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The Effects of Gender and Mathematics Ability on Academic Performance of Students in Chemistry

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Abstract
This research was designed to investigate the effect of gender and mathematics ability on academic performance of students in Chemistry. The sample size comprises one hundred (100) SS 1 chemistry students in two secondary schools in Uyo metropolis. The instruments used were the Chemistry Achievement Test (CAT) and the Mathematics Ability Test (MAT). Independent t-test statistic tool was used to analyze the data collected. The result of the test indicated that gender does not have any significant effect on the academic performance of students in Chemistry. It was also observed that students with high mathematics ability performed significantly better than those with low mathematics ability in chemistry. From the findings of the study, it was recommended that both male and female chemistry students should equally be encouraged to excel in their studies and that science students who choose chemistry as a core subject should be made to understand the importance and relationship between mathematics and chemistry and apply themselves seriously to their studies.

Introduction

In all nations of the world (Nigeria inclusive) science and mathematics are given first class attention due to numerous benefits derived from them (Ekeh, 2003). Chemistry which is believed to be the mother of science equips

students with knowledge in areas such as drugs, diseases, pollution, food, chemicals etc which when applied to the society improves man standard of living. Despite the importance of chemistry to our society, the choice and interest of students are influenced by several factors and variables among which gender and mathematics ability are major factors.

Concepts of Gender

Gender is a cultural construct that distinguishes the roles, behaviour, mental and emotional characteristics between females and males developed by a society. Umoh (2003) defines gender as a psychological term used is describing behaviours and attributes expected of individuals on the basis of being born as either male or female.

According to Okeke (2003), the study of gender is not just mere identification of male and female sexes. Scholars have gone further to identify responsibilities assigned to opposite sexes and to analyze the conditions under which those responsibilities are assigned. Furthermore, Okeke (2003) specifically notes that the study of gender means the analysis of the relationship of men and women including the division of labour, access to resources and other factors which are determined by society as opposed to being determined by sex. It further involves the study of the socio-cultural environment under which responsibilities are assigned and the relationships emanating from it.

Thus, gender equally projects the properties that distinguish and classify organisms on the basis of their reproductive and cultural expectant roles. It relates to the cultural and psychological attributes of men and women through their socio-economic contributions, expectations and limitations.

Thus the concept of gender does not support or suggest the dominance of male over female or vice versa in academics and other human resource development areas but it stresses equality and equity in enhancing effective and efficient recognition, development and utilization of competencies and endowed capabilities of both sexes.

Gender Education

It is generally recognized that one of the major if not the most important functions of the school system is to produce the pool of skilled manpower which a nation needs to grow. To this effect countries all over the world depend on their educational systems for the development of their future workforce (Ekeh, 2003). Thus education is an important instrument through

which human resources development is achieved without gender discrimination.

Gender education according to Kano (2004) refers to instructional sensitization practices devoid of cultural bias and prejudice and as a process, it employs equity in the specification of subject matter, methodology, strategy and evaluation as regards the students irrespective of their sex. Role expectations are not stereotype but based on the ability of each student. He further ascertain that the major sources of data for planning gender education are the positive and progressive factors or attributes of the society, the student and the subject matter. The sociological and psychological screening of the society for instance is usually employed in the selection of educational objectives. Therefore those attributes that intervene with positive instructional practices are subdued, ignored, sidetracked, if not entirely eliminated or discarded. Gender education as further stated by Kano (2004) emphasizes the non-recognition of cultural biases and prejudices in the role specification of students in the school. It advocates equity in the provision of learning opportunities, content, strategies and textbook pictorial illustrations.

Gender education is free from sex stereotyping, sex inequalities, sex discrimination and sex-role differentiation. It is a pivot through which the curriculum planners and implementers revolve for maximum success in the school since it endorses a more comprehensive and challenging gender sensitive curriculum.

Therefore the nation should show concern and develop interest on how the two sexes will develop academic competencies which will later be transferred to professional competencies for effective and efficiency manpower development in our society.

Gender Stereotyping in Schools and the Society

It is obvious that every culture holds male superior to their female counterpart and this is evident and confirmed even in our society. Traditionally, sex role stereotyping and the differential valuation of male and female roles have been viewed as an integral part of the socialization process and the development of the adult male and female potentials. Males as naturally endowed have power and prestige thereby having higher and superior status than women (Umoh, 2003). This illustrates the high level of gender stereotype in education and the society at large.

While sex stereotyping limits choices of both male and female, it is particularly constraining for women because few occupations are perceived as being appropriate for women. Besides the fewer job areas available for women might be of low status and income and thus seem discouraging (Umoh, 2003). Okeke (2003) points out that many developing societies have specific roles for different sexes, their varied abilities not withstanding and set roles defined by individual change over time.

Gender role stereotyping is further encouraged in text books through pictorial illustrations which are powerful means of communication. Male are often portrayed as doctors, lawyers, engineers, professors while female are portrayed as nurses, cooks, mothers etc. This creates a mental picture in the mind of the reader of the role expectations from the society (Umoh, 2003).

Most times even the teachers who should motivate and encourage the learners to become all that he/she is capable of being tend to encourage gender stereotype by giving different treatment to males and females in terms of paying or giving more attention to male. The adverse effect is that the female in the same class or subject may develop low self-esteem and confidence and reduced interest (Okeke, 2003). Thus, those social and cultural practices that prevent the provision of ample learning opportunities to both male and female students should be checked by both teachers and the curriculum planners such that they do not permeate into the school system.

Gender and Academic Performance of Students in Chemistry

Gender is a major factor that influences career choice and subject interest of students. Further explanation in this context shows that Home Economics, Nursing, Secretary-ship and other feminine related careers have been traditionally regarded as aspects of the school curriculum reserved for females (Umoh, 2003). Based on this, males chose male stereotyped occupations and females chose female stereotyped occupations.

According to Umoh (2003) more difficult tasks are usually reserved for males while less difficult ones are considered feminine in a natural setting. Example of this is breaking of firewood, which is often seen as manly task while washing of plates could be seen as a female task at home. Thus at school males are more likely to take to difficult subject areas and challenging problem-solving situations while female on the other hand prefer simple subjects and often shy away from difficult tasks and problem-solving situation.

Ekeh (2003) discovered that male secondary school students performed better than females in science and mathematics. These differences in performance can be attributed to gender stereotyping which encourages male and female students to show interest in subjects relevant and related to the roles expected of them in the society. The National Assessment of educational Progress in 1992 showed that males had higher average scores than girls between the ages of 9, 13 and 17. Studies have shown that co-education has negative impact on cognitive performance of students as girls perform better without the boys and vice versa (Okon, 2003). She also stated that the association formed between genders as it applies to co-educational institution causes psychological inferiority complex and this hinders effective classroom participation. Furthermore, it is a known fact that attitude developed by young people during their study of science can be as important as the skills they acquire and the knowledge they obtain. This is because attitude regulates behaviour not only in the classroom but in all other areas of human experience. Concluding, Okon (2003) maintains that gender has no significant influence on students' performance in science

The Role of Mathematics in Chemistry

A careful study of the senior secondary chemistry curriculum in Nigeria and West African Senior Certificate syllabus reveal that a proper understanding of the mathematical concepts on Isotopy, formula, equations, solubility, chemical kinetics, quantitative and molar ratio, radioactivity, pH and laws of chemical equilibra etc in chemistry needs a good knowledge of basic mathematics and generally involves a lot of computation which make mathematics an important aspect of it (WAEC, 2006).

Adeboyel (1999) ascertains that the understanding of mathematical concepts improve student problem- solving abilities and develop a healthier attitude towards chemistry. As such, it is imperative that enhanced performance in chemistry would be fostered by good background knowledge of mathematics.

Mathematics Ability and Academic Performance of Student in Chemistry

Mathematics has generally been accepted as the foundation of science and technology and it is a very important subject in the secondary school curriculum, therefore, every nation needs it for sustained scientific and technological development.

Also, mathematics is considered as a service tool for the study of sciences

especially chemistry. But despite its importance and usefulness, it is a subject that is most feared by students at primary, secondary, even in the tertiary levels of education. Hence student with poor mathematics knowledge cannot solve calculation problems in chemistry (Krammer, 2005; Onwioduokit. 1999). According to Badru (2004), the choice of science subjects in Nigerian schools is much dependent on the learner's ability in mathematics because proficiency in mathematics is of basic importance to the study of science.

Bayliss and Watts (2002), in explaining why mathematics form the basis for the study of chemistry maintains that mathematics is necessary in enabling chemistry students to draw useful conclusion about compositions, yield and energy, balances in reacting systems and other chemistry concepts that requires computation and calculations. Adeboyel (1999) and Udousoro (1999) reported significant differences in the performance of students of different mathematics ability levels in science.

Since this disparity is peculiar to science as a whole, this study aims at investigating the effects of gender and mathematics ability on academic performance in chemistry specifically.

Statement of Problem

The major concern and an important function of the school system is to .improve the academic performance of students and produce a pool of skilled manpower that will help a nation to grow and develop irrespective of their sex or gender The Nigeria science education system is plagued with a lot of problems and one of the most serious problems is continuous poor performance of students in chemistry and other science subjects.

It is obvious that the Nigerian culture regards male as superior to their female counter parts, thus gender-role differentiation is very much pronounced in our society. This places a very serious constraint on the academic performance of male and female students in chemistry because role differentiation or distinction limits the full participation, development and utilization of individual potentials either directly or indirectly.

Also the WAEC chief Examiner's report of May/ June 2002 opines that the poor performance in chemistry is as a result of students' lack of basic mathematics concepts necessary for proper understanding of chemistry.

In view of these problems, will gender and mathematics ability significantly affect the academic performance of students in chemistry in Uyo metropolis?

Research Questions

i. What is the difference in academic performance of male and female students in chemistry?

ii. What is the difference in academic performance of students with high mathematics ability and those with low mathematics ability in chemistry?

iii. What is the difference in academic performance of students with high mathematics ability and those with low mathematics ability in chemistry given their gender?

Method

A survey design was used in this study. The data reported in this paper originate from a large project which investigated the effect of gender and mathematical ability on the academic performance of students in the sciences. The survey was conducted in selected secondary schools in Uyo Metropolis. The performance of the Chemistry group is here reported.

Sample and Sampling Technique

The study sample was made up of 100 SS I chemistry students in intact classes in two secondary schools in the study area. The sample size consisted of 56 males and 44 females. The simple random sampling technique was used.

Instrumentation

The following instruments were used to gather data for the study:

1. Chemistry Achievement Test (CAT)
2. Mathematics Ability Test (MAT)

A researcher-made test on chemistry called Chemistry Achievement Test (CAT) was used as an instrument for collecting data and measuring of students' performance. The CAT was a 20 item-4-option multiple choice test constructed from the following content areas:

- Separation techniques
- Particulate nature of matter
- Symbols, formulas and equations
- Chemical bonding

- Gaseous state and gas laws
- Acids, bases and salts
- Carbon and its compound
- Industrial chemistry

The Mathematics Ability Test (MAT) developed by the researcher was also a 20 item –4- option multiple choice test from the following concept areas;

- Basic mathematical operation
- Ration and proportion
- Percentages
- Indices and logarithms
- Simple algebraic equations

MAT was used to classify subjects into high / low mathematical abilities.

The instruments were developed by the researcher and were subjected to face content validity by two science educators and three chemistry teachers to check the content coverage and appropriate item representation to suit the level and age of the students. Their contributions were used in selecting the final items in the instruments.

The test-retest method was used to determine the reliability of the CAT and MAT The 20 item- 4-option multiple choice tests were administered twice to the same group of students in a school which was not part of the main study on two separate instances and the test scores were compared and it yielded a reliability coefficient of 0.75.

Each item on the Chemistry Achievement Test (CAT) and Mathematics Ability Test (MAT) was assigned a score of 1-mark respectively. Thus the total score of the 20-items was 20 marks for each instrument. Scores in the range of 0 – 10 in MAT were regarded as low mathematical ability while those in the range of 11 – 20 were rated high.

The t-test analysis was used to test the effect of the mathematical ability and gender on the achievements of students.

Results

Research Question 1: *What is the difference in academic performance of male and female students in chemistry?*

The analysis on Table 1 provides the answer to this question. Table 1 shows that the calculated t-value is 1.48 while its corresponding table value (t-critical) is 1.96 at 0.05 alpha level. The calculated value is less than the critical value. This means that there is no significant difference in the performance of male and female students in chemistry. This implies that gender does not have any significance effect on the academic performance of SS 1 chemistry students.

Research Question 2: *What is the difference in academic performance of students with high mathematics ability and those with low mathematics ability in chemistry?*

The analysis on Table 2 provides the answer to this question. Analysis of the result on Table 2 indicates a significant difference as the calculated t-value of 2.38 is greater than the t-critical value of 1.96 at df = 98 at 0.05 alpha level of significance. This shows that there is a significant difference between the achievement of students with high mathematics ability and those with low mathematics ability in chemistry. In other words, students who perform well in mathematics also perform well in chemistry and vice versa.

Research Question 3*: What is the difference in academic performance of students with high mathematics ability and those with low mathematics ability in chemistry given their gender?*

The analyses on Table 3a and Table 3b provide the answer to this question. Table 3a shows that the calculated t-value is 1.94 while its corresponding table value is 1.96 at 0.05 alpha level. The calculated value is less than the critical value. This means there is no significant difference in academic performance of male and female students with high mathematics ability in chemistry.

Table 3b shows the calculated t-value is 0.22 while its corresponding table value is 1.96 at 0.05 alpha level. The calculated value is less than the critical value. This means that there is no significant difference in academic performance of male and female students with low mathematics ability in chemistry.

Discussion of Findings
The discussion is based on the results of the three research questions posed in the study.

Performance of Students Classified by Gender
The findings on Table 1 revealed that there is no significant difference in academic performance of male and female students in chemistry. This means that the gender of a student whether male or female does not affect the academic performance of the student. This finding agrees with the views of Okon (2003) that gender is not a significant factor in science achievement.

It also agrees with the opinion of Inyang and Archibong (1998) that the achievement of boys and that of girls are similar in chemistry. Furthermore, the finding is consistent with the findings of Kano (2004) that gender difference among adolescents achievement in science is not significant. The disparity in scores may be attributed to changes in self concept of girls about their capability in coping with the sciences and the increasing societal emphasis on women empowerment as argued by Okeke (2003).

Performance of Students Classified by Mathematics Ability
The finding on Table 2 revealed that students with high mathematics ability performed better than students with low mathematics ability in chemistry. The finding agrees with the views of Udousoro (1999) that students with poor mathematics knowledge cannot solve mathematical problems in science. This is because there is a correlation between mathematics and problem solving abilities. The findings also support the work of Onwioduokit (1999) who said that there was a close relationship between students' performance in mathematics and chemistry. The finding also agrees with findings of Okwon (2005) that mathematics skills are required for the understanding of science and the teaching of practical chemistry. This implies that, without mathematics, subjects like Chemistry and other sciences would vaguely be understood, analyzed and evaluated.

Performance of Students Classified by Gender and Mathematics Ability
The findings on table 3a and table 3b revealed that there is no significant difference in academic performance of male and female students with either high or low mathematics ability in chemistry. This means that male with high mathematics ability and female with high mathematics ability do not perform differently. It also means that students with low mathematical ability do not differ in their performance in chemistry. This finding agrees with the views

of Kano (2004), Udousoro (1999) and Okon (2003) that; gender does not affect academic performance of students in science and mathematics.

Conclusion

From the findings of the study, it was concluded that gender does not have effect on students' performance in chemistry whereas mathematics ability has.

Recommendations

1. Academic competency and better performance in chemistry does not depend on gender. Hence both male and female students studying chemistry should equally be encouraged in their studies for full participation, development and utilization of their potentials.
2. Students who choose chemistry as a core subject should be made to understand the relationship between mathematics and chemistry and should be advised to put in more effort in studying mathematics if they want to pass well in chemistry and other sciences.

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Table 1: t-test comparison of students' performance classified by gender

Variables	N	X	SD	df	t-cal	t-crit	Decision at 0.05 alpha level
Male	50	13.50	3.20	98	1.48	1.96	Not significant
Female	50	12.58	3.02				

Table 2: t-test comparison of students' performance classified by mathematical ability

Variables	**N**	**X**	**SD**	**df**	**t-cal**	**t-crit**	**Decision at 0.05 alpha level**
High	79	14.2	2.62	98	2.38	1.96	Significant
Low	21	7.0	1.50				

Table 3a: **t-test comparison of students' performance classified by gender and mathematics ability**

Variables	N	X	SD	df	t-cal	t-crit	Decision at 0.05 alpha level
Male High	41	14.8	2.55	77	1.94	1.96	Not Significant
Female High	38	13.6	2.38				

Table 3b: **t-test comparison of students' performance classified by gender and mathematics ability**

Variables	N	X	SD	df	t-cal	t-crit	Decision at 0.05 alpha level
Male Low	9	7.44	1.24	19	0.22	1.96	Not Significant
Female Low	12	7.58	1.56				