Table 10: t-test Analysis of Post-Test Mean Scores of Male and Female Subjects in Correlatioinal Reasoning Skill after Treatment in the Study Group

Group	N	XI	SD	SE	DF	t-cal	t-crit	P-value
Male	21	0.43	0.60	0.11				
					39	2.42	2.02	0.02
Female	20	0.80	0.79	0.17				

significant at P ≤ 0.05

The results in Table 10 shows that there is a significant difference in achievement between the male and female subjects in correlational reasoning ability after exposure to learning cycle teaching strategy. The null hypothesis is rejected. The female subjects performed significantly better than their male counterparts in the correlational scheme.

Table 11: t-test Analysis of Post-Test Mean Scores of Male and Female Subjects in Combinatorial Reasoning Skill of the Study Group After Treatment

Group	N	$\bar{X}$	SD	SE	DF	t-cal	t-crit	P-value
Male	21	0.70	0.26	0.07	39	0.81	2.02	0.42*
Female	20	0.13	0.24	0.07				

**** not significant at P ≤ 0.05***

The results in Table 11 shows that there is no significant difference in the mean scores of male and female and subjects in combinatorial reasoning skill after exposure to learning cycle teaching strategy. The null hypothesis is accepted.

Table 12: t-test Analysis of Post-Test Mean Scores of Male and Female Subjects in Probabilistic Reasoning Skill in the Study Group after Treatment

Group	N	$\bar{X}$I	SD	SE	DF	t-cal	t-crit	P-value
Male	21	0.86	0.57	0.11	39	0.36	2.02	0.72
Female	20	0.90	0.50	0.12				

****not significant at P ≤ 0.05***

The results in Table 12 shows that there is no significant difference in the achievement of male and female subjects in probabilistic reasoning ability after exposure to learning cycle teaching strategy. The null hypothesis is accepted.

Findings

1. The mean reasoning ability of males and females did not differ significantly before and after treatment.
2. There was no significant difference in the performance of male and female subjects in proportional, combinatorial and probabilistic reasoning skills after exposure learning cycle teaching strategy.
3. There was significant difference between male and female subjects in conservational, control of variables and correlational reasoning skills after exposure to learning cycle teaching strategy.

Discussion of the Results

The results of the analysis in tables 5 and 6 shows that there is no significant difference in the mean scores of boys and girls in their reasoning ability before and after exposure to learning cycle teaching strategy. The results suggest that learning cycle teaching strategy is gender friendly. The finding is in disagreement with the general believe that males are superior to females on science reasoning ability. The findings support the observation of Thomas (2004) and Zember & Blume (2009) that the gap between and male and female in science is shrinking. The

gender related difference in science reasoning ability often reported by researchers may be due to role expectations and varied motivations of male and female in a society. In this study, the subjects in the study group are children of mostly enlighten parents. It is therefore reasonable to assume that both the male and female children of these parents could have received the same motivations towards science. This could be the reason for the lack of significant difference in the mean scores of boys and girls in their reasoning ability before and after treatment.

The results in tables 7, 8 and 9 shows that there was no significant difference in the performance of male and female subjects in proportional, combinatorial and probabilistic reasoning skills after exposure to learning cycle teaching strategy. This finding is in agreement with that of Mari (2001) where he found that there was no significant difference in the performance of boys and girls in the three skills after they were exposed to process skill instruction. On the other hand, the results (tables 10, 11, 12) show that there is significant difference between male and female subjects in conservational, control of variables and correlational reasoning skills after exposure to learning cycle teaching strategy. The male subjects achieved better than the female subjects in conservation and control of variables and the female achieved better in co-relational reasoning skills. This means that the learning cycle teaching strategy seems to promote the acquisition of conservation and control of variable reasoning skills better in males and promote correlational skills better in females.

Conclusion

The study has shown that:

(i) The mean reasoning ability of males and females did not differ significantly before and after treatment.

(ii) The learning cycle teaching strategy was effective in promoting the acquisition of conservational and control of variables reasoning skills better in male than female subjects and effective in promoting the acquisition of correlational reasoning skill better in female than male subjects.

Recommendations

(i) Since results have shown that learning cycle teaching strategy is gender friendly, it could be used to promote the acquisition of formal reasoning ability of both males and females.

(ii) Since results have shown that learning cycle promotes the acquisition of conservation and control of variables skills better in males and promotes the acquisition of correlational skills better in females, there is the need to use variety of instructional methods in science teaching to promote equal cognitive gains in both male and female students.

Limitations of the Study

The study has the following limitations.

1. The subjects used for the study all came from private co-educational schools with adequate facilities. Federal, State, and private schools with fairly and inadequate facilities were not used. The findings cannot therefore be generalized to Federal, State and private schools with fairly and inadequate facilities.

2. The study was conducted only in Kaduna state and only in Sabon Gari Local government Area. The findings cannot be therefore generalized to other states and other local government areas of Kaduna state of Nigeria.
3. The development and execution of learning cycle teaching strategy activities is a very difficult task. It requires time, materials, competency among others. Time and other constraints could not permit the development and execution of learning cycle activities on genetic concepts as expected.
4. It was practically impossible to control all other variables that might influence the formal reasoning ability along the period of the study of the participants.

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