Gender Differences and Mathematics Achievement of Senior High School Students: A Case of Ghana National College

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Abstract
A quasi-experimental research was conducted to find out differences in mathematics performance of students using performance assessme[nt-driven instructions at the senior high school level at Ghana National College in Cape Coast. Two Form 1 science classes were used for the study and were assigned as experimental and control groups. These two classes were randomly chosen for the study. The experimental group consisted of forty-two students and the control group forty students. Data was collected through the use of an open ended test in mathematics. The independent sample t-test and paired sample t-test were used to find the differences between the groups. The experimental group differed significantly on the post-test scores from the control group. This study identified that PA-driven instruction improved students' problem-solving abilities and showed no bias among gender. It is recommended that mathematics teachers use PA-driven instructions and performance assessment task in their mathematics lessons.
Keywords: Gender, performance assessment and performance-driven instructions.

Introduction

Teaching of mathematics has undergone a lot of reforms over the years. Mathematics educators are calling for reforms that will inculcate into students the habit of problem solving and also be able to apply mathematics to daily activities. The focus of the reforms according to Cohen, McLaughlin and Talbert (1993) can be described as teaching for understanding and for improving all students' ability to apply mathematics knowledge in novel ways. Recent reform efforts further emphasize complex problem solving, discovery, and hands-on experimentation in mathematics (Fuhrman, 1993). Stein, Grover, & Henningsen (1996) described this trend as supporting the establishment of an instructional environment characterized by an increased emphasis on problem solving, sense making, and discourse.

Regarding reforms in mathematics instruction, many have called for abandoning curricular that promote thinking about mathematics as a rigid system of externally dictated rules governed by standards of accuracy, speed, and memory (Porter, 1989; Stodolosky, 1988). As Porter and Stodolosky contend, traditional mathematics instruction consists almost entirely of teachers directing students to memorize presented facts or apply formulae, algorithms, or procedures without attention to why or when it makes sense to do so.

In presenting some criteria for excellence in mathematics instruction, Pechman (1991) suggested that mathematics teachers should engage students in a variety of learning experiences designed to promote mathematical exploration and reasoning. She noted that these experiences should engage students actively in mathematics, help them discover meaning through manipulations with concrete materials, enable them to learn individually and in groups, and lead them to construct meaning using a variety of resources and instructional materials. Pechman also asserted that mathematics instruction should make appropriate and regular use of technology, supplementary programs, and enrichment activities to extend mathematics instruction beyond the classroom. Further, homework should extend students' mathematics learning and encourage them to apply new study skills.

On the contrary, most mathematics home works in Ghanaian high schools do not challenge the mathematical thinking abilities of the students rather the home works focus on recall of simple mathematical facts from the mathematics lessons.

According to Fennema, Carpenter and Peterson (1989) students who experience this reform are encouraged to explore, develop conjectures, prove, and solve problems. The assumption is that students learn best by resolving problematic situations that challenge their conceptual understanding. Students are also encouraged to discuss their ideas and results, often within small, cooperative groups as well as with their teachers. As a result, students are offered opportunities to develop intellectual autonomy and become mathematical authorities themselves. The teacher's role is generally that of a facilitator and not a dictator of mathematical rules.

The National Council of Teachers of Mathematics, NCTM (1996) articulated that high school teachers listed the following strategies as particularly relevant to mathematics education in enhancing academic performance: (a) application to daily life, (b) use of calculators, (c) use of computers, (d) hands-on manipulation, (e) working in cooperative groups, (f) integration of mathematics subject, and (g) deeper coverage of fewer concepts. Similarly, White, Porter, Gamoran, and Smithson (1996) highlighted the following pedagogies as contributing innovative strategies and variations in high school mathematics transition courses: (a) use of manipulatives, (b) a more integrated curriculum, (c) a focus on the infusion of technology, (d) active participation of students working together in groups, and (e) an emphasis on problem solving and mathematics problems based on real-life situations.

However, mathematics teachers are compelled to completely teach a list of topics irrespective of whether the students have understood the concepts or not. The aim is to prepare the students for end of programme examination. The teacher's aim here should be to build a firm mathematical foundation by doing deeper coverage of few concepts.

According to Silver and Stein's (1996) work with the Quantitative Understanding: Amplifying Student Achievement and Reasoning (QUASAR) Project at the University of Pittsburgh which was aimed at altering the form and content of pre-college mathematics instruction in urban middle schools, they asserted that conventional mathematics instruction has failed to help many students in urban schools to develop desirable forms of mathematics proficiency. Their alternative is instruction that is oriented toward helping students develop a meaningful understanding of mathematical ideas through engagement with challenging mathematical tasks. They found that instructional programs provided to students at QUASAR schools led to improved mathematical understanding, reasoning and problem solving. Although these instructional practices are believed to enhance mathematics performance generally, the vision of mathematics reform is that high academic standards must be applied to all students, not just those preparing for advanced careers in mathematics and science.

Notwithstanding, an overall vision of how reform fits into the mathematics classroom context remains very illusive because the instructional process includes diverse and frequently changing perspectives (NCTM, 1989, 1991, 2000). In order to make sense of mathematics in their own terms, students must take mathematical actions, represent their ideas, make conjectures, build models, collaborate with other students, and give explanations and arguments [(NCTM), 1989,2000; National Research Council , (NRC), 1989].

According to Smith (1996) mathematics teachers must embrace changes in the teaching of mathematics to enable learning. They can no longer present content through mere demonstrations; instead, they must create the conditions that will allow students to take their own effective mathematical actions and construct their own mathematical understanding (NCR, 1989).

Currently, in the teaching of mathematics, emphasis is being placed on the process of arriving at an answer and problem solving as opposed to questions that require single answers and computation. Teachers are to incorporate more problem solving approaches in their instructions. This process of integrating problem solving tasks into mathematics instructions could be enhanced by teachers with rubrics based on the process rather than right answers only (Shepard, 2000).

An important component of effective teaching is knowing what kind of assessment that will provide the best picture about students' performance: that is using the most appropriate method to get the information (Mehrens & Lehmann, 1991).

Educators are therefore interested in students' performance because "so often what a person knows is not a good predictor of what a person can or will do" (Mehrens & Lehmann, 1991 p.175). The student's ability to do something or make something is, therefore, an important instructional objective. It important that mathematical lessons are linked to the type of performance students are expected to exhibit after a period of study. This therefore, calls for the use of performance assessment in the teaching and learning of mathematics in the classroom.

Stenmark's (1991) definition for performance assessment (PA) in mathematics education seems to capture the important aspects of this approach. Stenmark states; "A performance assessment in mathematics involves presenting students with a mathematical task, project, or investigation, then observing, interviewing, and looking at their products to assess what they actually know and can do" (1991, p. 13).

The concept of performance assessment is to offer the individual the opportunity to express himself in providing an answer to a particular question. Performance assessment requires a student to bring to bear all his thinking abilities into solving problems, letting the teacher into knowing what he actually knows and the level of his understanding. This is made possible because most performance assessments make use of open-ended test items. The open-ended test formats allow examinees to order unexpected and sometimes "unconventional" methods in solving problems which would unlikely be included as distracters in multiple choice tests. This produces an extremely rich source of information about examinees performance. In addition, it will also serve as a source of evaluating a lesson (Hibbard, 1996).

For the purposes of this study performance assessment has been defined as testing students' abilities and competencies in solving open-ended mathematics problems which border on higher order thinking skills. Students actually demonstrate proficiency not as in traditional sense of assessment where students only select the correct answer either by guessing or by solving the problem.

Performance assessment allows students to use their previous knowledge to build new knowledge structures and be actively involved in exploration and inquiry through task-like activities, and construct meaning for themselves from educational experience. It has the potential to engage and actively involve students with complex tasks. Furthermore, the tasks allow teachers to assess the processes students use as well as the products they produce.

Traditional assessment is often criticized for focusing on the disconnectedness between the limited range of skills taught in the classroom and what the student will face in the 'real world' but what performance assessment does is to bridge this gap between classroom work and the activities of event outside the classroom.

2. Gender Differences in Mathematics

Koller, Baumert, and Schnabel (2001) studied gender differences in mathematics achievement, which favoured males in achievement, interest, and placement in advanced mathematics courses.

Literature on gender differences in mathematics suggest that the number of female students pursing mathematics up to the higher level reduces (Eisenberg, Martin, & Fabes, 1996) but various researchers report that gender differences in the mathematics attitudes of American and European students may still be prevalent. Benbow and Stanley (1980, 1983) found, that among talented junior high school mathematics students, boys' outperformed girls on the quantitative SAT, a test that was obviously advanced for this age group. One can clearly state that a general pattern has begun to emerge: women perform roughly the same as men except when the test material is quite advanced; then, often, they do worse.

Though globally, the issue of gender inequality in Science, Technology and Mathematics Education (STME) has produced inconclusive results, one meta-analysis covering the period 1974 – 1987 on mathematics and gender led to two conclusions: the average gender gap is very small (statistically not significant), and the fact that the differences tend to decline with time (Friedman, 1989).

According to Hyde, Lindberg, Linn, Ellis and Williams (2008), a meta-analytic findings from 1990s indicated that gender differences in math performance in the general population were trivial, $d = -0.05$, where the effect size, d, is the mean for males minus the mean for females, divided by the pooled within-gender standard deviation.

However, measurable differences existed for complex problem-solving beginning in the high school years ($d = +0.29$ favouring males), which might forecast the underrepresentation of women in science, technology, engineering and mathematics (STEM) careers, Hyde, Lindberg, Linn, Ellis and Williams (2008).

Abiam and Odok (2006) found no significant relationship between gender and achievement in number and numeration, algebraic processes and statistics in Nigerian schools. They however found the existence of a weak significant relationship in Geometry and Trigonometry.

Several national surveys in the United State (Armstrong, 1981; Ethington & Wolfe, 1984; Fennema & Sherman, 1978; Levine & Ornstein, 1983; Fennema & Sherman, 1978) reached the general conclusion that gender differences are more likely to emerge as students take more difficult course work in high school and college.

Explanations of these differences have tended to fall into two camps. Benbow and Stanley (1980, 1983) have argued that they reflect genetically rooted sex differences in math ability. On the other hand (Eccles, 1987; Fennema & Sherman,1978; Ornstein, 1983; Meece, Eccles, Kaczala, Goff, & Futterman, 1982) argue that these differences reflect gender-role socialization, such that males, far more than females, are encouraged to participate in mathematics and the sciences and that the cumulative effects of this differential socialization are most evident on difficult material.

3. Statement of the Problem

Mathematics has over the years been seen as preserve for male students. However, recent findings suggest that gender differences in mathematics achievement up to the high school level have diminished (Eisenberg, Martin, & Fabes, 1996).

Similarly, Hyde, Fennema, & Lamon (1990) in an extensive review of the literature found that males did not outperform females in computational ability or understanding of mathematics concepts, but did outperform them in advanced problem solving at the high school and college levels. Kimball (1989) found virtually no gender differences in mathematics course work except for college level calculus and analytical geometry courses, where males did better.

One attributable reason for a gap in mathematics performance between males and females is the inherent unfairness in school-based assessment (Grifith, 2005;Njabili, et al. 2005; Asim, 2007) which may result from teachers' incompetency in assessment (Asim, et al. 2007). The study was therefore, to examine mathematics achievement in terms of gender differences using performance assessment tasks and performance assessment driven instruction in mathematics learning among senior high school students in Ghana.

4. Hypotheses

The following hypotheses guided the study.

1. H_0: There is no statistically significant difference in the mathematics achievement of female students' who are taught with performance assessment driven instruction (experimental group) and female students' who are taught using the traditional approach (control group).
2. H_0: There is no statistically significant difference in the mathematics achievement of male students who are taught with performance assessment driven instruction (experimental group) and male students who are taught using the traditional approach (control group).
3. H_0: There is no statistically significant difference in the mathematics achievement of male and female students within the experimental group.

5. Purpose of the study

The study was to provide insight into the differences between male and female students in mathematics learning among Senior High school students in Ghana using performance-driven instruction and performance-based assessment tasks.

6. Delimitation of the Study

Due to the nature of the school system, the performance assessment tasks used were not the extended types which require students to take weeks to present their answers but in this particular study, the duration for each test was two hours.

7. Research Design

A quasi-experimental non randomised control group, pre-test-post-test design was used for the study. According to Ary, Jacobs and Razavieh (2002), quasi-experimental designs do not include randomisation and is used where true experimental research is not feasible. The quasi-experimental design was used for this particular study because in a typical school situation it is very difficult to reorganise classes to accommodate a research study. It was, therefore, necessary to use intact classes. A coin was tossed and the head was assigned to the control group and tail to the experimental group.

In this design, the two groups of subjects were given a pre-test, then the experimental group was given a treatment and after the treatment, a post-test was administered to the two groups. The control group was also given a form of treatment (placebo) but this was different from that of the experimental group in terms of the mode of assessment during the period of administering the treatment.

7.1 Population

The population for the research consisted of all first-year senior high school students in Cape Coast Metropolis. The accessible population was the all the 400 first year students of Ghana National College.

7.2 Sample and Sampling Procedure

First-year science classes were allowed by the school authorities to take part in the research. Two of these classes were randomly selected from the five first-year classes for the study. A total of eighty-two students took part.

7.3 Instruments

Two equivalent performance-based assessment tests were developed. For the purposes of this study, the test developed was meant to be completed individually. Test items were developed based on the selected topics to reflect the purpose of the study by the researcher. Answers to the equivalent performance-based assessment tests were developed with the help of assessment and mathematics experts.

The reliability estimates for pre-test and post-test were 0.67 and 0.70, respectively, using K-R 20 formula. The content validity was also established by matching the test questions to specific objectives as required by the mathematics syllabus.

7.4 Data Collection Procedure

Initially the two groups were pre-tested. They had eight periods of mathematics each week and a period was 40 minutes. This means that a total of 320 minutes was used each week to administer the treatment. The focus of the treatment was on group work and sharing of ideas in solving mathematical problems. Six weeks were used to administer the treatment. After the treatment the two groups took a post-test.

7.5 Data Analysis

The independent samples t-test was used to test the first two hypotheses at $\alpha = .05$. The third hypothesis using paired sample t-test at $\alpha = .05$.

8. RESULTS AND DISCUSSION

8.1 Pre-test Results

The pre-test result for both experimental and control groups are presented in Table 1. Table 1 displays the descriptive statistics and the independent samples t-test values of the pre-test scores of the students who participated in the study.

Table 1: Means, standard deviations and independent samples t-test values of pre-test scores of students in the Experimental and Control groups

Group	N	Mean	SD	Df	t-value	p- value
Experimental	42	18.4	6.7			
Control	40	16.2	10.0	78	1.2	.24

The independent samples t-test results indicated that there was no significant difference between the experimental ($M= 18.4$, $SD= 6.7$) and control ($M= 16.2$, $SD= 10.0$) groups $t\ (78) = 1.2$, $p> 0$.

8.1 Hypothesis 1

$H_{0:}$ There is no statistically significant difference in the mathematics achievement of female students' who are taught with performance assessment driven instruction (experimental group) and female students' who are taught using the traditional approach (control group).

To test hypothesis 1, the mean scores, standard deviations and independent samples t-test values of post-test scores in mathematics for female students in both experimental and control groups were computed.

Table 2: Means, standard deviations and independent samples t-test values of post-test scores of female students' in the Experimental and Control Groups

Group	N	Mean	SD	Df	t-value	p-value
Experimental	14	40.8	22.9			
Control	21	23.6	10.9	17.05	2.58	.02

The independent samples t-test result indicates that there is a statistically significant difference in the mathematics achievement between the experimental group and the control group for females. The null hypothesis is, therefore, rejected. The two groups were significantly different in terms of their mathematics achievement after the treatment.

The mean score of the female students of the experimental group was greater than that of the females from the control group (40.8 > 23.6). This significant difference in the mathematics achievement of the female students from the experimental group is partly as a result of the use of performance assessment-driven instructions which made the students manipulate information and ideas. The students are by this are able to combine facts and ideas in order to synthesize, generalize, explain, hypothesize, or arrive at some conclusion or interpretation. Manipulating information and ideas through these processes allowed the students to solve problems and discover new meaning and understanding.

This result supports Eshun and Abledu (2001) study involving female pre-teachers' on the effect of alternative assessment on their mathematics achievement found significant improvement in the performance of the experimental group indicating that the performance assessment activities notably increased the students' ability to use problem solving approaches in new situations. The significantly higher performance exhibited by the females' in the experimental group indicates that female students can do well in mathematics.

8.2 Hypothesis 2

$H_{0:}$ There is no statistically significant difference in the mathematics achievement of male students who are taught with performance assessment driven instruction (experimental group) and male students who are taught using the traditional approach (control group). Table 3 shows the descriptive statistics of the two groups and the result of an independent samples t-test.

Table 3: Means, standard deviations and independent samples t-test values of male students' Descriptive Statistics mathematics scores for both Experimental and Control Group

Group	N	Mean	SD	Df	t-value	p-value
Experimental	27	45.6	16.6	39	2.22	.03
Control	14	39.1	18.0			

The result of the independent samples t-test shows that there is a statistically significant difference in the mathematics achievement between the experimental group ($M = 45.6$, $SD = 16.6$) and male students from the control group (M = 39.1, SD = 18.0), t (39) = 2.22, p= .03. The null hypothesis is, therefore, rejected. The performance of the experimental group was statistically better than that of the control group.

The significant difference in the performance of male experimental and control group students' is an indication that as students' are exposed to performance assessment driven instruction combined with performance tasks the students' mathematical abilities are enhanced and their performance is also improved.

It is also worthy to note that males generally like mathematics but, their interest in mathematics could increase when students are exposed to mind stimulating mathematical tasks with appropriate instructions.

The importance of aligning teaching methods and assessment tasks cannot be over stressed with results obtained from the study as it is possible to suggest that the performance assessment tasks improved students' mathematics performance. One can conclude that teaching and assessment are inseparable in the learning process. Assessment does not stand outside the teaching and learning but stands in a dynamic interaction with them.

Furthermore, the result obtained emphasises that effective assessment of mathematics learning comprises the use of the following; the use of multiple strategies such as the use of open-ended assessment tasks coupled with the teacher teaching in teams. Also students should be allowed to participate in hands-on activities and must be given time to spend in cooperative groups than have been done in the past. Effective assessment practices are essential to support mathematics instruction that produces improved student performance.

8.3 Hypothesis 3

H_0: There is no statistically significant difference in the mathematics achievement of male and female students within the experimental group.

The mean scores, standard deviation and independent samples t-test values of the post-test scores in mathematics for the experimental group were computed. Table 4 shows the descriptive statistics of the two groups and the values of the independent samples t-test.

Table 4: Means, standard deviations and paired sample t-test values of Males and Females in the Experimental Group

Group	N	Mean	SD	Df	t-value	p-value
Male	27	45.6	16.6	39	.82	.42
Female	15	40.8	22.7			

The result of the paired sample t-test shows that there is no statistically significant difference in the mathematics achievement between male and female students from the experimental group (M = 45.6, SD = 16.6), (M = 40.8, SD = 22.7), t (39) = .82, p= .42. From Table 6 the p-value (.42) is greater than the significance level of 0.05. Therefore, fail to reject the null hypothesis.

This is an important finding in the sense that male students are generally perceived to do better in mathematics than female students. Studies have shown that, on the average, girls do not score highly as boys do in mathematics tests, especially if these tests involve higher level cognitive tasks (Leder, 1990). On the contrary, in this study there was no significant difference in the mathematics performance between males and females students in the experimental group.

Carpenter, Fennema and Franke (1996) reviewed published studies on gender differences in mathematics performance and concluded that no significant differences exist between boys and girls mathematics achievement before they entered elementary school or during early elementary school years. However, in upper elementary and early high school years significant differences existed but were not always apparent. In this particular study the difference in mathematics performance between males and females is not significant. This result shows that performance assessment tests are not gender biased and also contradict the assertion that boys perform better in mathematics than girls with particular reference to early high school level in Ghana.

Costello (1991) reported that "almost all literature on this topic points to the commonly held perception that doing mathematics is consistent with a male self-image and inconsistent with a female self-image." This self-image is usually caused by the peer pressure. Males are more inclined towards mathematics than females on being the male dominated domain. It is found that at secondary school level most of the girls don't actively participate in mathematics classes due to their poor perceptions about mathematics.

9. Conclusion and Implications of the Findings for teaching mathematics

The use of PA-driven instruction in the teaching and learning of mathematics in this study provided an equal platform for both sexes in terms of mathematics learning and achievement. The study shows that performance assessment tests are not gender biased and also contradict the assertion that boys perform better in mathematics than girls with particular reference to early high school level in Ghana.

Students' achievement in the mathematics also improved. PA-driven instruction encouraged the student to own the process of solving the given problem. The student is engaged in a process of constructing individual interpretations of their experiences. Instruction must be aligned to the assessment as it provides an excellent picture of the student performance.

10. Recommendations

The following recommendations are made based on the findings:

1. Mathematics teachers at the senior high school level should make performance based assessment tasks as part of their lessons.
2. Mathematics teachers should give female students equal opportunities in the classroom so that their confidence in the subject will be high.

11. Limitations of the Study

The present study has some limitations that warrant mentioning. The sample used for the study is not large enough to permit meaningful generalisations to other Senior High School students in Ghana. Also purposively selecting Ghana National College for the study decreases generalisability of the findings. Since students were in the same school there was the likelihood of students from the experimental and control groups interacting.

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