Factors Responsible For Underrepresentation Of Females In Physics Classroom

OMAGA, Joy Okache & MOHAMMED, Sa’adatu Abubakar

1Assistant Lecturer, Department of Science Education, Faculty of Technology Education, Abubakar Tafawa Balewa University Bauchi, Bauchi State, Nigeria

2Lecturer I, Department of Science Education, Faculty of Technology Education, Abubakar Tafawa Balewa University Bauchi, Bauchi State, Nigeria

ABSTRACT
Underrepresentation of females in physics has been a major concern to educationists. Previous research findings have showed that males and females are more similar in terms of cognitive abilities and academic achievements than they are different; however, there exist inequality in the enrollment of females in physics. Findings from the United States and reports from the chief examiner on physics indicated that the percentage of females to males is very low though there seems to be no difference in their performances in physics. Some of the factors responsible for the underrepresentation are societal factors, teachers’ factors, the nature of the physics syllabus and the nature of physics examination questions. It was recommended that women physicists should feature on radio and television programme to discuss the importance and the various advantages that abound from studying physics; teachers should provide an environment in which females can learn and achieve and should never belittle, ignore or harass the female students. Also parents should encourage their daughters in the exploration of things that are both mechanical and electrical in nature.

Keywords: cognitive abilities, SSCE physics enrollment, gender differences

INTRODUCTION
In this age of scientific and technological advancement, the role of physics in the actualization of the needed technological advancement cannot be overemphasized. This will remain a dream if the rate of low enrollment of females in the subject is not addressed. This is because physics have a significant impact on our lives and standard of living and we face a short fall of scientists and engineers in the future if the contribution of both genders is not taken seriously.

Underrepresentation of females in Physics have been a continuous debate for generations which have raised a lot of concern in education; researchers have been trying to balance the perceived inequity in Physics through suggesting various approaches to balance the academic enrolment of males and females. Previous researches conducted by Hyde as cited in Nachiappian, Veeran and Andi (2012) asserted to the fact that males and females are more similar in terms of cognitive abilities and academic achievements than they are different. While research findings conducted by Ogunyi and Grant as cited in Ogunneye and Lasisi (2008) showed that females are endowed with the ability to study physical sciences as they are endowed to study biological sciences, the reality however is that more females are found in biological sciences than in physical sciences (Eccles, 2001; Nkpa as cited in Asoegwu, 2006; Nnaka, 2006; Ceci & Williams, 2010). There are no gender differences in the overall intelligence or in the academic achievements in most school subjects as noted by Ogunneye and Lasisi (2008) who stated that the
differential enrolment between male and female students in studying physics could not be attributed to intellectual ability or capacity to learn. Hence knowing a person’s gender is not a reliable indicator of her or his cognitive abilities or personalities. This was further buttressed by Oanda and Akudolu (2010) who indicated that female students perform better than male students; however, the problem is that fewer females enroll for Physics.

A close observation of Physics classrooms or examination halls indicate that there are more males than females who enrol for Physics examination or who enroll to offer Physics as a subject. This was supported by Zheng (2007) in a statistics report gotten from the National science foundation (NSF) in the United States which showed that in 2004, 26 percent of female students intended to major in science and engineering fields as compared to 41 percent of male students. In the same year, female students were only about 22 percent of all physics bachelor’s degree awarded students in the United States significantly less than male students. This was further stressed by the Chief Examiners report on physics from (2009-2013) who showed that the percentage enrollment ratio of male to female is higher for male candidates though there was no significant difference in their overall achievement scores in physics (Table 1).

<table>
<thead>
<tr>
<th>YEAR</th>
<th>MALE %</th>
<th>FEMALE %</th>
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<tbody>
<tr>
<td>2009</td>
<td>83.2</td>
<td>16.8</td>
</tr>
<tr>
<td>2010</td>
<td>83.5</td>
<td>16.5</td>
</tr>
<tr>
<td>2011</td>
<td>82.8</td>
<td>17.2</td>
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<tr>
<td>2012</td>
<td>81.4</td>
<td>18.6</td>
</tr>
<tr>
<td>2013</td>
<td>82.8</td>
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These reports indicate that the percentage enrollment of female students as compared to male students in physics is very poor. This situation seems to have prevailed for some time despite studies done by Linver, Davis-Kean & Eccles, 2003; Ezirim, 2006; Njoku, 2006; Nwosu, 2006; Schulten, 2010; McCullough, 2011, and researches conducted in the area of gender equality, which showed that gender difference still exist in sciences hence the need for this article. The article was written to highlight the factors responsible for the underrepresentation of females in Physics and the need to promote equality between males and females in Physics. They are a number of factors that have being attributed to be the reason why fewer girls enroll for Physics. Some of these factors include;

1. **Societal factors:** Amali (2013) stated that different societies have norms that prescribe ways of behaving for males and females combined with certain tasks which are considered to be appropriate behavior for males and females. Gurian as cited in Amali (2013) asserts that females learn very early from their families and the society which behaviors are appropriate or not, hence the desperate need for approval force the females to behave in ways that conforms to what the society sees as appropriate for her sex, while Nwosu (2006) stated that as soon as a female child is born, the family starts training her to be a woman who play feminine roles. The family is further supported in the task by the educational system, religious practices, traditional beliefs, ritual and the media. Some parents will prefer to fund the education of boys leaving girls (Nnaka, 2006). The early marriage of girls in some culture is also a factor that limits the height women can attain in academics (Ogunleye & Lasisi, 2008). Hence, by this a female learns what the society expects of a woman which agrees with Okeke (2001) that socio-cultural factors are in the heart of women and these factors operate more visibly in Nigeria where cultural influences are very strong. This can even be found in most homes where it is seem that parents give male children more mathematical and scientific toys than they give girls. Girls are given more dulls and teddy bears to play with while from the onset the males are given scientific toys to play with and in the process develop their manipulative skills. This was further stressed by Baird (1997) who said that childhood experiences are important as a foundation for learning and applying physical principles. Toys marketed for girls are usually passive, simple and related to nurturing while toys marketed for boys are active, more complex and often related to sports or things mechanical or electrical in nature. Some of these factors are gender
stereotyping at home, in the society and even in the schools. The society’s expectation on both males and females tend to discriminate against females and this may have affected the choice of the subject the females may want to choose. For instance, the society has infused some negative beliefs in the female students in school and this may have prevented them from achieving equity with their male counterparts in the study of Physics as in other subjects in the school curriculum (Erinosho, 1994). Physics which is defined as a science that deals with the fundamental constituents of the universe and the forces they exert on each other (Microsoft Encarta, 2009) is viewed by many students as abstract with a lot of mathematical applications incorporated into it. This Harbor-Peters (2001) as cited in Ikwong (2013) stated that Physics have been male stereotyped since is viewed by students as abstract, difficult and only reserved for males. With this societal view about Physics, it is observed that more males than females venture into the field of Physics. A researcher suggested that the exclusion of females in Mathematics and Physics began with the Greek mathematician Pythagoras (Baird, 1997). Margaret Wertheim, author of Pythagoras’ Trousers: God, Physics and the Gender Wars cited by Baird (1997) recalls that the male mathematicians of Pythagoras era associated masculine and feminine qualities with numbers. Odd numbers were considered male and good and even numbers were considered female and bad. Pythagoras formed a society and religious order known as The Brotherhood. This established mathematics and science (Physics) as priestly studies. This culture was preserved when the Catholic Church of the middle Ages began establishing the world’s first universities. The purpose of those institutions then was to educate men wishing to become clergy. However, these universities were the only place to study mathematics and physical sciences. So again, women were excluded from these studies. Wertheim goes on further to state that when you consider the number of physicists who have been writing books in the past few years with titles like ‘The Mind of God; or Physicist Talking about the Mind of God’, there is this enormously strong association in our culture of mathematical science as the priestly science. The researcher thinks that this represents a very powerful cultural barrier in our society and girls absorb it in a very strong way. Thus, this explains why females are unrepresented in the Physics classroom and Physics examination hall. School counselors also discourage females from enrolling for Physics by telling them that Physics is difficult and meant for boys, hence the females do not have a need for the subject. These are due to the erroneous notion that Physics is for males rather than for females. However, studies have shown quite convincingly that students’ performance in Physics is not dependent on gender, although females tend to have less positive attitude about Physics; perhaps due to messages received by parents, teachers and media (Adeyemo, 2010). Another reason for underrepresentation of females in Physics as noted by Felter which was cited by Baird (1997) is that girls should not be taught Physical science (Physics) except at the elementary level, because the expenditure of nervous energy involved in the mastery of analytic concepts would be injurious to their health’. Other researchers also argue that males were superior to females in intellect; some however said that males and females have the same have intelligence but males have a broader range of intelligence while females remained huddled around some average value. As a result, the most intelligent males were considered far more superior to the most intelligent females. Physics have a significant impact on our lives and standard of living. One often imagines what our standard of living would be had our forefathers welcomed the contributions of women. We face a short fall of scientists and engineers in the not so distant future and will need the contributions of individuals from the entire population. Continued exclusion of the majority gender from science can only lead to negative consequences for the standard of living we expect in this 21st century.

2. **Teachers’ factors;** most Physics teachers are unaware of gender issues in Physics hence the practice of gender stereotyping in their classrooms is an unconscious behavior as they themselves are a product of gender divided society (Njoku, 2006). Amali (2013) asserted that teachers questioning techniques seems to support the ways males learn but serve to inhibit and discourage females. According to Asoegwu (2006); Nnaka (2006) & Njoku (2006), they stated that Physics teachers often hold lower expectations for the girls in their classes. They further said that teachers are more likely to ask girls lower order questions than boys; call on boys to answer specific questions; respond to boys with precise praise, criticism or remediation and respond to girls with simple acceptances such as okay or uh-huh. To further
buttress this, Sadker and Sadker as cited in Amali (2013) stated that females are more likely to receive criticism rather than praise for risk taking behavior such as answering a question. While teachers may reward females for being compliant, quiet and helpful which are stereotypic feminine behaviors males on the other hand are praised, hence they are more likely than females to answer teachers questions, a risk taking behavior which is expected of males. Physics is a science that demands high cognitive ability and cooperation among the learners if they are to understand clearly the underlining concepts and principles of Physics. The need to encourage the females as well as males to be actively involved and cooperative learning should be emphasize in Physics lesson as it promotes learning among students and high cognitive thinking which is required of Physics subject and not one gender dominating the other. Njoku (2006) stated that Physics teachers use competitive approaches in teaching Physics and previous studies done by Fennema and Peterson as cited in Njoku (2006) revealed that when females are subjected to competitive learning situations, the less they are likely to learn as such relegate the females to a disadvantaged position, hence the need for cooperative learning to boost their confidence. Also, Ogunleye and Lasisi (2008) stated that some Physics students complain that Physics teachers teach them as if they are all endowed with the same ability. They also say that the comments of some Physics teachers on the students at times are too harsh for the females in particular to bear. While some boys do not mind the comments that tend to show they are of low ability, girls are naturally affected by such comments. However, females are equally endowed with the same intellectual ability as boys; the challenge is in the teaching methods adopted by teachers when teaching physics as the teaching method teachers adopt tend to fit male learning style than female. The teaching methods of some Physics teachers are crucial reasons why the learning of Physics will continue to be a no go area for majority of students especially the females as some Physics teachers treat females like invisible objects while according to Tadafferuwa, Ogundare, Obe and Njoku as cited in Njoku, 2006, they said some teachers treat females as a waste of resources and others treat them as potential sex partners, thus dampening their motivation and interest in physics. The highhandedness approach adopted by most Physics teachers may not attract women; hence they leave Physics for those who can accommodate the highhandedness that characterizes Physics teaching (Ogunleye & Lasisi, 2008). If Physics teachers are made aware of the effects of some of these practices on their students, they will make their classroom teaching strategies to become more gender inclusive and this will remove obstacles that inhibit female students’ interest and enrolment.

3. **Physics Syllabus:** Physics syllabus is broken into Mechanics, Heat, Wave Motion, Light, Electricity and Atomic Physics. Study done in the UK by Elwood and Carlisle, 2003 showed that females are more likely to perform less well on Physics questions that focuses on Electricity, Mechanics And Radioactivity as they consider these aspect of the Physics syllabus to be geared towards the males than females while they seem to perform well on questions that focuses on Light, Heat and Wave Motion. They consider these aspects of the Physics syllabus to have more practical application to everyday life situations and the relevance of these concepts to the society is stressed throughout in the syllabus (Adeyemo, 2010). The study of Physics is said to depend on the high knowledge of mathematics, however, Muzur as cited in Ogunleye and Lasisi (2008) stated that we do not need much of mathematics ability to understand most Physics concepts. He saw mathematics as a mere tool that provided a shorthand and notation for solving Physics problems easily. Elwood and Carlisle (2003) stress that females are more likely to do better on questions which use everyday context and also on those questions that consider medical or health applications of Physics concepts. Though questions with regards to the applications of Physics concepts to everyday situations are included in Physics public examinations such as UTME (Unified Tertiary Matriculation Examinations) conducted by JAMB (Joint Admissions and Matriculation Board), SSCE (Senior Secondary Certificate Examinations) conducted by NECO (National Examination Council) and WASSCE conducted by WAEC (West Africa Examinations Council). However these questions with everyday applications are few in number and most times the marks allocated to them is not much. Ikwong (2013) observed that females have a dislike for the subject because the subject contents demand for perseverance, constant practice and also a lot of higher order thinking and they do not see traces of human touch in Physics teaching; these most females lack and more so, they are prevented from giving the subject the required attention by their peer group involvement, parental assignments, social
engagements and their marital responsibilities. Hence only a few of them with much perseverance and dedication to the subject are likely to enroll and perform well in the examinations. Achume cited in Abe, Egbon and Adulolu (2013) observed that early education curriculum was designed to train women as Teachers, Nurses and Clerks. They were not prepared for courses like Engineering and Technology and Physics is the building block of these courses. The situation however still prevail though there have being massive campaign in the education sector that the teaching of science involve applying the knowledge learned to other new context and also for solving problems at home and in the society not just at the classroom level. The teaching and learning of Physics is also meant to foster creativity among learners but the curriculum is poorly implemented as most teachers of Physics do not understand the Physics curriculum, hence poor delivery and the students suffer the impact. This also is one reason few females still enroll for Physics and according to Saavedra and Opfer (2012) is attributed to the fact that educational systems are hard to change and teachers find the old convectional method of teaching Physics more convenient and less time and energy consuming than the inquiry/discovery method. Another challenge with the secondary school Physics curriculum is the frequent reference of military and sports applications as can be found in most physics textbooks. The inclusion of military and sports applications in physics can be traced back to the historical development of physics. This is as a result of the Physics community seeking out real world applications to hold and gain the interest of students. But this attempt to build real world applications into the curriculum made it a male dominated Physics teaching community as it has an off putting effect on girls. In most instances, when school children are asked to draw a Physicist, they draw an unattractive male in a white lab coat surrounded by laboratory working equipment usually working alone, if they do not see a Physicist as being a woman, it is because of the lack of such images in the Physics textbooks. Physics is viewed by students as a field in which solitary work and competition are keys. Girls prefer communication, collaboration and working as part of a team. However, professional engineers of either gender point out that they spend most of their time communicating and collaborating, girls are unaware of that and typically drop out of mathematics or science career paths before they have a chance to find out.

4. **Nature of Physics examination questions**: Physics examination papers that are SSCE and WASSCE are made up of two papers – paper I which comprise the practical aspect and paper II – containing both objective type questions and essay type. One striking feature of the Physics examination paper is the amount of recall demanded on candidates (Elwood & Carlisle, 2003). Most of the questions on the Physics examination be it practical, theory or objective type paper, demands the recall of contents or concepts from students. Candidates are usually asked to define terms, explain concepts, state certain facts and theories and describe experiments they have performed or watched being performed. They are also asked to identify apparatus and label them. There are also questions that demand candidates to calculate particular values, draw graphs, interpret them and provide proof of certain formulas. There are however, very few questions that deal with the applications of physics concepts to situations, this, Elwood and Carlisle (2003) said that there is little use of everyday context in framing and positioning problems to be solved. The 21st century requirements for Science (Physics) evaluation require that evaluation should be all round and that it should have the society as the centre of focus when evaluating students. This is to say that students should be evaluated based on problems arising from the society as Science (Physics) and society impact greatly on each other.

Other researches carried out in UK also indicated that 80% males enter for Physics public examination but females seem to perform better overall and this is due to the fact that females who enroll for Physics public examinations are extremely able females who tend to do better than their male counterparts (Elwood & Carlisle, 2003). This is attributed to the high level of recall that Physics examination demands and it is due to the fact that candidates who are more likely to do well in an examination are candidates who are better prepared and more organized. The researchers further ascertain that females are better prepared and more organized than males when it comes to examinations and it is this preparation that put them at an advantage in the types of examinations they encounter.
CONCLUSION
Physics is the bedrock of every scientific and technological development of any nation, thus, the need to encourage learners not just to learn Physics for examination purposes but to be actively engaged in the teaching–learning process as that would erase every gender bias from the minds of learners and in turn foster deeper understanding and interest in learners. The teaching of Physics must be given special attention to make both males and females desire to make its study a success and also go for careers in Physics related fields.

RECOMMENDATIONS
Based on the findings of the study, the following recommendations were made. This was done in other to ensure equity and improved performance in Physics public examinations.
1. Conscious efforts should be made by parents, teachers, school administrations and managements, media and the society to remove the gender stereotype put on Physics.
2. The curriculum, text books and materials for teaching Physics should be gender inclusive; textbooks publishers should also recognize the need to remove various forms of bias from their books and classroom resource materials.
3. Teachers should foster cooperative learning among Physics students and also ensure that females are actively involved in the practical class not just saddle with the responsibility of taking down experimental data.
4. Parents should encourage their daughters in the exploration of things, which is mechanical and electrical. Counselors should also encourage girls to engage in the study of physics.
5. Teachers should provide an environment in which females can learn and achieve. They should never belittle, ignore or harass female students, in giving examples and applications of physics in real world application, things that are familiar to both male and females should be used instead of applications involving military and sports.
6. Women Physicists should feature on radio and television programmes to discuss the importance and the various advantages of studying Physics by females in secondary schools.

REFERENCES


