Gender & Behaviour, Vol. 18 No. 2, June 2020 15654 - 15662
 ISSN: 1596-9231

SEX DIFFERENCES IN INTEGRATED SCIENCE ACHIEVEMENT AT BECE IN CAPE COAST METROPOLIS

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Abstract

Science allows students to explore their world and discover new things, hence, it is an important part of the foundation for education for all children. The purpose of the study was to determine differences in performance of boys and girls in Integrated Science at Basic Education Certificate Examination (BECE). The study intended to find out if significant differences exist in the performance of boys and girls in Integrated Science and further investigated if gender has any effect on students' achievement in the subject. Comparative and relational designs were employed for the study. The study was conducted in some selected Junior High Schools (JHS) in Cape Coast Metropolis. The accessible population was a set of mixed public JHS in the OLA circuit. In all, three JHS were selected from the schools in the circuit using the simple random sampling technique. The BECE results in Integrated Science for the past five years (2013-2017) were used. Independent samples t-test and chi square were used to analyze the data. The trend in performance seemed to favour the boys more than the girls. The study discovered statistically significant difference in the performance of boys and girls, with boys performing better than girls. Moreover, it was found out that gender has no significant effect on students' performance. The findings suggest that the level of achievement in science is not gender-dependent. It is therefore proposed that, assessment techniques and pedagogical practices that improve girls' knowledge, attitude and participation in science should be employed by teachers.

Key words: Integrated Science; achievement in science; gender differences; BECE; pedagogical practices

Introduction

Gender differences in academic achievement have been a subject of great interest not only to educational or social researchers but to the public as well. Education both formal and informal, has become not only the most powerful channel for spreading the forces of change but also for societies emancipation. But since ancient times education either formal or informal has tended to be gender discriminatory (Ampiah, 2002). According to Ampiah, the British colonial educationist introduced a curriculum for African girls stressing domestic activities instead of Art and Sciences as was pursued by the male counterparts. Equal participation of boys and girls in education in Ghana became an issue with the reforms in 1987. More than decades after the introduction of the reforms, participation of girls in science at Senior High School (SHS) level is low (Buabeng, Ampiah & Quarcoo-Nelson, 2012).

The promotion of gender equality and empowerment of women is the Goal 5 of the Sustainable Development Goals (SDGs) in which United Nations (UN) members have pledged to meet by the year 2030. Recent studies that attempted to evaluate the progress of SDGs toward girl child education has shown dismal progress made in bridging the gender divide worldwide (Mamoon, 2017; Modi, 2017; Sengupta & Roy, 2018). Several debates concerning performance levels in education have been identified both in literature and in the press. It is pertinent to note that significant improvements have been recorded over the years in terms of levels of performance in education across a wide spectrum of subjects and courses worldwide (Fink, 2013; Gammie, Paver, Gammie & Duncan, 2003). Encompassed within the general attainment level is the differential performance of males versus females, and a gender issue within the educational literature is an area which has attracted a lot of attention.

Studies on the biological explanation of gaps in performance between male and female learners suggested that differences in brain structure, hormone production, and/or maturation rates may account for differentiated performance in school-related tasks (Gurian, 2010; Kimura, 2005; Viadero, 2006;). Studies further show that the parts of the brain responsible for processing verbal information and permitting the exchange of information between hemispheres were more highly developed in girls (Gurian, 2010; Kimura, 2005). Girls

also demonstrated earlier development in the brain regions responsible for impulse control, and, in general, matured earlier than boys (Viadero, 2006). However, the extent to which these biological differences manifested themselves in behavioural differences and their implications for learning is unknown. In the literature many inconsistent findings exist, for example, studies have shown that girls and boys are found to perform equally well if instructional context is fair and conducive (Campbell, Jolly, Hoey & Perlman, 2002, Erinosho, 2008).

Okwo and Otunba (2007) reported that gender influence achievement by 13.39% of the total influence factor. The authors further reported that boys performed better than girls in physics essay test. The joint influence of cognitive style and gender on the achievement of students in physics essay test was significant. Moreover, Adesoji (2008) also discovered that girls performed creditably well than boys in chemistry which involves visual representation of matter.

Gender differences in science achievement on the National Assessment of Educational Progress (NAEP) and science courses taken between boys and girls in United States of America (USA) were minimal (Coley, 2001). Raimi and Adeoye (2002) in their study on gender differences among college students as determinants of performance in Integrated Science found out that there is significant difference between male and female students in terms of their science achievement. However, the findings showed that males performed better than their female counterparts in Integrated Science achievement scores. Also, Raimi and Adeoye's (2002) findings revealed that there is a significant difference between male and female students in term of their attitude towards Integrated Science in favour of males. Perhaps, this has been the reasons for males' better performance in Integrated Science achievement. Furthermore, Olasehinde and Olatoye (2014) examined scientific attitude, attitude to science and science achievement of senior secondary school students in Katsina State, Nigeria. The findings of the research showed that there was no significant difference between male and female students in overall science achievement ($t = -0.678$, $p>0.05$). Notwithstanding, Fabunmi (2004) found that gender composition influenced the performance in science of secondary school students in Nigeria states of Edo.

Aside the fact that studies are not conclusive on gender and science performance, gender differences in science performance tend to be concentrated on SHS and also schools in the developed jurisdictions. This calls for more empirical investigation to be done on the subject of gender and science performance with particular focus on Junior high Schools (JHS). There is the need to find out whether any relationship exists between gender and performance in Integrated Science at the Basic Education Certificate Examination (BECE) level. It is also necessary to find out if the performance in Integrated Science is gender-dependent so that the necessary recommendation can be made for consideration. The study was therefore guided by the following research questions:

1. What is the trend of performance for boys and girls in Integrated Science from 2013 to 2017?
2. Is there any significant difference in Integrated Science achievement between boys and girls at the BECE?
3. Is the level of achievement in Integrated Science at BECE dependent on gender?

Theoretical Framework

The study was underpinned by sex-based differences in brain function theory. However, sex-based differences in brain function was not explored in the field research for the fact that theoretical and research work in this area has largely been abandoned. Its review therefore was just to provide a historical context for the substantial issue of 'sex differences in science achievement between male and female students.'Brain-based sex difference theories assert that male and female brains function differently and thus give rise to varying levels of success for females in a variety of pursuits (Baird, 1997). In the seventeenth and eighteenth centuries, western scientists began to develop biological theories to explain the superiority of the male intellect. One early theory was that males were more variable than females (Shields, as cited in Baird 1997). This, according to Shields meant that while males and females might have the same average intelligence, males were given to a broader range of intelligence while females remained clustered around some average value. As a result, the most intelligent males were far superior to the most intelligent females and the least intelligent males were far inferior to the least intelligent females.

The theoretical work moved from the abstraction of variability to the physical characteristics of brain. Early researchers asserted that males were more intelligent than females due to their greater brain size (Baird, 1997; Harvey & Krebs, 1990; Restak, 1984, 1995) This argument was abandoned when it was determined that animals with larger brains (elephants and whales, for example) should have greater intelligence than humans of either gender. The brain size theory was then modified to place importance on the ratio of brain mass to body mass; this was abandoned when it was found that females came out with a higher ratio (Baird, 1997; Gaub & Carlson, 1997; Irwing & Lynn, 2005; Lynn, 1999). As brain research became more sophisticated, so did the arguments for the superiority of male intelligence. First, the frontal lobe was thought to be the seat of intelligence, and researchers observed that the frontal lobe was larger and better developed in males while the parietal lobe was larger and better developed in females (Baird, 1997; Fausto-Sterling, 2008; Goldberg, 2002; Stuss & Anderson, 2004). But later research suggested that the parietal lobe was a better indicator of intelligence than the frontal lobe, and around that time researchers came out to say that the parietal lobe was larger and better developed in males while the frontal lobe was larger and better developed in females (Alvarez & Emory, 2006; Fausto-Sterling, 2008). Eventually, the theories revolving around the physical size or characteristics of the brain died out; none are considered valid in modern brain research. Accordingly, they were replaced by a host of theories revolving around the genetic differences between males and females.

Genes are the cellular material known to determine a number of traits and characteristics passed from parents to offspring via chromosomes (Baird, 1997). Since males and females have different chromosomal make-ups, it seemed natural for researchers to look for a genetic rationale for male superiority. One of the most high-profile examples is the work of Benbow and Stanley who claimed to have found the male mathematics gene (Benbow & Stanley, 1980, 1981, 1982). They administered the mathematics portion of the Scholastic Aptitude Test (SAT) to mathematically gifted JHS students in USA. The result was that males consistently outperformed females. Since males and females are exposed to the same level of instruction in mathematics from elementary school through JHS, Benbow and Stanley concluded that the difference was due to genetically inherited ability. Critics were quick to point out that girls and boys undergo different experiences with mathematics in the classroom and are given different kinds of encouragement outside the classroom. The parents of the children in the study were found to have given boys more mathematics and science toys than girls (American Association of University Women [AAUM], 1989). Moreover, the parents also had higher educational expectations for their boys than they did for their girls (AAUM, 1989).

Critically looking at the literature, one is left to wonder why nearly all of the brain and genetic research was directed toward scientifically proving male superiority. Perhaps it might be as a result of the male-dominated society in which we live (Baird, 1997). Arguments supporting brain-based sex differences and genetic characteristics remain relevant in the current literature because it has been shown that hormones affect brain function and lead to differences in ways individuals go about solving problems (Kimura, 1992).

Research Methods

Design

Comparative and relational designs were employed for this study. In comparative research, the researcher is interested in identifying similarities and/or differences between or among group of persons (Creswell & Clark, 2011; Sarantakos, 2005). This study intended to compare the differences in performance of boys and girls in Integrated Science. Also, the study sought to find out whether differences in performance between boys and girls were gender-associated. The relational research design is primary concerned with determining the extent of the association between two or more variables. The design enabled the investigator to analyze the association between the variables (gender and performance) and also developed possible generalization that will make it possible to extend its conclusion beyond the schools that were in the study (Sarantakos, 2005).

Population and Sample

The target population for the study was the JHS in Cape Coast Metropolis of Central region in Ghana. However, the accessible population was a set of public mixed JHS in OLA circuit within the Metropolis. OLA circuit was selected because it has the highest number of schools in the Metropolis. The circuit has a total of 11 JHS, at the time of the study. this number was made up of eight public schools and three private schools. The schools selected for the study according to the Metropolitan Assembly are considered as urban

schools. Three mixed public JHS were purposively sampled as a convenience sample for the study (Creswell, 2007). Reasons for selecting these schools included easy accessibility of result documents and willingness of school leaders to engage with the researcher. BECE results for these schools for the years 2013 to 2017 were used for the study. All the candidates in each year were included in the study. In all, 614 students comprising of 330 boys and 284 girls were used for the study. The breakdown numbers in relation to the years is presented in Table 1.

Table 1: Gender Distribution of the Sample

Year	Number of Boys	Number of Girls	Total
2013	64	58	122
2014	81	59	140
2015	60	57	117
2016	60	51	111
2017	65	59	124
Total	330	284	614

Instruments

The main instrument that provided the researcher with information was students' final BECE results that had been released by the West African Examination Council (WAEC). Data were collected from documents containing students' final examination results or grades in Integrated Science at the BECE for 2013 to 2017 academic years.

Data Analysis

The analysis was done by research questions. Research question one was analyzed using descriptive statistical methods – percentages, means and graph where appropriate. Inferential statistics – independent samples t-test and chi-square were employed for the analysis of research questions two and three. The descriptive statistics not only enabled the researcher to gain an overall view of the findings but also allowed the researcher to identify the trend and displayed the relationship between parts of the findings. The independent-samples t-test and chi-square were used to investigate the difference in performance of Integrated Science between boys and girls, and the association between the variables (gender and performance) respectively.

Findings

Trend of performance of boys and girls in Integrated Science

Research question one sought to determine the trend in performance of boys and girls in Integrated Science over the years under consideration, 2013-2017. The data for analysis of research question 1 were organized into frequency tables for each year and mean scores were computed. The distribution of the grades of the JHS boys and girls for 2013 is presented in Table 2.

Table 2: Frequency Distribution of Grades for the Year 2013

Grade (x)	Number of Boys (f)	Number of Girls (f)	fx (Boys)	fx (Girls)
1	23	15	23	15
2	15	10	30	20
3	7	12	21	36
4	2	5	8	20
5	8	3	40	15
6	3	7	18	42
7	4	3	28	21
8	1	1	8	8
9	1	2	9	18
Total	64	58	185	195

Table 2 shows that 45 students out of a total of 64 male students had grades from 1 – 3, 13 had grades from 4 – 6 whereas 6 obtained grades from 7 – 9. Also, out 58 female students, 37 girls obtained grades from 1 – 3, 15 had grades from 4 – 6 and 6 had grades from 7 – 9.

The mean grades for the boys and girls for 2013 were computed from Table 2 as follows:

$$\text{Mean grade for boys } = \frac{\Sigma fx}{\Sigma f} = \frac{185}{64} = 2.89$$

$$\text{Mean grade for girls} = \frac{\Sigma fx}{\Sigma f} = \frac{195}{58} = 3.36$$

This shows that the average grades in Integrated Science for the boys and girls in 2013 were 2.9 and 3.4 respectively. The distribution of the grades of the JHS boys and girls for 2014 is presented in Table 2.

Table 3: Frequency Distribution of Grades for the Year 2014

Grade (x)	Number of Boys (f)	Number of Girls (f)	fx (Boys)	fx (Girls)
1	25	14	25	14
2	20	20	40	40
3	6	5	18	15
4	4	1	16	4
5	6	0	50	0
6	11	8	66	48
7	6	8	42	56
8	2	3	16	24
9	1	0	9	0
Total	81	59	262	201

Table 3 shows that 51 boys and 39 girls obtained grades from 1 – 3 and 21 boys and nine girls had grades from 4 – 6. However, the number of boys and girls who obtained grades from 7 – 9 were nine and 11 respectively. Similarly, the mean grades for the boys and girls for 2014 were computed from Table 3 as follows:

$$\text{Mean grade for boys} = \frac{\Sigma fx}{\Sigma f} = \frac{262}{81} = 3.23$$

$$\text{Mean grade for girls} = \frac{\Sigma fx}{\Sigma f} = \frac{201}{59} = 3.41$$

This shows that the average grades in Integrated Science for the boys and girls in 2014 were 3.2 and 3.4 respectively. The frequency distribution of grades for 2015, 2016 and 2017 followed the same pattern as shown in Table 2 and Table 3. The overall mean grades (performance) of boys and girls in Integrated Science from 2013 to 2017 is presented in Table 4 and Figure 1.

Table 4: Mean Grade of Students in Integrated Science from 2013 to 2017

Year	Boys	Girls
2013	2.9	3.4
2014	3.2	3.4
2015	2.4	3.1
2016	3.3	3.6
2017	2.1	3.3

The means scores and their corresponding years were used to plot a graph to investigate the trend of performance as shown in Figure 1. The BECE grades in Ghana is such that the lowest point communicates the best grade. The grade points begin from 1 to 9. This is to say that the bigger the point, the lesser the grade, for example, grade 5 is lesser than grade 4, and grade 4 lesser than 3 in that other to the last and better grade 1. However, the lowest grade is 9.

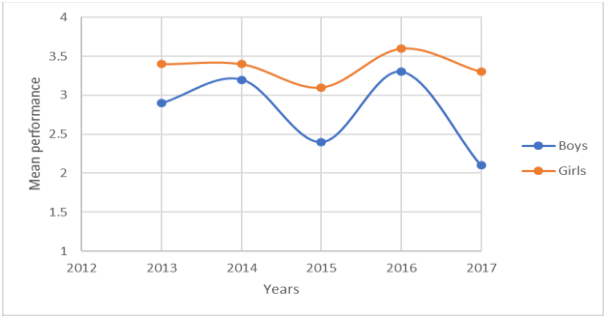

Figure 1: Trend of performance of JHS boys and girls in Integrated Science

Figure 1 revealed that performance of students over the years did not follow any particular trend. The trend of performance can be seen as undulating in nature – rising and falling. The boys mean grade was better (M = 2.9) in 2013 but declined (M = 3.2) in 2014. In the year 2015, the mean grade of the boys was far better (M = 2.4) than the previous years. However, the performance declined (M = 3.3) in 2016 and rose to 2.1 in 2017. The best performance of the boys was recorded in 2017. With respect to the mean grades of the girls, the pattern was not too different from that of the boys. The mean grade was constant (M= 3.4) for the first two years (that is 2013 and 2014). The performance improved (M= 3.1) in 2015. In the year 2016, the performance for girls declined (M= 3.6) and became slightly better (M= 3.3) in 2017. Clearly, the data show that, performance of students at BECE in the OLA Circuit for these five years has been that of "rise and fall" type with the boys performing better than girls.

Differences in the Performance of Boys and Girls in Integrated Science Subject

Research question two sought to determine whether there was any significant difference in performance between boys and girls at the BECE Integrated Science subject. When an independent samples t-test was conducted to investigate the difference, the results of the test, as presented in Table 5, were statistically significant, t (612) = -2.89, p = 0.004. That is, on the average, male students performed relatively better (M = 2.80, SD = 2.21) than female students (M = 3.40, SD = 2.37).

Table 5: Independent Samples T-Test of Differences in Level of Performance between Boys and Girls in Integrated Science

Variable	Group	N	Mean (M)	Std. dev. (SD)	t	p-value
Students achievement in Integrated Science	Boys	330	2.80	2.21	-2.89	0.004*
	Girls	284	3.40	2.37		

*Significant, P < 0.05 df = 612

Effect size statistics (r), also called eta squared, however, showed that the magnitude of the difference observed was small (r = 0.12). That is, only 1.4% of the variance in students' achievement in Integrated Science was explained by gender. The threshold values for interpreting effect size are given as follows: r = 0.10 for small effect; r = 0.30 medium or moderate effect; and r = 0.50 large effect (Cohen, 1988; Field, 2009; Pallant, 2007).

Association between Gender and Performance

Research question three sought to determine whether the level of performance of boys and girls in Integrated Science at the BECE was dependent on their sexes. The purpose of this question was to find out whether, on the basis of the obtained results, there is a relationship between gender and achievement, that is, whether achievement is gender based. Chi-square test was employed for this purpose. In the language of the chi-square test, are the variables (gender and achievement) dependent or independent? To analyze the data obtained, students' grades for the years under review were coded into three categories namely high (for

grades 1 – 3), medium (for grades 4 – 6) and low (for grades 7 – 9). The coded categories were cross tabulated and result presented in Table 6.

Table 6: Chi-Square Crosstabulation Analysis of Performance Dependency on Gender

			Achievement			
			1-3 (high)	4-6 (medium)	7-9 (low)	Total
Sex	Boys	Count	238	59	33	330
		Expected Count	225.2	65.0	39.8	330.0
		% within sex	72.1%	17.9%	10.0%	100.0%
		% within achievement	56.8%	48.8%	44.6%	53.7%
		% of Total	38.8%	9.6%	5.4%	53.7%
	Girls	Count	181	62	41	284
		Expected Count	193.8	56.0	34.2	284.0
		% within sex	63.7%	21.8%	14.4%	100.0%
		% within achievement	43.2%	51.2%	55.4%	46.3%
		% of Total	29.5%	10.1%	6.7%	46.3%
Total		Count	419	121	74	614
		Expected Count	419.0	121.0	74.0	614.0
		% within sex	68.2%	19.7%	12.1%	100.0%
		% within achievement	100.0%	100.0%	100.0%	100.0%
		% of Total	68.2%	19.7%	12.1%	100.0%

Pearson Chi-square = 5.277 Asymp. Sig. (2-sided) = 0.071

As can be seen from Table 6, 72.1% of the boys and 63.7% of the girls obtained grades from 1 – 3 and 17.9% boys and 21.8% girls had grades from 4 – 6. The percentage of boys and girls who obtained grades from 7 – 9 were 10.0% and 14.4% respectively. The Pearson Chi-Square value is 7.277, with an associated significance level of 0.071. To be significant, the Sig. value needs to be 0.05 or smaller. In this case, the value of 0.071 is larger than the alpha value of 0.05 therefore, the result is not significant. This means that the proportion of boys who obtained grades 1 – 3, 4 – 6, and 7 – 9 is not significantly different from the proportion of girls who obtained similar grades. Thus, there is no association between achievement and gender at BECE. In order words, achievement in the subject (Integrated Science) does not depend on gender.

Discussion and Implications

The observable patterns that emerged from the performance of Integrated Science at BECE for the five years under review established an undulating performance. In other words, performance was in a "rise and fall" pattern. The best performance of the boys was recorded in 2017 and the lowest performance was recorded in 2016. The best performance of the girls was in 2015 and the lowest performance was in 2016. Clearly, the performance in Integrated Science for boys and girls was very poor in the year 2016, however, performance improved slightly in 2017 for both gender but with boy's performance being better than girls. The undulating nature of performance for students, especially, girls create room for concern for stakeholders in education. Stakeholders attention need to be directed to this situation for further deliberations and investigate into this nature of performance. With promotion of gender equity and empowerment of women in Goal 5 of the SGDs and Science, Technology, Engineering, Arts and Mathematics (STEAM) education across basics and senior high school levels in Ghana, one would expect to see a linear and upwards trend of performance of the students in Integrated Science.

Further, investigation into the difference in performance of boys and girls in Integrated Science showed that boys performed relatively better than girls. This situation is a worrying especially, in a society whereby most of our policy framework is directed towards bridging the gap in science and technology for both sexes. The finding does not differ from what is known in the literature. In order words, the supreme performance of boys over girls appear to be a global situation. For example, Okwo and Otunba (2007) further reported that boys performed better than girls in science related courses. They further intimated that the reason for supreme performance of boys might be due to joint influence of cognitive style and gender on the achievement of science. Moreover, Raimi and Adeoye (2002) in their study on gender differences among college students as

determinants of performance in Integrated Science also found out that there is significant difference between male and female students in terms of their science achievement with boys performing better than girls. Further, Coley (2001) discovered significant differences in boys and girl's performance in science in the United States and found boys to be better.

In spite of the significant difference found between boys' and girls' achievement in Integrated Science, further analysis showed that the magnitude of the difference observed was small (r = 0.12). It was found that only 1.4% of the variance in students' achievement in Integrated Science was explained by gender. It shows that there are other factors that hinder students' performance in the subject especially within the target population. This calls for stakeholders in science education to work assiduously to identify factors that will help eliminating the significant difference in Integrated Science achievement between boys and girls. The current study has also established that no association exists between achievement and gender at BECE. That is, the level of achievement in Integrated Science is not gender-dependent. This means that both sexes have the potential to perform at equal levels. This finding is contrary to Gardener's (1985) assertion that gender is probably the most single important variable related to students' performance in science. The findings also do not support the arguments about the brain-based sex differences and genetic characteristic theories. Even though gender composition may influence achievement in science of senior secondary school students as reported by Fabunmi (2004), the same cannot be said about performance in basic school science as reported in this current study.

Conclusion and Recommendations

The study reveals that sex differences in Integrated Science achievement exist between boys and girls at BECE with boys performing better than girls. However, the difference in the performance is not gender-dependent, i.e. the two variables are independent. This means that the differences in performance between both sexes could not be attributed to the brain-based sex differences and genetic characteristics. It is not clear why male students perform relatively better than their female counterparts. The findings suggest that there are other important factors that could hinder girls' performance in basic school science. It is therefore recommended that researchers should intensify efforts to find out possible variables that will improve students' achievement in science among JHS female students. Also, stakeholders in science education should design policies and programs which respond to the differential and experiences of both sexes in the JHS Integrated Science subject. In addition, it is proposed that, assessment techniques and pedagogical practices that improve girls' knowledge, attitude and participation in science should be employed by teachers. Again, future studies should investigate female students' learning progress and their science learning experience in the classrooms of the JHS.

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