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# Unequal Achievement of Science Undergraduates: Does Sex Influence the Differences?

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The major purpose of this study was to determine if gender influences grade points earned by university students who majored in biology, chemistry and physics. The design of the study was Ex-post facto, considering the academic records of science students admitted from 2003 to 2007. The total number of subjects used for the study was 637 students of biology, chemistry and physics education students. The instrument used for data collection was the students' data cards. The major findings of the study included: (1) Females dominated enrolment in biology, males dominated enrolment in physics, and enrolment in chemistry was nearly equal for males and females; (2) Male students significantly out-performed the females on grade points earned in chemistry and physics, while there was no significant difference between males and females in biology; (3) There was no significant difference between males and females of high ability in chemistry and physics and of middle and low abilities in biology, while significant differences were found between males and females of middle and low abilities in chemistry and physics; and (4) There was significant difference in GPA (grade point averages) between males and females by discipline and level.

*Keywords:* gender, enrollment, discipline, ability, level and grade point

## Background to the Study

### Historical Overview

The unequal achievement of science students has been a persistent problem in science education. When the author spoke about unequal achievement, we refer to the different academic performance of children from different social origins (Ansalone, 2009). The topic of unequal outcomes for men and women in science and math in academia was brought to the consciousness of the general public, when Summers (2005) remarked publicly on these discrepancies. Some few issues, like under-representation of females in science courses and the question of why women are not seeking careers in information technology occupations, have sparked off more controversies than the question of why science students at similar age and from similar social origins differ in science achievement. Linver, Davis-Kean, and Eccles (2002) noted that there has been a renewed debate on the controversial issue of gender differences on math and science achievement. They stated that this current debate focuses on the question of why women are not seeking careers in information technology occupation. Apart from the ongoing debate on gender issues in science education, the whole exercise has sparked off a lot of studies in this area. Recently, a new life has been infused into this discussion (Ansalone, 2009) as studies continue to support that student's achievement in certain science disciplines are related to

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sex. For example, Bennett (2003) stated that there are evidences from research which suggest that girls now outperform boys in all science subjects apart from physics at most levels during schooling, and that the gap in performance appears to be widening.

Historically, Bennett (2003) stated that the first upsurge of interest in gender issues in science education occurred in the late 1960s. In the UK, the publication of a report by the Dainton Committee (DES, 1968) documented a “swing from science” in the school-age population as a whole, and he established that the number of boys studying physical science subjects beyond the compulsory period far outweighed the number of girls. One outcome of the legislation which followed the report was a very close scrutiny of the curriculum which revealed very different provisions made for boys and girls in a number of subjects, including science.

By mid 1980s, the struggle to have an educational system that offers equal opportunities for all sexes has been vigorously intensified. For example, Bennett (2003) stated that the Educational Reform Act in England and Wales made a broad and balanced science course part of the curriculum for pupils throughout their period of compulsory schooling. This was seen as a solution to girls’ under-involvement in school science. As science gradually shifted from the realm of philosophy to contents of physics, chemistry and biology, greater participation of women began to surface (Ivowi, 1987). All those who develop the frontiers of science from late classical to current modern periods have had equally commendable contributions and rewards. A good number of them have contributed significantly to the development of science. Among them, the most notable are Barbara McClintock and Marie Cuvie who earned Nobel prizes in biology and physics, respectively.

Studies undertaken by IEA (International Association for Evaluation) from 1970 to 1973 and from 1983 to 1986, established a gender gap in favor of boys in all branches of science with the most apparent differences in physics. However, the TIMSS (third international mathematics and science) reported no significant statistical difference overall in performance for either 12- or 13- year-old except in chemistry. Survey conducted by PISA (Programme for International Students Assessment) in 2000 indicated that boys no longer have edge over girls.

Bennett (2003) reported that recent studies on gender differences in performance in science of pupils in England and Wales showed that there is now no significant difference in attainment in science between boys and girls aged 14 and 16 for lower attaining pupils. These studies, however, specifically looked at aggregate marks for science (biology, chemistry and physics). The braking of aggregate marks for science into separate marks for biology, chemistry and physics for students in general revealed that boys do significantly better in physics than girls with 60% for boys attaining the equivalent of a grade C compared with 49% for girls (Bennett, 2003).

Overall, Bennett (2003) noted that evidences from recent studies suggest that girls now outperform boys in all science subjects apart from physics at most levels during schooling, and that the gap in performance appears to be widening. Bennett (2003), however, stressed that since the gender comparison now is based on specific subjects, the changes in assessment strategies may have played a significant role in painting this picture. To buttress this point that males outperform females in physics, Summers (2005) stated that his hypothesis on the subject matter focused on the finding that there are many fewer females than males in advanced math and physical science. This, therefore, calls for more researches in the field.

Linver et al. (2002) stated that research of Halpern (2000) has shown only two gender differences in specific sub-areas of spatial and verbal abilities, three-dimensional mental rotation (favoring men) and speech production (favouring women). Continuingly, they further stated that other researches have also shown a decline in the differences between the genders in the past few decades on standardized test, suggesting that the more exposure that women are getting to math and science classes, the better their scores. Halpern (2000) noted that most comprehensive reviews of the research in the area of gender differences have shown few differences in math and verbal abilities between men and women.

**Rationale for the Study**

Recently, in Nigeria, there have been serious complaints of under representation of females in science and science related fields and disciplines and of unequal performances of male and female graduates in public examinations in those fields. On the average, females are found to perform worse than their male counterparts. The issue of under representation in a field is not entirely a matter of not requiring a particular sex in a field, but to a great extent, a matter of the sex not possessing the skills and capabilities required in the field. This argument is hinged on the fact that since females are in the minority in all science and science related fields in Nigeria, a sex related factor may be responsible for it. Summers (2005) argued that the reason is because women are unwilling to reduce their time with family to work long hours required to achieve high academic level. Taking science teaching as a case in point, among all the science teachers teaching science in secondary schools, only about 30% of them are females, while most of them are teaching biology. In the tertiary institutions, less than 25% of females lecture science in the faculty of science. These observations perfectly agreed with the report of Halpern, Benbow, Geary, Gur, Hyde, and Gernsbacher (2007). To balance gender representation, most institutions reduce cutoff scores for females to enable them get fair representation. Employment in a bank in Nigeria requires an applicant to possess at least second class upper division degree in either social science or science, but this condition is specific for only males. However, for females, second class lower division is accepted. These dispositions tend to give official proof to gender effects on graduates' achievement and needs to be investigated. This in part forms the major rationale for this study. Can similar results be obtained as reported in the past and when the secondary level of education was used to determine gender effects on achievement? Can gender effects at the undergraduate level, if detected be explained with similar reasons adduced for findings at the secondary level of education? These questions also contributed to carrying out this study.

Although current research reviews indicates a declining gender effect on science achievement over a few decades because of increasing students' exposure that the differences ever exist between males and females on science achievement, which is not normal. Even though recent research findings tend to raise the question as to whether gender differences still exist in academic achievement (Linver et al., 2002), many researchers in science education are still finding differences in science achievement when sex is used as a parameter. These current findings informed the subsidiary rationale to carry out this study, because our knowledge on the role of sex in science learning is not complete. However, the area which this study emphasized is directed at the role of gender on undergraduate science achievement which has very limited literature in Nigeria.

## Theoretical Framework

This study can be hinged on the cultural differences model of sociology theory and sex role theory. The cultural difference model contended that some disadvantaged children did in fact have a culture and that it was not pathological or lacking (Ansalone, 2009). They considered this culture to be a separate and distinct set of values and rules like sex roles. Proponents of cultural difference suggest that the possibility for school failure to be increased, when there are marked differences culturally. Ansalone (2009) discussing the findings of Cazden, John, and Hymes (1974), Health (1983) and Labov (1972) argued that interactional difficulty in school is clearly related to differences in styles of communication arising from cultural variations and that academic achievement can be improved, if teachers adapt and show greater respect for the culture of minority students, like the peculiar characteristics of different sexes.

A link between school cultural difference models and school subject achievement indicates that boys as well as girls may be victims of societal expectations and that students of both sexes can do well in the same subject. Using reading as an example, Good and Brophy (1980) while discussing the findings of Maccoby and Jacklin (1974) stated that young girls, in America on the average, consistently outperform boys on a variety of verbal performance measures. However, later research suggests that the superior reading ability of young girls is not true of all cultures. Good and Brophy (1980) who discussed the findings of Johnson (1976) reported that in the United States and Canada girls outperformed boys in reading among the second, fourth and sixth graders, but in Germany, England and Nigeria boys outperformed the girls. These comparisons show strong sex and culture interaction (boys and girls perform better in some culture than other ones). Current research by Halpern, Bentow, Geary, Gur, Hyde, and Greensbacher (2007) has disproved the findings of Johnson (1976). Using 33 countries to study reading ability, they found that fourth-grade girls outscored fourth-grade boys on reading test.

Studies on sex differences in achievement of adults as far back in the 70s show that males are more likely to reach their full intellectual and creative potential than females and are more likely to become prominent in the arts, sciences and professions. Thus, the apparent advantage that girls enjoy in the early grades does not hold up over time because of the emergence of a conflict between sex role and student role.

The main reason for this is the gradual change in the relationship between the sex role and the student role (Good & Brophy, 1980). As boys get older and move into high school and college, the conflict that once existed between the student role and the male sex role disappears, and achievement in school is perceived as a stepping-stone towards later achievement as the family breadwinner. An occupation becomes a basic part of the sex role expectation. In contrast, the harmony between the student role and the female sex role that exists when young girls are in the first few grades of elementary school is gradually reduced, so that in high school and college, girls experience conflict between the demands of the student role (competing for grades and prepare yourself for a full-time occupation) and the traditional female sex role (avoiding competition for grades and other activities that might make you unattractive or threatening to boys and preparing yourself to be a wife and mother) (Good & Brophy, 1980).

The gradual change in the relationship between the sex role and the student role assigned by the society, as boys and girls grow older perfectly, agrees with this study which compared the variation in science achievement among undergraduates. The undergraduates are adults who are under the influence of both the student and sex roles to meet cultural and societal expectations.

## Literature Review

Literature on sex differences in higher education indicates that male/female differences are increasingly apparent as one moves up to the educational and vocational continuum (Lane, 1999; Lawler, 1999; 2002; Marvis, 1999a; 1999b; 2000; Sax, 2001; Harper et al., 2007), with the disparity actually increasing dramatically at the highest level (National Research Council, 2001). Committee on Women Faculty (1999) reported that in the 1990s, the ratio between male and female were 1.5:1.0 among undergraduates in science at MIT, but more than that among faculties, 11.4:1.0. Gottfredson (1997) still reported the same pattern of increasing discrepancy at higher levels of achievement.

Although literature shows that women now surpass men in the rate at which bachelors and masters degree in all areas are earned, the author still find fewer women than men in the physical sciences (Harper et al., 2007). Studies conducted by National Science Foundation (2002a), Nelson and Rodgers (2004) and Valian (1998; 2005) found that while women are about par with men in the life sciences, they are under-represented in the physical sciences and engineering.

Although this study specifically concentrated on finding out the influence of sex on students achievement in undergraduate science, the scope of literature covered was expanded to: societal and cultural; school and teachers, the image and nature of science; personality and attitudes to science influences on science achievements variation between males and females. No data was collected on them but they were included in the literature to increase the knowledge of intervening variables which could combine with sex to bring about variability in science achievement.

Literature on the differential involvement and achievement of males and females in science identified inherent influences: societal and cultural influences; school and teachers effects; the image and nature of science; personality and attitudes to science as the major factors responsible. In the past, it was believed that girls possess some inherent differences which limited their ability to acquire scientific knowledge. Kelly (1981), who discussed (Felter, 1906 argument), stated that girls should not be taught physical sciences except at the most elementary level, because the expenditure of nervous energy involved in the mastery of analytic concepts would be injurious to their health. This position did not, however, stand the test of time. The work of Whyte (1986) demonstrated that girls who had participated in a six-month programme activities aimed at improving spatial ability performed as well as boys in spatial ability tests. This resulted in conclusions that differences between boys and girls are not induced by biological facts.

Research reveals that teachers usually pay less attention to girls and interact more frequently with boys. Some researchers even suggest that teachers often devalue the work of females relative to males. As a result, they asserted that the self-confidence and esteem of women may be seriously damaged (AAUW (American Association of University Women), 1998). De Marrais (1991) found that more aggressive behavior of males is encouraged in the classroom than females who wait to be called. These then influence female’s achievement variation. The society on its own ascribes gender roles to males and females. Ansalone (2009), for example, asserted that in the area of extra-curricular activities, girls are encouraged to participate in sports as cheerleaders and reminded of the importance of being attractive. On the other hand, boys are encouraged to participate in athletic programmes which promote competition and achievement. This competitive drive may have influenced their achievement in science. On students’ role of the reported differences in sciences achievement, Ansaolone (2009) found that less girls than boys register in math and science, because they perceive less opportunities in these fields. This invariably influences female students’ achievement in science.

On societal and cultural influences, Archer and Lioyd (1982) found that as early as three years of age, parents have already programmed children to exhibit gender and appropriate behaviors. Johnson (1989) and Dawson (2000) in their studies found that boys have emerged as more likely than girls to have hobbies which involve making models, playing with electrical and mechanical devices and such interests. It has been argued that such dispositions of parents are more likely to predispose boys to be interested in physical science subjects and to provide them with opportunities for acquiring skills and knowledge which can later be consolidated in science lessons.

Studies on classroom interactions have gathered evidences of the differential treatment of girls and boys by some science teachers which resulted in the reaffirmation of stereotypes and discouraged girls from participating in science. Ansalone (2009), for example, stated that some researchers have uncovered that many teachers often hold quite different expectations for males than for females, and in so doing, it actually influences the academic performances of these students. Research also shows that teachers address more male's questions and accept their more answers than females (De Marrias, 1991). However, the study on school type and students achievement by Daves (1996) showed that there was no significant difference in academic achievement of either boys or girls, whether taught in mixed or single-sex groups. Girls from the single-sex groups reported the increased interest in science, the increased confidence in their abilities in science and an increasing willingness to contribute in science lessons.

Literature on image and nature of science indicated that science is "masculine" and not "girl friendly". Kelly (1985) showed four reasons why science is masculine: more males choose science; the content learned in science suits the interest and motivation of boys; in the science class boys and girls play gender roles; and since science was constructed in the male dominated society, science is itself inherently masculine. Collings (1981) undertook a survey of 17 and 18 year olds students and found that the girls who had chosen to study science subjects formed a distinct group, who were more intelligent, less person oriented, tougher minded and had a more negative self-image than girls who had not chosen science subjects. These findings agreed with that of Head and Ramsden (1990). Harding (1996) noted that much of the physical science curriculum used in schools are presented in a depersonalized, abstract form which attracts a certain type of a more emotionally balanced person, who usually is a male, who has developed the need to control, abstract and suppress ambiguity.

Generally, most studies on attitudes to science indicated that most young people show negative attitude to science. They believe that scientists are males and that science is for males. A study by Weinburg (1995) on gender differences in attitudes showed that negative attitudes to science are more prevalent amongst girls than boys, though so less in the case of more able girls. Further studies by C. Woodward and N. Woodward (1998), Sjoberg (2000), and Breakwell and Robertson (2001) demonstrated that boys show a preference for physical science topics and girls for biological/medical topics.

It is very clear from the ongoing discussions that the controversy over sex differences in academic achievement particularly in science has not been conclusively resolved. There are still much needs to carry out further research into the effect of sex of the learners on academic achievement of science students at least in Nigeria. The choice of finding out the influence of gender on science student's achievement at the undergraduate level as stated in the rationale for the study was made because of the strategies employed in correcting gender imbalance in all institutions in Nigeria. This study is aimed at specifically finding out, if gender really influences science achievement at the undergraduate level or if what is observed and reacted by the society is a mere extension of the notion about achievement of students at secondary school level of education.

The consideration of other intervening variables like student's attitudes, interest, motivation, self-concept and background knowledge was not made in this study, since the design of the study was ex-post fact. The data considered in this study already existed before the commencement of the study. Consideration of the interaction effects between the sex and the intervening variables will be very useful in the extension of this study. The study was restricted to only one university to reduce the influence of peculiar environmental and intervening variables which vary in scope and magnitude from one university to another and affect the findings of the study. A fusion of findings from smaller entities with their peculiar intervening variables which can be controlled by the researcher in the unit will produce a more reliable result than the results of a study at once a global entity.

This study again considered the results of students admitted from 2003 to 2007 and graduated from 2007 to 2010. This provided four sets of students' results for analysis after four academic sessions. This design afforded the researcher the opportunity to determine to some degree of accuracy the actual abilities and achievement of students in the respective science disciplines. This is a deviation from the earlier procedure adopted by earlier researchers where one singular achievement test is administered to students to determine achievement variations arising from sex.

## Statement of Problem

Although some recent science education researches on the effect of gender on science achievement reported non-significant gender effect on achievement in most school science subjects, some pockets of very recent studies have reported significant differences particularly in mathematics and physics. Those who found non-significant differences on achievement in most school science subjects using sex as a variable argued that the results were products of improved methods of instruction which enabled all of the students to learn well and use more effective strategies of assessing students' learning outcomes. It must be noted at this point that most of these reported studies centered on secondary school science. In Nigeria, studies on influence of gender on undergraduates' science achievement are scanty and thus need to improve our knowledge of the field. The statement of the problem therefore is; will the analysis of grades earned in courses in different science disciplines over a period of four academic sessions, indicate gender biases?

### Research Questions

The study was guided by the following research questions:

(1) What effect does gender have on student's enrollment to study biology, chemistry and physics education?

(2) What effect does gender have on grade points earned by students on biology, chemistry and physics courses specific for biology, chemistry and physics education?

(3) What effect does gender have on grade points earned by students of high, middle and low abilities on specific courses for biology, chemistry and physics education?

(4) What effect does gender have on GPA (grade point averages) earned by students at 100, 200, 300 and 400 levels?

### Research Hypothesis

The research hypotheses tested at significant level of 0.05 are as follows:

$Ho_1$: The mean grade points earned by male and female students in specific courses for chemistry. Biology and physics education will be significantly different;

$Ho_2$: The mean grade points earned by male and female students of high, middle and low abilities on the specific courses for biology, chemistry and physics education will be significantly different;

$Ho_3$: The GPA earned by male and female students of biology, chemistry and physics education at 100, 200, 300 and 400 levels will be significantly different.

The hypotheses were stated in a positive form based on the fact that studies still continue to support that student's achievement in certain sciences disciplines are related to sex. This study tends to confirm if that position is correct.

Students in year one in 2003/2004, 2004/2005, 2005/2006 and 2006/2007 sessions were merged together to give a 100 level students; students in year two in 2004/2005, 2005/2006, 2006/2007 and 2007/2008 session were merged to give 200 level students; students in year three in 2005/2006, 2006/2007, 2007/2008 and 2008/2009 were merged to give 300 level students and students in year four in 2006/2007, 2007/2008, 2008/2009 and 2009/2010 were merged to give 400 level students.

## Methodology

**Design of the Study**

The study employed Ex-post Facto longitudinal design. The Ex-post Facto design was appropriate and right, since the past records of the students (particularly the past results) were used to make inferences about them. Any study which employs the past records of a given sample of subjects to reach a conclusion about them is assumed to have been carried out using Ex-post facto design (Wiseman, 1999, Johnson & Christensen, 2000). The study is longitudinal, because the study covered a four-year period from each year of admission. In all a span of eight years was used, considering the results of those admitted from 2003 to 2007 and graduated from 2007 to 2010. The results of the students in biology education, chemistry education and physics education were analyzed for four sessions, i.e., from 100-400 level. The design consisted of three science disciplines as stated above, sex (male and female), ability (high, middle and low) and class level (100, 200, 300 and 400). The main independent variable was sex while the intervening variables were ability and class level. The dependent variable was grade earned in each semester course.

Science Education department in the faculty of Education of Delta State University offers five programmes, which include biology, chemistry, integrated science, mathematics and physics education. The curricula for biology, chemistry and physics education programmes which are the focus of this study specify 70% specific subject area courses made of core and electives and 30% general education courses on teaching methods. All these courses are taken within eight semesters, (four academic sessions) with students having to pass all the core courses and obtaining a minimum of 120 units of passed courses before the award of B.Sc (Ed) in science education. Only the core courses specific for each of the subject disciplines were used in the derivation of total grade points earned and grade point averages of the students.

**Population and Sample of the Study**

The total number of students used for the study consisted of all biology education, chemistry education and physics education students admitted from 2003 to 2007 sessions and graduated from 2007 to 2010. This brought the total number of students used for the study to 637. No sampling was done. All the students admitted from 2003 to 2007 academic sessions in three units (biology, chemistry and physics) of Science Education Department of Delta State University were used for the study. The subjects were grouped following this order: (1) discipline line; (2) sex line; (3) ability line and (4) class level line. Lines (1), (2), (3) and (4) were restricted to each discipline. The minimum duration to obtain a B.Sc degree in biology, chemistry and physics education lasts for four academic sessions.

The equivalence of the subjects on the basis of their background knowledge was established at the point of admission into the programmes through the application two conditions. The first was that all the students in the various programmes were admitted based on specified departmental requirements for the various programmes. The second was that only students who scored within a given range of marks specified for each programme in a UME (University Matriculation Examination) were offered admission to study the course of biology, chemistry or physics education. This brings all the students to be at the same level at the point of admission.

**Instruments**

The major instrument used for this study was the students' data cards. The students' data cards contain the courses registered and grades earned by a student throughout the period of student's stay in a programme. The data cards also show the summary of the number of units registered per-semester/per-session, unit passed, total grade points earned, grade point average, cumulative grade point average and student's academic standing.

The instrument was not validated, as it was not necessary. Validation was not necessary, because instruments gotten from the original source do not need to be validated, and all data collected from such instruments are seen to be correct and reliable (Thorndike & Hagen, 1997; Wiseman, 1999; Johnson & Christensen, 2000).

However, before results are compiled in the students' data cards and which are done at the end of every semester, the following steps are taken to validate the scores. All raw scores are considered in a departmental board meeting to enforce standards. Even before the departmental board meeting, the quality assurance of students' scores in any course is enhanced by the use of only matriculation numbers as the only identify for examinations. The writing of students' names in an examination answer sheet is prohibited. Before compiled results are sent to the University Senate for approval, they are first sent to the Business Committee of Senate for scrutiny. It is only after the senate's approval of compiled results that results in students data cards are adjudged as valid, authentic and reliable.

## Method of Data Collection

The students' data cards from which the students grades in the courses registered were collected are kept by the course advisers for the various disciplines of study (biology, chemistry and physics education). After expressed permission from the head of department of the unit of study, the students' data cards were obtained from the course advisers.

Delta State University after approval by its senate uses a five point letter grade scale for score reduction. The grades include: A, 70 and above (5 points); B, 60-69 (4 points); C, 50-59 (3 points); D, 45-49 (2 points), E, 40-44 (1 point); and F, 0-39 (0 point). For every course, there is a specified unit assigned to it based on the number of hours allocated for its teaching per week. The determination of the total grade point and grade point average follows this order. Using the letter grade, the score obtained by a student in a particular course is first converted to the appropriate letter grade and then grade point. This grade point is then multiplied by the unit assigned to the course and the product is called credit. The sum of the credits earned in all the courses taken within a specified period (e.g. semester, session/sessions) gives rise to the total grade point. When the total grade point is divided with the total unit of all courses registered per period (e.g. semester, one session), what is obtained is called GPA. The grade point average becomes CGPA (Cumulative Grade Point Average), when the sum of all the credits earned in the courses taken in more than one semester (i.e., within the period) is divided with the total units of courses taken within the period under consideration.

The total number of courses for each science discipline from which scores were collected included: biology 24 courses; chemistry 28 courses; and physics 23 courses. Scores in elective courses were not used for the study since not all the students took the same elective courses. All students on probation and extension were isolated from the study, because they have abnormal total number of registered courses. The period of collection and analysis of students scores/grades in the data cards lasted for two weeks. The students grades in courses registered in each of the specified disciplines were sorted out and arranged using sex as the major independent variable and two intervening variables of class level and ability. On class level, the male and female students grades in courses registered in each of the disciplines were sorted out and arranged from 100 through 400 levels. On ability, the students were grouped into three: high ability, middle ability and low ability using the CGPA standard recommended by Delta State University Senate. Using the Delta State University Senate rule, students are categorized in this order:

CGPA3.50 – 5.00 = High ability;
CGPA2.40 – 3.49 = Middle ability;
CGPA1.00 – 2.39 = Low ability.

All the data collected were summarized and shown in Tables 1, 2, 3 and 4. Two main statistics were employed in testing the stated hypotheses at significant level of 0.05. The statistics included students *t*-test and ANOVA (analysis of variance).

## Results

Table 1

*Enrollment in Science Education Programmes 2003-2007*

| Science discipline | No. of males | No. of females | Total |
|---|---|---|---|
| Biology | 72 | 230 | 302 |
| Chemistry | 86 | 84 | 170 |
| Physics | 89 | 76 | 165 |
| Total | 247 | 390 | 637 |

Table 1 shows the distribution of male and female students in three programmes under science education. When the enrollments of students in biology, chemistry and physics programmes are taken together, Table 1 shows that more females (390) than males (247) enrolled in the programmes.

Table 2

*Gender Differences in Mean Grade Points and t-Test Analysis of Grade Points Earned By Gender and Discipline*

| Science discipline | | *N* | Mean | *t* | Critical value for t at 0.05 | *df* |
|---|---|---|---|---|---|---|
| Biology | Male | 72 | 97.22 | 1.168 | 1.960 | 300 |
| | Female | 230 | 89.783 | | | |
| Chemistry | Male | 86 | 149.479 | 2.388 | 1.960** | 168 |
| | Female | 84 | 127.571 | | | |
| Physics | Male | 89 | 156.103 | 3.412 | 1.960** | 63 |
| | Female | 76 | 131.316 | | | |

*Note.* **Significant at 0.05.

Table 2 shows grade points earned variability between males and females among disciplines. The table also shows *t*-test comparison between males and females on mean grade points earned among biology, chemistry and physics education programmes. Significant differences were found between male and female students in chemistry and physics education programmes. In view of this, $H_{O1}$ was rejected by chemistry and physics education students.

Table 3 shows the mean grade point score variability among students of high, middle and low abilities and among students in biology, chemistry and physics programmes. Table 3 also shows the *t*-test summary of the comparison between males and females of similar abilities and among biology, chemistry and physics programmes. Significant differences were found between males and females of middle ability in chemistry and physics and low ability in chemistry and physics. This was hinged on the fact that the obtained *t* was greater than the critical value for *t*. In view of this finding, $Ho_2$ was rejected by middle and low ability students in chemistry and physics education programmes.

Table 3

*Gender Differences in Mean Grade Points and Score Variability by Ability and Discipline*

| Discipline/ability level | Male | | | Female | | | *t* | Critical value for *t* at 0.05 | *df* |
|---|---|---|---|---|---|---|---|---|---|
| | *N* | Mean grade point | *SD* | *N* | Mean grade point | *SD* | | | |
| Biology | 72 | | | 230 | | | | | |
| High | - | - | | - | - | - | - | - | 68 |
| Middle | 30 | 124.375 | 31.487 | 40 | 128.250 | 25.354 | 0.383 | 1.994 | 230 |
| Low | 42 | 75.500 | 17.322 | 190 | 79.432 | - | 0.717 | 1.960 | - |
| Chemistry | 86 | | | 84 | | | | | |
| High | 8 | 170.000 | 34.641 | 16 | 201.250 | 21.225 | 1.964 | 2.074 | 22 |
| Middle | 49 | 161.615 | 20.018 | 52 | 126.167 | 25.318 | 5.514 | 1.982** | 99 |
| Low | 29 | 116.333 | 40.329 | 16 | 72.000 | 16.411 | 3.249 | 2.014** | 43 |
| Physics | 89 | | | 76 | | | | | |
| High | 12 | 230.250 | 27.248 | 4 | 224.000 | 0.000 | 0.310 | 2.145 | 14 |
| Middle | 58 | 155.947 | 32.543 | 40 | 124.364 | 14.769 | 4.292 | 1.982** | 96 |
| Low | 19 | 107.167 | 20.814 | 32 | 129.000 | 31.378 | 2.051 | 2.008** | 49 |

*Note.* **significant at 0.05.

The most striking feature shown in Table 3 is the absence of high ability groups of males or females in biology education programme. This may be explained with the high load of courses taken by the students in biology education. The students take courses in the subject discipline and teaching method. This may have weakened their ability to excel in the discipline courses in biology.

Table 4 shows the mean GPA of students in biology, chemistry and physics education programmes among the four class levels (100-400), and shows no trend in the GPAs of students except that among class levels in each of the disciplines except among the females in physics education. Table 4 also shows ANOVA summary of the comparison of GPAs among class levels in each specific discipline. Significant differences were found among class levels on GPA in biology, chemistry and physics. In view of this result, $Ho_3$ was rejected.

Table 4

*Gender Differences in Mean GPA and Score Variability by Discipline and Level*

| Level | | *N* | | GPA | | *F* | Table *F* at 0.05 |
|---|---|---|---|---|---|---|---|
| | | Male | Female | Male | Females | | |
| Biology | 1 | 72 | 230 | 2.1322 | 1.7183 | 4.300 | 2.103** |
| | 2 | 72 | 230 | 1.4189 | 1.3966 | | |
| | 3 | 72 | 230 | 1.9144 | 1.5211 | | |
| | 4 | 72 | 230 | 1.4428 | 1.7028 | | |
| Chemistry | 1 | 86 | 84 | 2.2481 | 1.6514 | 9.037 | 2.126** |
| | 2 | 86 | 84 | 1.9019 | 1.7224 | | |
| | 3 | 86 | 84 | 2.3976 | 2.0995 | | |
| | 4 | 86 | 84 | 2.7021 | 2.4190 | | |
| Physics | 1 | 89 | 76 | 2.4033 | 2.0866 | 4.675 | 2.103** |
| | 2 | 89 | 76 | 2.6367 | 2.0635 | | |
| | 3 | 89 | 76 | 2.1931 | 1.9495 | | |
| | 4 | 89 | 76 | 2.3290 | 1.9263 | | |

*Note.* ** Significant at 0.05.

## Discussion

This study is still relevant and significant in that its findings will further broaden the author knowledge on the controversy of whether sex really influences science achievement. This study was predicated on the need to put in place an educational system where every student will learn equally irrespective of sex differences and other parameters. Although most recent studies tend to suggest that the gap in gender differences in science learning is closing up as a result of improvements in methods of instruction arising from the application of technology in teaching and learning and increasing number of females pursuing career in sciences, it should be noted that the bulk of literature on gender issues and science learning are mostly centered on the secondary level of education. Not much studies, particularly in Nigeria, have been committed to finding out if sex influence science achievement at the tertiary level of education. The findings of this study will, therefore, contribute to painting the clear picture of how sex influences science achievement at the tertiary level of education. In essence, the findings of studies that used the secondary science acted as a spring board for this study.

The decision to use the variables of sex and achievement in this study was a direct reaction to the conception in Nigerian society that female science graduates generally scores less than their male counterparts in public examinations and the strategies adopted to reduce gender imbalance in all institutions in Nigeria. Summers (2005) made similar observation in United States that the major strategy employed in this direction was the reduction of cutoff marks for females in all selection examinations to enable equivalent number of females to males to be selected. This conception and the disposition tend to suggest before any study that there already existed differences in achievement between male and female science graduates. The confirmation or disproval of this conception forms the major rationale for this study. On the other hand, the investigation of the interaction of variables of interest, motivation, cultural background, background knowledge, social economic status and student's self-concept with sex to influence student's achievement was not done. The major reason for this was that since the design of the study was Ex-post Facto, it was not possible to incorporate such variables into the study. The study mainly considered the outcome of events which took place long before the commencement of the study. These uninvestigated variables could be used as the bases for extension of the findings of this study.

Enrollment in science as shown in Table 1 indicates that more females than males enroll in science disciplines. This agrees with the findings of Ansalone (2009) and Halpern et al (2007) that more than 50% of undergraduates in USA are women. However, when the various science subjects were considered separately, mixed results were observed. For biology, more females than males enrolled. This agreed with Ajaja's (2010) finding in a study on the influence of Post UME screening on science education students' achievement. The study found that more female students enrolled in biology than males. A similar study carried out in Scotland and reported in the annual report of 1998 indicated that 15,323 girls and 6,732 boys took Standard Grade Biology. the number of males and females who respectively enrolled in chemistry is almost equal. This was, however, not the case with the enrollment in physics where the males dominated the females. These distributions as found in this study were exactly what were reported by Halpern et al. (2007). This trend may be explained with the conclusion of Halpern et al. (2007) that early experience, biological factors, educational policy and cultural context affect the number of women and men who pursue advanced study in science and math, and that these effects add and interact with each other in complex ways. These parameters and their interactions may have influenced and pre-determined what sex studies what science most. This is consistent with the stand of Ansalone (2009) that less females enroll in some science disciplines, because they think they lack opportunities there.

In addition to the above explanation, motivation as a factor might influence gender differences in science choice. Eccles, Adler, Futterman, Goff, Kaczala, Meece, and Midgley (1983) and Jacobs, Lanza, Osgood, Eccles, & Wigfield, (2002) noted that Eccles et al.'s Expectancy Value Model suggests that people's choices are strongly determined by their values and self-concepts of ability. This position held by these researchers agrees with Ajaja's (2008) finding in a study on students' attitudes towards biology using personal and environmental influence as parameters. It was found that females showed better attitudes than the males did. Female's value for biology may account for their high number studying the subject. Thornburg (1982) stated that diversity is the characteristics of young adolescents. This assertion becomes even more important as educators and researchers consider grade difference and achievement (Lee, 1998).

On the effect of gender on students grade points earned in the three science disciplines, this study produced various results. For biology, no significant difference was found between the male and female students on achievement. This finding contradicts some earlier studies and positions held by some researchers using secondary school students. It also confirmed a few recent studies. For example, the survey conducted by PISA in 2000 indicated that boys no longer have edge over girls in science. Chang (2008), on analysis of the data collected from TIMSS 1999 and 2003 database for Taiwanese eight graders, stated that statistics showed that gender differences become smaller over time. The finding of Bennett (2003) that girls now outperform boys in all science subjects apart from physics at most levels during schooling did not hold here. The lack of significant differences between male and female students on biology achievement at the tertiary level of education may have been due to the reduced influences of society, culture, and attitude to science which are still linked to achievement in science. In fact, among the biology education students, the conflict between sex and students roles may have been at an equilibrium resulting in both males and females scoring within the same mean.

The finding of significant differences in grade point earned by males and females in favor of males in chemistry and physics contradicts the earlier report of Bennett (2003) in secondary science particularly for chemistry but confirms it for physics. The earlier finding of Bennett (2003), on secondary science activity, showed that breaking aggregate marks for science into separate marks for biology, chemistry and physics revealed that boys did significantly better in physics than girls with 60% of the boys attaining the equivalent of a Grade C compared with 49% for girls. Still, in line with this finding, AAUW (1992), Halpern et al. (2007) and Chang (2008) found that at the upper level of science study, boys outperformed girls and had larger variance. In addition, they stated that boys outnumbered girls in the top 25% in science performance. The finding by researchers that boys always had higher self-concept of ability and subjective science values may be the reason why males outperformed females in chemistry and physics at the undergraduate level.

This, therefore, agrees with the sex role and the student role conflict theory. Good and Brophy (1980) stated that as boys get older and move into college, the conflict between the student role and the sex role disappears, they become more serious with their studies, which enables them acquire skills and qualities for future bread winners roles. In contrast, as the females go into high school and college, they experience conflict between the demands of the student role (compete for grades and preparation for a full-time occupation) and the traditional female sex role (looking good to attract boys and preparation for wife and mother). Summers (2005) in one of his explanations noted that sex-related differences in socialization or discrimination may be responsible for sex variation in science attainment.

The comparison of gender effect on grade points earned among students of varying abilities in the three science disciplines indicated that in biology, middle and low achievers showed no significant difference between the male and female students. For physics and chemistry, among the high achievers, non-significant differences between the male and female students were found. However, among the middle and low achievers in chemistry and physics, significant differences were found. These findings may be explained with the differences in level of variance between males and females in the various ability groups. In the various ability groups where no significant difference was found, they had very little differences in variance between males and females. This explanation may be true for biology group dominated by females. Females are known to naturally exhibit very minimal variance among them. The direct opposite is true of males. Large variance differences between males and females in the various ability groups where significant differences were found are true. In physics dominated by males, the difference in variance between males and females was great. This indeed may have contributed to the significant differences found. This explanation agrees with the findings of Chang (2008) that the upper level boys who outperformed girls had larger variance.

On comparison of grade point averages earned by male and female students in the three science subjects across the four levels as shown in Table 5, significant differences were found in all the subjects. The significant differences in GPA's earned by students in the various science disciplines across the various levels may be accounted for by the high variance in students test scores from one level to another. The possible sources of variance which may have influenced the differences in GPA from one level to another, include: (1) variation in nature and scope of contents studied from one level to another; (2) variation in the difficulty level of contents studied from one level to another; (3) variation in the method of presentation of content materials to students arising from the change of lecturers form one level to another; and (4) ability variation of students which influence GPA's form one level to another. These listed parameters may have interacted with each other to bring out the variance which created the significant differences in GPA found among the students in the three disciplines and across the four levels and gender.

## Conclusions

The findings of this study has reaffirmed the findings of some researchers and contradicted that of others. The researcher gave reasoned explanations to justify the reason why the results obtained were the way they are. In view of the strength of this, the following conclusions are drawn.

From the pattern of distribution of sexes in the three science disciplines, it can be concluded that the distribution is hinged on choices arising from value and perceived abilities of different sexes which may have been based on societal and cultural expectations.

Although the major findings of this study showed that male students significantly earned higher grade points in physics and chemistry disciplines than the females, yet this position may not be explained with biological factors, since there is no consistent evidence from research on the effect of sex on achievement. Rather the differences in grade points earned between males and females may be explained with the influences of other intervening variables and not necessarily sex. Considering the notion in the Nigerian society which formed the major rationale for this study that male science graduates outperform females in public examinations and in reaction reduced criteria of entry for females to reduce gender imbalance in all institutions, it is clearly shown that the variation in achievement between males and females to a great extent is induced by societal and cultural role expectations. The idea of reducing gender imbalance suggests that there is already in existence segregation based on gender on what people do, where they work and what students study in schools as demanded by cultural affiliations and societal roles. Based on this analysis, it may be concluded that the significant variation between males and females on achievement in physics and chemistry at the undergraduate level may be due to the conflict between the student and sex roles. That the male students outperformed the females in physics and chemistry may have been due to a reduction in conflict between the male sex role and the student role which paved way for them to be more serious with their studies for acquiring the appropriate skills for adulthood functioning in the society. For the females, there may have been a heightened conflict between the female sex role expectations and the student role which resulted in their distractions from studies which may have affected their achievement in the two subjects.

On the non-significant differences between males and females on biology achievement, it may be concluded that since biology is the study of life and the desire of all students to understand how biological systems work may have created a harmony between sex and student roles in both sexes.

The major implications of the findings of this study is that since science education emphasizes teaching strategies that will enable all students to learn equally irrespective of gender, science teachers should adopt teaching strategies that will significantly reduce individual differences among students arising from cultural and societal role expectations which existed before they were born.

The argument that the findings of significant higher performances of males than females in physics and chemistry may not be essentially due to gender differences, suggests a replication of this study in other universities, localities and even in other countries. Incorporating other intervening variables, such as student background, interest, motivation, self-concept, societal roles and cultural affiliations can throw more light on the persistent issue of gender effect on achievement and particularly at the tertiary level of education.

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