Is Gender a Factor in Mathematics Performance among Nigerian Senior Secondary Students with Varying School Organization and Location?

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Abstract—**The mathematics performance of graduating senior secondary year three students over a period of 10 years was investigated for possible gender differences. Data were drawn from students' (880 males and 900 females) mock examination mathematics results from eight secondary schools (2 rural schools, 2 urban schools, 2 single-sex schools and 2 co-educational schools) in southeastern part of Nigeria. The independent t-test analysis of significance revealed a significant effect of gender in mathematics performance among the sample data. Also, there were significant differences in the mathematics performance of single-sex male and female students and rural male and female students, all in favour of male students. Based on the findings, the study recommended among others that more co-educational secondary schools be established to engender healthy rivalry between the male and female students in mathematics education since co-educational schools have the tendency to mitigate the performance gap between male and female students in mathematics.**

Keywords— **Gender difference, mathematics performance, school location, school organization**

1. INTRODUCTION

Is male's superiority in mathematics genetically programmed? Efforts at addressing this question dominated the 20^{th} century and the increasing influence of feminist perspectives has stimulated many large-scale studies in the 21^{st} century. Obviously, males and females in view of their biological structures are naturally different. While males are physically strong the females are weaker and this sometimes creates poor patronage in physically demanding careers by females [4]. Certainly, "many more males than females" are in engineering, medicine or any science-related careers which are physically demanding and use "advanced mathematics beyond arithmetic" [19].

The topic of this study is premised on the current world trend and research emphasis on gender issues following the millennium declaration of September 2000 [8] and the Agenda for the Future developed at the 1997 UNESCO Conference [6]. Both organizations sought the promotion of gender equity, the empowerment of women and the elimination of gender inequality at all levels of education. Despite these bold attempts, gender inequality in education generally and in mathematics education in particular has remained a perennial global phenomenon [4, 5, 7]. There is an avalanche of research literature that apparently confirms the perturbility of male superiority in mathematics virtually at all levels of education, the pre-kindergarten level inclusive [4].

In Nigeria, and perhaps Africa, gender gap in mathematics is still very prevalent although findings on this issue are equivocal [2, 4]. In Nigeria, [1] found no significant relationship between gender and achievement in number and numeration, algebraic process and statistics. They however found the existence of a weak significant relationship in Geometry and Trigonometry. Reference [3] concluded that there exists significant gender difference in rural students' mathematics achievement in favour of males in Nigeria. Globally, the issue of gender gap in mathematics has produced inconclusive results. Throughout the senior high school years, male superiority in mathematics is well pronounced [13, 23, 28] and more males than females are frequently reported as doing better on problem-solving tasks and applications [12, 15, 30]. Exceptions to these results are studies by [13] in which substantial differences favouring females are the rule or no differences at all [25, 26].

It is apparent that possession of robust mathematical knowledge remains the gateway to virtually all occupations and more males than females possess it. Without mathematical knowledge "women can never achieve true occupational equality with men" [19]. Broadly, [24] gave two reasons for gender differences in mathematics as internal and external. Internal factors have been defined as biological, cognitive and affective factors. The external factors are defined in terms of significant others and classroom interaction that directly influence learning. The significant others can be regarded as the peers, parents etc of the individual while the classroom factor may relate to the teacher with whom the individual interacts in the learning environment [24].

Many scholars in mathematics education have identified a number of intervention programmes, which can be designed and implemented in schools to combating the perceived gender gap in mathematics achievement and participation. [19] gave a range of such programmes to include ‘anxiety clinics’ designed to combat mathphobianism; remedial programme to fill the gap in knowledge of mathematical content; programmes designed to enhance spatial skills, and programmes designed to keep gifted women in mathematics [34] have several ideas of how to promote equity in mathematics classes. One suggestion is to offer opportunities to look at how students view mathematicians and encourage discussion of women mathematicians and students. This provides girls with the opportunity to have female role models in mathematics and lessen the stereotype of mathematicians as being old men.

Another way to foster equity is to become aware of the teacher-student interactions in the classroom. It is important to ask if girls are being ignored in the classroom. Differential treatment may lead to limited mathematics participation. Boys will often demand attention but girls may be passive. Reference [34] suggests giving girls opportunities to construct and contribute their ideas. Keeping girls from sharing their ideas and feelings in mathematics class may limit their future opportunities and lower mathematics enrollment.

One educational variable that appears to be influencing both male and female students in the learning of mathematics is school organization. The effect of single-sex and co-educational schools on performance in mathematics is equivocal and boys and girls behave differently in those schools [4, 35] examined achievement in language and mathematics for a sample of Belgian high school students. They found that, after due allowance was made for selection factors, single-sex schooling had no significant effect on boys’ and achievement but, for girls, it had significant effect on mathematics achievement. Reference [11] found that there were significant differences between single-sex and coeducational schools in the size and direction of the gender gap. At coeducational schools, there was a statistically significant gap favouring females, while at single-sex schools there was a non-significant gap favouring males. These results indicate that single-sex schooling may mitigate male disadvantages in educational achievement.

Other studies have found that the effects of single-sex schooling are the same for males and females. Reference [36] found that gender differences in science achievement in Australian high school students were similar at single-sex and coeducational schools after accounting for design effects. While single-sex school environments have tended to be more closely associated with positive attitudes towards mathematics and better performance, particularly by girls [16], single-sex classrooms girls experience an environment in which they are not subject to the same higher levels of sexual harassment and bullying found in mixed-sex classrooms [18, 29, 31, 33].

In general, boys in the co-educational schools appear to hold more positive attitudes toward mathematics and are confident in their abilities to deal with more advance mathematics [4]. It has been observed that single-sex schools, particularly for girls tend to favour girls’ preferred lower levels of social competition and a warmer teaching style [17]. While advocating that single-sex schools, particularly for girls will engender equity in mathematics education, [19] concluded that single-sex schools for girls must be approached with caution. This is against the back drop that co-education has more potential for counter-sexist practices to be effective [27, 32]. Reference [41] claims that current coeducational school systems favour girls' preferences over boys', and schooling boys and girls separately is the best way to cater to boys' needs without disadvantaging girls.

School location is a variable in achievement that tends to affect male and female students in the learning of mathematics. While rural students tend to manifest more simple social relationships due to greater interpersonal ties in rural settings [3] urban students show complex social relationships. Thus, one is led to wonder whether gender gaps exist in the mathematics performance of junior secondary school students in Cross River State based on school location. It is noted that popular cultures view rural education as a deficit model [9] whereas others are of the conviction that there is no difference between rural and urban education [10]. However, this study investigated gender difference and mathematics performance of senior secondary students with varying school organization and school location in Cross River State, Nigeria. While it may be pretty difficult for a school to usually change its location, the location conceivably may have great consequences for how well students learn at the school.

II. HYPOTHESES

The following null hypotheses are stated and tested in this study:

H01: There is no significant difference between the mathematics performance of male and female students in Cross River State, Nigeria.

H02: School organization and school location taken independently, are not significant factors in the mathematics performance of male and female students in Cross River State, Nigeria.

III. METHOD

Mock results of senior secondary year three students in preparation for their external examinations were collected as the data for the study. Mock examinations are teacher made tests which are locally administered on the students in preparation for any impending external examination(s) under the close supervision of the school authorities. In all, 1,780 senior secondary year three mathematics students’ results were analysed. The data were for the students who graduated from eight secondary schools (2 rural schools, 2 urban schools, 2 single-sex schools and 2 coeducational schools) in the southeastern part of Nigeria between 2001 and 2010.

The data were pooled together but segregated according to gender, school location and school organization. About 49.44% of the participants were males (880) and 50.56% were females (900), 43.82% of the participants were from single-sex schools (780) and 56.18% attended co-educational schools (1000) in the study. The mean age of participants was 18.20 years (SD = 1.724). The mock examinations were based on the prescribed senior secondary year three national mathematics curriculum and covered five basic areas of number and numeration, algebraic processes, geometry and mensuration, trigonometry and statistics and probability as contained in the curriculum.

Examination questions set by individual mathematics teacher were internally moderated by the head of department and some senior colleagues and marked examination scripts were vetted by an internal second examiner to ensure internal quality controls. Collected data were used to prove whether there was a gender difference in mathematics performance. Also, gender differences in the single-sex and coeducational groups; rural school and urban school groups were tested. To achieve these, independent samples t-tests were computed based on the identified independent variables: gender, school organization and school location.

IV. RESULTS

The results of the study are summarized in accordance to the hypotheses set for the study.

Hypothesis 1: There is no significant difference between the mathematics performance of male and female students in Cross River State, Nigeria.

Table 1 shows that the male students obtained higher mean performance score in mathematics ($\bar{x}$ = 62.47; SD =7.42) than their female counterparts ($\bar{x}$ = 57.41; SD = 7.16). However, this difference was significant (t = 14.64; df = 1778; $p<0.05$). Hence, it was concluded that there was a significant difference between the mathematics performance of male and female students. Thus, hypothesis 1 was rejected.

Hypothesis 2: School organization and school location taken independently, are not significant factors in the mathematics performance of male and female students in Cross River State, Nigeria.

From table 2, it is seen that the performance of male and female students differed only for those in single-sex schools and for rural schools. In single-sex schools, the male students recorded higher mean performance score in mathematics ($\bar{x}$ = 62.87; SD = 7.82) than their female counterparts ($\bar{x}$ = 53.82; SD = 7.47). However, this difference was significant (t = 16.51; df = 778; $p<0.05$). In rural schools, the male students achieved higher mean performance score in mathematics ($\bar{x}$ = 62.64; SD = 7.87) than their female counterparts ($\bar{x}$ = 53.62; SD = 7.41). However, this difference was significant (t = 16.76; df = 798; $p<0.05$).

At other levels of the variables, there was no statistically significant difference i.e. the performance of male and female students did not differ in either co-educational schools or urban schools.

TABLE 1
INDEPENDENT t-TEST ANALYSIS OF SIGNIFICANCE DIFFERENCE BETWEEN THE MATHEMATICS PERFORMANCE OF MALE AND FEMALE STUDENTS

Variable	N	$\bar{x}$	SD	Df	t
Male	880	62.47	7.42	1778	14.64*
Female	900	57.41	7.16		

* Significant at p<0.05.

TABLE 2
INDEPENDENT t-TEST ANALYSIS OF SIGNIFICANCE DIFFERENCE BETWEEN THE MATHEMATICS PERFORMANCE OF MALE AND FEMALE STUDENTS BY SCHOOL ORGANIZATION AND SCHOOL LOCATION

Variable	Level	Gender	N	$\bar{x}$	SD	df	t
School Organiz.	Single-sex	Male	380	62.87	7.82	778	16.51*
		Female	400	53.22	7.47		
	Co-education	Male	500	62.24	7.91	998	0..32
		Female	500	62.08	7.83		
School Location	Rural	Male	400	62.64	7.87	798	16.76*
		Female	400	53.62	7.41		
	Urban	Male	480	62.98	7.47	978	0.14
		Female	500	62.91	7.87		

* Significant at p<0.05.

V. DISCUSSION

The results of this study obviously showed significant differences in the mathematics performance of male and female students (t_{1778} = 14.64; $p<0.05$) in favour of males; single-sex male and female students (t_{778} = 16.51; $p<0.05$) in favour of males and rural male and female students (t_{798} = 16.76; $p<0.05$) in favour of males. The finding that showed the existence of significant gender performance difference in favour of males is consistent with popular results obtained in gender literature [3, 13]. One possible explanation for the result obtained in this study in which the male students performed better than their female counterparts in mathematics may be due to difference in strategies employed to solve the mathematics tasks.

Research evidence indicates that boys are more favourably disposed to use abstract strategies in solving mathematics problems while girls are actively engaged in the use of concrete methods. Reference [20] found that boys often used abstract strategies showing conceptual understanding and were more flexible in their strategies, using derived facts or invented algorithm. The girls were more likely to adopt concrete methods such as modeling or counting strategies to solve mathematics problems. They argued that the girls who used algorithms might not have the same conceptual understanding or yield success in extension problems. In a similar study, [21] claimed that this lack of conceptual understanding would hinder understanding in later mathematics classes.

As postulated by [21], the differences in strategy use by males and females in high school mathematics also exert considerable influence on the disparity in their mathematics achievement. Although some strategy use do overlap from female to male, [22] found that that females were more conventional and males were more unconventional in their problem solving strategy. The unconventional strategy use and achievement on unconventional problem correlated positively. Further supporting the disparity in strategy use, [14] asserts that females want organization which is enhanced by algorithmic rote learning that leads them to only short term success while [37] claims that the males are more flexible and risk takers and are more likely to try different strategies than the one modeled in class. It is, however, not surprising that the female students record little success on application problems in mathematics.

Given these differences in strategy use one can say that the female students are already at a disadvantage in mathematics classrooms. This disadvantage is exacerbated by differences in motivation occasioned by stereotyping of mathematics as a male domain. It is common to hear female students saying mathematics is for boys. This negative perception for females may lower their motivation to solve mathematics problems.

The general stereotyping of mathematics as a male domain tends to feature prominently in the nurture theory. This theory tends to favour male dominance in mathematics over their feminine counterparts in Nigeria. Environmental provision and societal gender role fixing for male students make them physically fit to cope with tasks requiring high intellectual challenge, computation and rigour. Whereas female students are treated as weaker vessels that require less physically and intellectually demanding tasks. More often than not female students are preoccupied with domestic chores, including child rearing. These differences in environmental provisions and societal gender roles fixing may account for the observed gender differences in mathematics performance obtained in this study.

However, one factor that still tends to influence performance in mathematics is that in studies of attitudes to the subject, males still tend to be more confident than females of their mathematical ability [38, 40]. This difference in confidence levels interacts significantly with examination systems that offer different levels of entry. Girls are more likely to opt for a lower level of examination due to lack of confidence in their ability to succeed and thus restrict their chances of taking their mathematics further [39].

The second hypothesis showed that school organization and school location as correlates of students' performance in mathematics were only partially gender sensitive. That is, whereas there was no significant performance difference between male and female mathematics students from the co-educational schools, significance was established for the performance of male and female students from the single-sex schools. Also, whereas, the male and female students exhibited homogenous mathematics performance scores in the urban schools, there was a significant difference in the mathematics performance scores of male and female students from the rural schools. All cases of significance were in favour of male students. The significant gender performance difference in mathematics in favour of males in single-sex schools is inconsistent with results obtained in several gender studies [35]. Also, the significant gender performance difference in mathematics in favour of males in rural schools corroborates similar results obtained in gender studies [3].

These results could be justified by the fact that urban schools are usually staffed with qualified teachers and they enjoy enriched school environment with tutorial disks and programmes available in video and good library. The rural schools are not always staffed with qualified teachers due to teachers declining posting to rural schools. Also, most rural schools lack enriched environment that could support student learning. Co-educational schools on the other hand have the potential for counter-sexist practices to be effective and these could engender healthy competition between both sexes thereby raising their performance.

This cannot be said of single-sex schools in which there are no representations of both sexes and as such male and female students could not compete, collaborate and gain from one another in mathematics teaching and learning. Thus, the healthy rivalry between sexes which could raise their level of motivation and consequently their performance is lacking. This study shows that exposure to coeducational schools might mitigate gender difference in mathematics performance. However, the results of this study could be seen as only suggestive of a relationship between school organization and the size of the gender difference in mathematics performance on one hand and school location and the size of the gender difference on the other.

The educational implications for this study are three folds. First, more co-educational institutions should be established to engender greater healthy rivalry between male and female students in mathematics education. Second, rural schools should be funded and enriched learning environment provided so that their capacity for efficiency and productivity can be improved. Third, teaching and evaluation strategies in mathematics classes should be gender-bias free. Thus mathematics teachers must be sure to call on girls for answers to questions, and to give them quality praise when appropriate.

The results of this study do not support the view that single-sex schooling reduces gender differences in mathematics performance; instead, the results suggest that there would be no gender differences in mathematics performance at co-educational schools. This study suggests that the ways in which schools are organised and structured can have a considerable impact on gender differences in mathematics performance.

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