Gender differences in Elective Mathematics Achievements of Senior Secondary School Students (SSS3) in Central and Western Regions of Ghana

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Abstract

The purpose of this study was to investigate the differences in elective mathematics achievements of final year Senior Secondary School students (SSS3) boys and girls in Central and Western regions of Ghana. The study investigates if there was any significant difference between the achievement in Elective Mathematics of SSS 3 male and female students in some selected schools. Achievement test results of participants and results of all SSS3 students from 1995 to 1999 (nationwide) were used to gather data for the study. Two (2) single-sex female schools, two (2) mixed-sex schools and two (2) single-sex male schools were purposively sampled from seventeen (17) Senior Secondary Schools. An achievement test made up of items on algebra, calculus and linear transformation, vectors, mechanics, statistics and probability was administered to 738 students; and t-test was used to analyze the data. The results indicate that although girls in the mixed-sex schools achieved higher than their male counterparts, the difference was not statistically significant; but there was significant difference in achievement in elective mathematics of boys and girls in the single-sex schools, which favored the girls. Comparison between all male and all female students’ achievement test scores in elective mathematics revealed female superiority over their male counterparts during the study period.

Keywords: Single-Sex Male; Single-Sex female; Mixed-Sex; Core Mathematics; Elective Mathematics, WAEC, SSS, SSSCE.

INTRODUCTION

Mathematics is among the subjects that have prominent positions in the curriculum in Senior Secondary Schools (SSS) in Ghana. The Mathematics subject is divided into: (1) Core Mathematics and (2) Elective Mathematics. Core Mathematics is compulsory for all students, from the basic school level to the Senior Secondary School level (Eshun, 1999). In the SSS level there is an aspect of mathematics called Elective Mathematics, formerly known as Additional Mathematics, this is optional and pursued usually by more mathematically inclined students or students who may need it as a prerequisite to other courses. In Ghana, the only source of data about the level of mathematics achievement of SSS students is the West African Senior Secondary School Certificate Examination, an annual examination, conducted in May/June by the West African Examinations Council (WAEC). Some aspects of the WAEC published data as indicated by Eshun 1999, were that:

(i) Only the combined results of males and females are provided,
(ii) It is not possible to obtain the separate achievement by the sexes (males and females),
(iii) The data cannot be used to measure the changes in students’ achievement over the years since the examination does not contain repeated questions from year to year to allow changes in performances to be...
measured.

In many countries, national and international assessments in mathematics have been conducted to provide information required for identifying the strengths and weaknesses of students. A large number of these assessments have reported about male superiority in mathematics (Hensel, 1989; Eshun, 1999; Masqysud and Khaliqye, 1991).

Fennema and Sherman, (1977) also found sex differences, in two of the four high schools in which males and females in the same classes were compared, in favor of males. In the view of Hall and Hoff, (1988) and Martin and Hoover, (1987) gender related differences in mathematics performance seemed to be present from an early age onwards and increase with age. According to Kimball, (1989) when students reach high school, boys often score higher on achievement tests that entail problem solving in mathematics than girls.

Societal belief about male superiority in mathematics had been rebutted by other researchers in mathematics education. Substantial body of statistical evidence gathered indicates that females out-performed males at mathematics (Peterson and Fennema, 1985; Plake et al., 1978). Studies by Hammond et al., (1987) in Hawaii, on gender differences in mathematics achievement, have indicated that girls have had higher mathematics achievement than boys. Similar results have been found by Lockheed and Lee, (1990) in Nigeria, Wood, (1976) in Britain and Wily, (1986) in New Zealand.

In a study by Linn and Hyde (1989), it was established that among older adolescents there was a decline in gender difference in quantitative ability on most measures since 1974. They argued that the differences were specific to particular cultures and were therefore not general. Accordingly, Saxe (1990) suggests that cultural practices lead to development of cognitive functions and this further leads to the question of whether gender difference in mathematical achievement will manifest in different cultures (Jinni and Edwin, 1992). Can this state of affair be true, particularly, among older adolescents in the Ghanaian Senior Secondary Schools?

Across different cultures and at different times, the pattern of studies on sex differences in mathematics achievements of Senior High School students is not quite clear. According to Opolut-Okurut and Opyene-Eluk (1995), the results of studies on gender differences in achievement in mathematics diverges and are sometimes contradictory making it difficult to make a general statement about sex differences in mathematics achievement. They pointed out that some studies reported up-to-date-held results that by the age of 13 there was a significant difference between the performance of males and females. However, other studies have reported that no significant difference existed between male and female achievement in mathematics and where it existed; it was in favor of boys (Fennema and Carpenter, 1981) as quoted by Opolut-Okurut and Opyene-Eluk (1995).

This apparent divergence in the trend in mathematical abilities of male and female students at the Secondary School level is explained by Keeves (1983) that the measurement of students performance at the end of high school was difficult due to specialization by that age and gender proportions in mathematics courses. When students are at the Secondary School, they have developed different career expectations and girls are not encouraged to choose mathematics studies irrespective of whether or not they are capable or interested in mathematics.

Statement of the problem

Gender differences in mathematics has decreased considerably and is almost nonexistent in developed countries such as USA, Japan, and Sweden but it exists in Ghana; but the trend favoring boys remains questionable as indicated by Eshun (1999). The question bothering many mathematics educators is whether or not male superiority in mathematics (elective) achievement of SSS 3 students still exists in Ghana. Due to the variation in gender differences in mathematics across cultures, the focus was on assessing the type of sex-related differences in elective mathematics achievement score-total of SSS3 students in two of the ten regions, the Central and the Western regions of Ghana using an achievement test in elective mathematics designed by the researchers.

Significance of the study

The significance of the study stems from the fact that it will:
- Provide information on gender difference in students’ achievement in elective mathematics at the SSS level.
- Assist in changing girls’ misconception about the study of elective mathematics at the SSS level.
- Help teachers to devise means of improving the teaching of elective mathematics to cater for both male and female students.
- Help generate interest in further research in areas related to achievement in elective mathematics at the SSS level.

Justification of the study

In Ghana, the only source of information about elective
A mathematics achievement of SSS final year students is the SSSCE examination results, from the examinations is conducted annually by WAEC in May/June. The grades are norm-referenced rather than criterion-referenced. In this case the raw marks for a given grade may differ from year to year. Also WEAC publishes only data on students’ grades and not their raw marks. The published data which takes the form of the combined results of males and female cannot be used to measure the changes in students’ achievements over the years. The study in this paper investigates the achievement of Senior Secondary School students in the Senior Secondary School Certificate Examinations from 1995 to 1999 at the national level by WAEC and in a similar Mock (trial) examination set specifically for the study by the researchers. The mock examination was used to provide detailed statistical information on the achievement of SSS3 students in the year 2000.

Limitation of the study

The study was limited to the achievements of the participants, in the study, who were final year students of selected Senior Secondary Schools in two of the ten administrative regions in Ghana.

First, the sample comprised of students in SSS 3 only, who were busy preparing for their final examination. They were not willing to respond to the achievement test items. However, repeated attempts were made to obtain their cooperation in the study. Since the study was limited to only SSS 3 students, the conclusions of the study cannot be generalized to cover all students who are enrolled in Elective Mathematics.

The second limitation was about the level of cooperation of the teachers and school administrators in the six schools visited. Some of the school administrators were unwilling to allow their students to participate in the study, while some of the Elective Mathematics teachers were also reluctant to assist in grading the students’ scripts despite the fact that the achievement tests were designed as Mock Examinations for the SSSCE Elective Mathematics. The study tests replaced the examination that the schools had prepared for their students. Although confidentiality was guaranteed, it was possible that students’ and teachers’ reluctance to participate in the study might influence the conclusions that were drawn.

Purpose of the study

The purpose of the study was therefore twofold:  
a) To determine and compare the combined male and female students’ pattern of performance in the SSSCE elective mathematics as measured by the:
i) WAEC examinations from 1995 to 1999
ii) Common Mock examination in 2000
b) To determine and compare the pattern of achievement of the:
i) Male and female students in the common mock examination in 2000.
ii) Various types of schools in the combined Papers 1 and 2 of the common mock examination in 2000.

Research Questions

The research questions investigated were:
1. Was there any significant difference between the achievement in Elective Mathematics of SSS 3 male and female students in selected single-sex schools?
2. Was there any significant difference between the achievement in Elective Mathematics of SSS 3 male and female students in selected mixed-sex schools?
3. Was there any significant difference between the achievement in Elective Mathematics of SSS 3 male and female students?

Hypotheses

The null hypotheses formulated to facilitate answering the above research questions were:
HO₁: There was no significant difference in the achievement in elective mathematics of SSS 3 male and female students in the selected mixed-sex schools.
HO₂: There was no significant difference in the achievement in elective mathematics of SSS 3 male and female students in the selected single-sex schools.
HO₃: There was no significant difference in the achievement in elective mathematics of all SSS 3 male and female students in the selected schools.

RESEARCH METHODOLOGY

The study consisted of two parts. First, the published results of the SSSCE examinations by WAEC from 1995 to 1999 were examined. The second part was a common mock (trial) examination set by the researchers and administered to 738 students in six Senior Secondary Schools in the Central and Western regions of Ghana. Six schools were purposively sampled, from seventeen (17) Senior Secondary Schools, in two regions, these include: Two (2) single-sex female schools, two (2) mixed-sex schools and two (2) single-sex male school.

Though the study was based on schools in these two regions, it is important to point out that all the six schools were boarding institutions and had students from all the 10 administrative regions of Ghana. All the students were in their final year (SSS3) in SSS who had
studied at least half of the elective mathematics syllabus. The common mock examination was used by the schools to prepare their students for the WASSCE in elective mathematics by WAEC. The achievement test was designed by analyzing the nature of 5 years of WAEC SSSCE questions in elective mathematics and setting similar questions for the participants. That is, the distribution of questions to the various content areas (Algebra, Calculus, Vectors, etc.) and the level of difficulty of the questions were similar to that of WAEC examination questions.

Paper 1 was made up of fifty multiple-choice items and four responses A-D of which only one was the correct answer. Paper 2 of the achievement test consisted of fifteen essay type test items which was subdivided into two sections, section A and B. Statistical tools used in analyzing the data were the mean, standard deviation, t-test and d-values.

The mock examination was conducted under strict examination condition by each school as the examination was a normal school activity except that the examination papers were set by the researchers. The scripts of the students were marked by the elective mathematics teachers of the six schools which were involved in the study after a moderation meeting had established inter-examiner reliability using a common marking scheme. Table 1 shows the distribution of males and females in SSS3 in the selected schools as well as those who studied elective mathematics.

There were 1,983 students in the final year (SSS3) in the selected schools. This was made up of 852 males and 1,131 females. Students who studied elective mathematics were 430 males and 308 females making a total of 738.

RESULTS

WAEC Examinations

Table 2 shows the percentage of SSS3 male and female students passing elective mathematics (i.e. obtaining grades A-E) from 1995 to 1999 at the national level.

In 1995 and 1996 more males than females passed the SSSCE elective mathematics examination. However, there was a sharp decline in the percentage pass by males in the years 1998 and 1999 as females improve their percentage pass exhibited in table 2. The percentage of males passing elective mathematics at the national level exceeded that of their female counterparts every year but the percentage differences were not dramatic. In 1995, the achievement of males in elective mathematics increased from 38.9% to 65% in 1997 while that of the females rose from 25% to 59.3%. For these years, as the percentage change for males passing elective mathematics increased by 26%, that of their female counterparts rose to 34%. From these results, at the national level, males’ superiority in achievement in elective mathematics weakened gradually from 1995 to 1999 as females improved their achievement considerably.

Mock Examination

In order to test the hypothesis that males performed better in Elective Mathematics than females by the end of Senior Secondary school, t-tests were performed. Table 3 shows the means, standard deviations, and t-values for the achievement for males and females in the study test, with MSM, MSF, SSM, SSF, AM and AF representing Mixed Sex Male, Mixed Sex Female, Single Sex Male, Single Sex Female, All Males and All Females respectively.

Comparing MSM and MSF achievements in elective mathematics as per the achievement test (common mock examination) 2000, the mean achievement test score ($\bar{x}$) for female students in mixed sex schools ($\bar{x}$ =41.08, s =18.44) was not significantly higher ($t = -0.61$, df =212, two- tailed, $p > 0.05$) than that of male students. It indicates that females in mixed sex schools outperformed their male counterparts in the achievement test.

To determine whether males performed better than females in the single sex schools by the end of SSS, the means ($\bar{x}$) of the achievement test were compared. Comparing SSM and SSF achievement in the common mock examination (papers 1 and 2), the mean achievement test scores ($\bar{x}$) for female students in the single sex schools ($\bar{x}$=55.40, s =18.09) was significantly higher ($t = -3.09$, df =522 two- tailed, $p < 0.05$) than that of their male counterparts. The mean scores ($\bar{x}$) indicate that there was gender difference favoring females. Further comparison between AM (all males) and AF (all females) revealed that the mean achievement test total score ($\bar{x}$) for all female students in the study ($\bar{x}$ =50.75, s =19.38) was significantly higher ($t= -2.27$, df =736, two-tailed, $p < 0.05$) than that of all male students.

Table 4 shows the magnitude of the differences in boys’ and girls’ mean achievement test scores, the d statistic (categorized by type of school).

To identify the magnitude of the differences in boys’ and girls’ mean achievement test scores, the d statistic (categorized by type of school) was computed for MSM and MSF, SSM and SSF, and AM and AF. Hyde (1981), as quoted by Bradon et al. (1987), strongly recommended reporting a comparable statistic such as d (i.e. the d-statistics, the magnitude of the difference between boys and girls achievement test scores) to permit comparison between studies. To find d, the boys’ mean score was deducted from that of the girls’ and the result was divided by the standard deviation for both
Table 1. Distribution of the number of students in SSS3 and those studying elective mathematics by school and sex

<table>
<thead>
<tr>
<th>Type of School</th>
<th>Number of SSS 3 students</th>
<th>Male</th>
<th>Female</th>
<th>Number students studying Elective Mathematics</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSS</td>
<td>961</td>
<td>398</td>
<td>563</td>
<td>114</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>SSF</td>
<td>568</td>
<td>-</td>
<td>568</td>
<td>-</td>
<td>-</td>
<td>208</td>
</tr>
<tr>
<td>SSM</td>
<td>454</td>
<td>454</td>
<td>-</td>
<td>316</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>All Schools</td>
<td>1983</td>
<td>852</td>
<td>1131</td>
<td>430</td>
<td>308</td>
<td></td>
</tr>
</tbody>
</table>

Source: Field data, (2000)

Table 2. Percentage of students passing SSSCE elective mathematics from 1995 to 1999 at the national level

<table>
<thead>
<tr>
<th>Year</th>
<th>Male</th>
<th>Female</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>38.9</td>
<td>25.0</td>
<td>13.9</td>
</tr>
<tr>
<td>1996</td>
<td>42.5</td>
<td>32.0</td>
<td>10.5</td>
</tr>
<tr>
<td>1997</td>
<td>65.2</td>
<td>59.3</td>
<td>5.9</td>
</tr>
<tr>
<td>1998</td>
<td>49.9</td>
<td>49.3</td>
<td>0.6</td>
</tr>
<tr>
<td>1999</td>
<td>46.5</td>
<td>45.3</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Source: WAEC Headquarters, Accra. (2000)

Table 3. Mean, Standard Deviation and t-values of students’ achievement scores in the achievement Test (Common Mock Examination).

<table>
<thead>
<tr>
<th>School</th>
<th>No. of Participants (N)</th>
<th>Mean (x)</th>
<th>Standard Deviation (s)</th>
<th>Degree of freedom (df)</th>
<th>t-calc</th>
<th>t-crit</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSM</td>
<td>114</td>
<td>39.49</td>
<td>19.49</td>
<td>212</td>
<td>-0.61</td>
<td>1.96</td>
</tr>
<tr>
<td>MSF</td>
<td>100</td>
<td>41.08</td>
<td>18.44</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SSM</td>
<td>316</td>
<td>50.32</td>
<td>18.65</td>
<td>522</td>
<td>-3.09</td>
<td>1.96</td>
</tr>
<tr>
<td>SSF</td>
<td>208</td>
<td>55.40</td>
<td>18.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM</td>
<td>430</td>
<td>47.45</td>
<td>19.46</td>
<td>736</td>
<td>-2.27</td>
<td>1.96</td>
</tr>
<tr>
<td>AF</td>
<td>308</td>
<td>50.75</td>
<td>19.38</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Field data, (2000); α = 0.05

Table 4. Mean, Standard Deviation and d values of students’ achievement scores in the achievement Test (Common Mock Examination).

<table>
<thead>
<tr>
<th>Type of school</th>
<th>No. of participants</th>
<th>Mean (x)</th>
<th>Standard Deviation (s)</th>
<th>d-Statistic (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSM</td>
<td>114</td>
<td>39.49</td>
<td>19.49</td>
<td>0.08</td>
</tr>
<tr>
<td>MSF</td>
<td>100</td>
<td>41.08</td>
<td>18.44</td>
<td></td>
</tr>
<tr>
<td>SSM</td>
<td>316</td>
<td>50.32</td>
<td>18.65</td>
<td>0.28</td>
</tr>
<tr>
<td>SSF</td>
<td>208</td>
<td>55.40</td>
<td>18.09</td>
<td>0.17</td>
</tr>
<tr>
<td>AM</td>
<td>430</td>
<td>47.45</td>
<td>19.46</td>
<td></td>
</tr>
<tr>
<td>AF</td>
<td>308</td>
<td>50.75</td>
<td>19.38</td>
<td></td>
</tr>
</tbody>
</table>


sexes. The average of the ds was computed across the sub groups. The d for MSM and MSF was 0.08. It represents very small difference favoring the females. The d for SSM and SSF and AM and AF were 0.28 and 0.17 respectively, indicating significant differences in the achievement in favor of females. All the d’s calculated...
were positive values (d>0) and it indicates the superiority of female participants over their male counterparts in the achievement test in Elective Mathematics.

The results from the achievement test shows that with regards to females in mixed sex schools and their male counterparts, no significant gender difference in elective mathematics achievement was realized but there was a significant gender difference in elective mathematics achievement of males in single-sex schools and females in single-sex schools favoring females. Females performed better than males in the Central and Western regions SSS on the basis of the achievement test.

DISCUSSION

At the basic level of education, all students study the same subjects so the girls’ access to Mathematics dependents on their rate of enrolment. However, at the Senior Secondary School level, Mathematics is divided into Core and Elective Mathematics. Core mathematics is compulsory for all students, from the primary school level to the Senior Secondary level (Eshun, 1999) while Elective Mathematics, formerly known as Additional Mathematics is optional and pursued usually by more mathematically inclined students or students who may need it as a prerequisite to other courses at the university level. At the Senior Secondary School, fewer girls than boys opt for the study of Elective Mathematics and consequently, fewer enter into Mathematics, Science and Technology based courses at the tertiary level. This means that more girls than boys rule themselves out of these career options before they complete Senior Secondary School. However, the educational system in Ghana provides equal opportunities at all levels of education to all citizens, regardless of sex differences or geographical location to participate and excel in any subject.

The achievement of girls who opted for Elective Mathematics in this study was well above that of their male counterparts. The higher achievement of girls in this study was consistent with the findings of Hanna and Kuendiger (1985); Hammond et al. (1987) and Peterson and Fennema (1985). Their findings showed Mathematics achievement gender difference favoring girls. The findings in this study run counter to the belief about male superiority in Elective Mathematic which has been accepted as fact almost without question for a long period of time.

It could be argued that the reason why girls outperformed the boys in this study was mainly due to the girls’ exposure to the Science, Technology and Mathematics Education (STME) Clinic, an intervention program by the Ghana Education Service (GES) to increase the participation and achievement of girls in Science, Technology and Mathematics courses in the SSS. The STME Clinic has succeeded and is on the path to breaking the myth surrounding girls’ achievement in Elective Mathematics. It has also helped to break down the misconceptions and psychological barriers that act as constraints to female participation and achievement in Elective Mathematics. As a result of this exposure to information, the career aspirations in the life of girls in the SSS have been modified and directed towards achieving high academic laurels in Mathematics. This sex difference in achievement identified in the study indicates that if special effort is made by all stake holders in education, including parents and classroom teachers, to encourage and assist females in SSS they can improve upon their achievement in Elective Mathematics.

CONCLUSIONS

Based on the study the following conclusions have been made;

- The males’ superiority in achievement in Elective Mathematics over their female counterparts declined from 13.9% in 1995 to 1.2% in 1999 at the national level. Females have improved their performance greatly and as a result they outperformed their male counterparts in the achievement test.

- Females in single-sex schools achieved higher than their male counterparts as per the achievement test in 2000.

- Similarly females in the mixed-sex schools outperformed their male counterparts as per the achievement test in 2000.

The study covered only two regions, the Central and the Western regions of Ghana. Other regions could be studied individually to explore the relationships existing between them and the perceived levels of achievement of girls in Elective Mathematics. This comparative study would highlight any similarities or differences and reasons for the situations. It would also show the extent of inequalities in the regions in terms of students’ achievements in Elective Mathematics.

The study on sex differences in achievement in elective mathematics of SSS 3 students has raised many questions and answers. Further research on the topic could be supplementary or complementary.

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