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BRIDGING THE GENDER GAP IN PHYSICS: THE ROLE OF GENDER-RESPONSIVE PHYSICS PEDAGOGY

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Abstract

Despite the cardinal role Physics play in human and National development, it is plagued by underrepresentation of females in the classrooms as students and also as teachers or lecturers. In physics classes in secondary schools and higher institutions, female students are not fairly represented. This in turn is affecting the number of female physics teachers as well as the number of female physics lecturers. Low representation of females in physics is influenced by some social, cultural, biological and environmental factors. The problem seems to be more socially related. This paper presents a theoretical review of underrepresentation of female gender in physics in the areas of teaching methods, classroom arrangement and learning materials. The paper also discussed how gender-responsive pedagogy relating to women's interest, persistence, and achievement in physics could change the narrative of low female enrolment in physics classes. Practical suggestions were made on how physics pedagogy could be made more gender-responsive with the aim of retaining more women in Physics. Among the recommendations is that there should be more female physics role models to female students who they can emulate and relate with freely.

Key words: *Bridging ,Gender gap ,Gender-responsive pedagogy , Physics education.*

Introduction

Science and technology oil the wheel of development all over the world. Its importance can not be overemphasized in all facets of human development. The political and economic strength of a country is dependent on her scientific and technological development (Babajide & Ogunleye 2011; Adepitan, 2003). Likewise, the development of any nation revolves around scientific and applications of its technological knowledge. This implies that for any nation to be classified as developed, Science and Technology must be an indispensable part of the nation's culture. Since Science and Technology form critical instruments for the enrichment of any nation's economy, it must form part of citizens' thinking on a daily basis.

Physics, no doubt is essential and unarguably must be of special interest to any nation committed to national development. Bello (2012) described physics as the foundation of science and technology. Zhaoya in Bello (2012) saw physics as the essential subject in science and technology. It studies the essence of natural phenomena and it helps people to understand the rapidly changing

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society in the area of technology. Knowledge of physics has led to inventions in various areas. Physics principles have been applied to economic, scientific and technological inventions such as information technology.

The industrialized nations of the world are mostly nations who have been able to tap into the huge potentials that abound in the field of physics. Nuclear energy is now a driving force for industrial development. It is used for the generation and sustenance of electricity. Automated machines now drive the industrial sectors of developed countries. The health and political sectors have also benefited immensely from the application of physics principles. The importance of physics to national development can never be over emphasized.

Despite the importance of Physics, the subject has over the years been plagued by underrepresentation of the female gender. Although, while in secondary school level, female to male enrolment in secondary school physics is at par (Sax et al., 2016), it is however observed that during the past four decades, the enrolment of females in physics and its related courses in post-secondary school level as well as their pursuit of career in Physics have sharply declined with female accounting for just 27% of physics graduates (American Physics Society Report, 2007). According to The Global Education Report of 2018, Tunisia and Nigeria have similar completion rates overall in STEM (Physics inclusive), but 75 females completed upper secondary for every 100 males in Nigeria, while 75 males completed for every 100 females in Tunisia. In the bid to overturn this gender imbalance in Physics, several research works have been carried out to identify the cause and proffer solutions to the prevailing dearth of women in Physics. Some of the identified problems were physics-learning environment that favors male students over female students (Jayson & Jonathan, 2016), less productive attitudes about learning physics, including interest, sense making effort, and problem-solving confidence (Kost et al., 2009), female students' perception of mathematics (Babajide & Akinoso 2020).

Despite the aforementioned challenges for which solutions were proffered, gender disparity in physics still persists, necessitating this theoretical review that focuses on the place of the application of gender-responsive pedagogy in bridging the gender gap in physics.

Gender-responsive pedagogy employed in teaching physics especially from secondary school level is essential in bridging the gender gap in physics because as teachers are central to the learning and teaching processes, their understanding and awareness of gender responsiveness is key to the effective participation of the girls and boys in learning processes (FAWE, 2005). Against this backdrop, it is expedient to theoretically review aspect of gender-responsive pedagogy and how these could enhance female students' taking up career in physics. The purpose of this study is to analyze various aspects of gender responsive pedagogy and how these could be used to bridge the gender gap in Physics.

Gender-Responsive Pedagogy

Pedagogy as a concept has to do with all teaching and learning processes. Within the Framework of classroom settings, pedagogy could be describe as what is taught, how teaching takes place and how what is taught is learnt. (FAWE , 2005). Gender-responsive pedagogy could be correctly seen to be beyond classroom activities of physics teacher. In the light of this, this paper will examine Gender responsive Pedagogy under four areas namely: teaching method, classroom arrangement

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and teaching and learning material. While the aforementioned four areas are not the only aspect of pedagogy, discussion will be limited to them.

Gender responsive teaching methods

Gender-Responsive teaching methods, according to the USAID (2018) are teaching methods that take into account the learning needs of female and male students. To this end, for Physics educators to improve female students' enrolment and subsequent retention in the field of Physics, it is pertinent to take cognizance of specific needs of learners especially those pertaining to their gender roles. This is true and in line with Bharadwaj and Pal (2011) who explained that teaching methods work well if they suit learners' needs because every learner interprets and responds to questions in a unique way (Chang, 2010). In view of this, alignment of teaching methods with students' needs and preferred learning will influence students' academic attainments (Zeeb, 2004). Teachers who are gender responsive understand and respond to the specific needs of girls and boys in the teaching and learning processes. They are aware of the special needs of girls and boys such as sexual maturation issues and by encouraging equal participation and involvement of boys and girls in class activities and ensuring equal access to learning materials. To achieve this feat, several innovative pedagogical approaches for the effective teaching of physics have been suggested by several researchers, including programmed, demonstration and project methods (Eltanahy & Sufian, 2019), Experimental teaching strategy(Bada et al., 2017) others are role plays, case studies, group discussions, demonstrations, skits, and study tours. None of these, however, is necessarily inherently gender responsive but requires the expertise and conscious effort of a teacher to make them attend to learners' unique gender- related needs. Practical or experimental science lessons can be exciting for students and effective in enhancing students' retention, internalization and interest in Physics principles and concept, for example, but many teachers do not take into cognizance the specific gender needs of girls and boys in planning and delivery of the lessons.

Irrespective of a physics teacher's choice of innovative teaching technique specific attention should be focused on making the lesson give both gender equal level of inclusiveness and participation. This is imperative because most people in the society ascribe science and math fields with "male" and humanities and arts fields with "female." Thus, bias is common, even among individuals who strongly reject these stereotypes (AAUW, 2010).

Therefore, to work towards retaining more female in Physics and its related field, physics teachers in secondary schools and colleges must ensure the use of innovative teaching methods in their Physics content delivery and take cognizance of gender-related needs of their learners.

The need for physics teachers who applies gender responsive methods makes it imperative for teacher training institutions such as colleges of Education and universities' faculties of education to reevaluate their curriculum with the aim of training gender responsive teachers (Ananga, 2021). For example, UNESCO (2015) indicates that:

> The curricula adopted by Teacher Education Institutions (TEIs) in preparing would-be teachers should be carefully revised. A quick look at the curricula set by many TEIs around the world … reveals a grave short-coming regarding issues of gender equality. For example, students being prepared to become school teachers are given courses on education theories, the psychology of learning,

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> teaching methodologies and class management, evaluation and assessment, and one or two practicum courses. Nowhere can any emphasis on gender equality issues be seen … This problem of omission needs to be addressed by curriculum designers of TEIs.

Kreitz-Sandberg (2013) also opined that "For gender sensitive teaching to be ensured, it is important to consciously and cleverly incorporate gender issues into the pedagogy of teacher training programs". While a policy is in place to ensure minimum standards on gender equality, a survey of 4,500 student teachers in 2014 showed that very few had an in-depth understanding of what gender equality in education might mean, while many were hostile to women's participation in public life and any form of social engagement.
Among respondents employed following graduation, teachers reported receiving no professional development on gender, a point echoed by other colleagues at the schools where they taught. Teachers who had the most egalitarian ideas about gender reported themselves the most frustrated of respondents and said that they were unable to put their ideas into practice (Unterhalter et al., 2017). These are few of frantic calls for the need for thorough foundation of teachers in effective usage of gender responsive teaching method.

Gender responsive classroom

A classroom setting is a product of psychological state, physical arrangements as well as cultural and social interaction among students which influence perceptions and evaluation of students (Özden, 2005). Classroom management is a process that involves teachers and school administrations to create as well as maintain suitable, appropriate and assertive behaviour of the students in particular classroom settings. Erden (2008) proposed that classroom management is a process entails various techniques and strategies to establish an effective learning environment ensuring effective students' behaviour according to the objectives of instructional and learning processes. Ahmed et al., (2018) suggests that a classroom is a place where educational environment is established in such a way that facilitates students learning, serves as a platform for meeting educational objectives and assures educational activities to be performed purposefully.

Typically, classroom physical arrangement often has desks lined up in an array of neat rows facing the teacher. This class arrangement popular in most teaching institutions and has certain strengths. However, a big drawback is that it reinforces the traditional socialization processes. Since girls are not often brought up to speak out – or rather, are brought up not to speak out – when they sit at the back of the class, they are less likely to participate in class activities unless the teacher makes a special effort to involve them thus giving them a sense of belonging in Physics. A different arrangement such as breaking the class into smaller groups of appropriate gender mixture may encourage the girls to participate better thereby enhancing and stimulating a long-term interest in Physics in them.

The need for conscious effort toward enhancing female students' sense of belonging in Physics through effective classroom arrangement have been dwelt on by researchers. According to Johnson (2018), girls receive less attention from teachers than boys do. This is may be due to the fact that, boys are more likely to call out answers to questions posed to the class even when they have not been called by the teacher. This, as unconscious as it may be noted (AAUW, 2018)

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is capable of discouraging female students from class participation and in turn stifle their long-term interest in physics.

Another aspect of classroom is visual aid material in the classroom such as wall charts. These as reported by several studies unwittingly depicts Physics as predominantly men's world. For instance, a study sponsored by AAUW linked female students' lack of interest to the fact that females don't see examples of female scientists and engineers in books, There are even fewer role models of Black women in math and science. Also Ogunleye and Babajide (2011) further explained that science subjects such as Chemistry and Physics are given masculine outlook by education stakeholders as they often refer to successful male scientists with few or even sometimes no mention of successful female scientists. This has led to a situation such that when men in physics question "do I belong here?", they encounter a resounding "yes!" from an environment replete with other men and positive stereotypes about their group; however, when women question whether they belong, their belonging is instead threatened by a lack of other women and negative stereotypes regarding women's intellectual abilities.

The lack of female role model has contributed to female student dropping physics later on in their academic ladder. Some researchers concluded in their findings that same-gender role models is likely to be a more effective option for drawing young women into STEM (Bussey & Bandura, 1999; Cheryan et al., 2011; Stout et al., 2011). In the same vein, there is evidence that among STEM women, perceptions of incompatibility between their gender and STEM identities (i.e. the extent to which people perceive their identity as a woman or man to fit with their identity as a STEM member) are related to a lesser sense of belonging, greater insecurity, and less motivation in STEM, as well as greater expectations of dropping out of STEM (London et al., 2011).

Gender responsive teaching and learning Material

Students spend between 80 and 95 per cent of their classroom time using textbooks and teachers make most of their instructional decisions based on the textbook (Sadker & Zittleman, 2007). In fact, in some situations, textbooks are the first – and may be the only – books a young person reads. This can have a lasting impact on his perceptions. This means that, through textbooks, discriminatory norms and values can be challenged. So, a textbook should be learner-centered and nurture the minds of young people, without strengthening stereotypes and gender biases. Unfortunately, images of girls and women are under-represented in textbooks and curricula. Such type of gender bias is rife in textbooks around the world. This is undermining girls' motivation and achievement in schools. Content contains the projection of stereotypical images of women (Zafar & Malick, 2006). Textbooks present a gendered picture of the world as both boys and girls are associated with separate and specific roles and behaviors in the society (Dean, 2007). In a study conducted by Good et al., (2010), on the effect of the use of chemistry textbooks that included images of women scientists, it was observed that female students performed significantly higher on the comprehension test when exposed to counter-stereotypical images of female scientists with an average of 9.38 correct answers out of 12 against 7.42 out of 12 when exposed to stereotypic images of male scientists.

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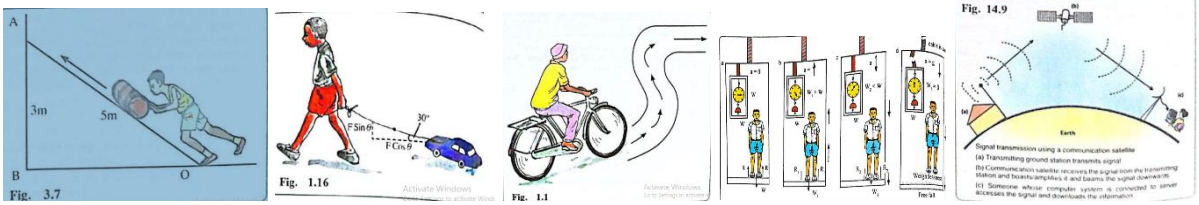
The issue of gender stereotyping continued to persist even in Physics textbooks. For example, in research conducted by Lawlor and Niiler (2020) on gender representation of figures in popular American Physics textbooks, it was discovered that these textbooks heavily used males in describing activities in Physics at the detriment of females.

It is clear that in modern history, including present day, a vast majority of images that include people in major Physics textbooks depict males with light skin. Females with light skin are the next highest represented group, though a distant second. The third most represented category is unknown, while all dark skin categories are grossly underrepresented. These groups do not rise above about 6 or 7% and much less in most cases.

Even though most of our locally popular and approved secondary school physics textbooks such as New School Physics by Anyakoha, Science Teachers Association of Nigerian Teachers Senior secondary School Physics textbook amongst others contain very scanty images of humans, when they do, they often portray images of the male gender. Below are just few images from the revised edition of the New School Physics By Anyakoha:



Out of about 15 pictures of human in this textbook, the picture on page 506 appears to be the only picture depicting a female. This is same situation in other physics textbooks and even worse many times. This is sure evidence of the need for a paradigm shift in the aspect of gender representation in physics textbooks in order to stimulate long-term interest of females in Physics and its related careers and bridge the gender gap in physics by using gender-responsive textbooks and other teaching and learning materials.

Recommendations

This review of studies on gender inequalities in Physics especially in post-secondary school level is intended as a starting point for teachers and researchers who are interested in promoting gender equity in Physics. This theoretical review represent only an initial effort to better define why there are not as much females in Physics. Though the scope of this work was limited only to three aspects of gender- responsive pedagogy, it is recommended that further and extensive research be carried out in these and other aspects of gender-responsive pedagogy in Physics and STEM in general. However, the following recommendations are given in respect of gender-responsive pedagogy:

- Experiments, laboratory activities and problem-solving opportunities should form the greatest part of science education in the schools as this would further help students to practice more, handle apparatus, manipulate equipment and attempt the use of science-process skills. The more students practice, the more they sharpen their process skills, the more they would become more committed to science endeavors and the more they would acquire and improve upon their practical skills.

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Regarding gender-responsive classroom, the steps below as recommended by FAWE (2005) are adopted:

The following should be considered for a gender responsive classroom set up to responds to the specific needs of both boys and girls:

i Classroom set up that enhances participation of both girls and boys

ii Arrangement of the desks that encourages girls to speak out and overcome their shyness.

iii Stools in laboratories that are appropriate in size and shape thus enabling effective participation of both girls and boys.

iv Fixtures and visual aids on the walls that send gender responsive messages.

v. Appropriate shelf heights in the libraries.

vi Appropriate size, shape and weight of desks and chairs.

Then with respect to gender-responsive teaching and learning material, both the authors and publishers of textbooks for physics should attempt to ensure further movement towards a balanced representation of the genders as new books are produced or revisions are made of existing books.

Conclusion

The fact is undeniable the women are underrepresented in the field of Physics, this is largely due to a gender-unresponsive nature of teaching Physics especially in secondary school which often make girls at this stage not to see themselves belonging to or even having anything to do with Physics after passing it in secondary schools as a prerequisite for taking up any science career.

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