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Making Physics Appealing to Female Students: Perspectives of Female Students and Physics Lecturers

Isaac Buabeng*

Department of Basic Education, University of Cape Coast, Ghana

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Abstract

This paper describes a qualitative study of how to improve females' involvement in the learning of physics at the tertiary level. The study was conducted at the University of Cape Coast (UCC) and some select Senior High Schools (SHS) in the Cape Coast Metropolis, Ghana. Participants for the study were undergraduate female non-physics students, undergraduate female physics students, SHS final year female science students and physics lecturers and tutors. The study found that majority of female students do not pursue physics at higher levels of education because they perceived the subject as difficult, irrelevant, and one that has no or limited career opportunities. The participants, however, were optimistic that female participation in physics can be improved if necessary steps were taken to erase the widely held perceptions that have been associated with the study of the subject and its related career opportunities.

Keywords: Females Physics Students, Female Non-physics Students, Appealing, Careers, Improve

Introduction

The professional studies of engineering, architecture, astronomy and physics are dramatically underrepresented by females. While women represent over half the general population, they represent only a tiny minority of professionals in physics with majority going into biology (Donnellan, 2003). History has it that this imbalance was thought to be the result of differing brain structures and functions. Indeed, some theorists still hold to that view. However, explanations based on gender-specific socialization have largely displaced the brain difference models. Theories of Socialization hold that females are directed away from physics and other related courses by parents, teachers, and peers (male and female) because such studies are considered to be unfeminine (Baird, 1996). Such theories according to Baird further argue that females themselves select out of physics courses because the careers involved in those fields do not match the careers with which girls are encouraged to be concerned of. Perhaps, what majority of females seem to know little about is that physicists may work in many fields such as Medical Physics, Health Service, Computing, Communications, Meteorology, Environmental Physics, Geophysics, among others.

In Ghana, issues on female enrolment in physics at higher education level are often taken for granted. It appears that in both official and private circles there is lack of awareness on female enrolment in physics. Either people do not have interest in it or simply disregard it. Ghana Government and UNICEF (1990) reported that if women are to be empowered to actively participate in all levels of development planning, policy formulation, analysis and implementation, the level and quality of women's education must also be of concern to all,

*Corresponding Author: Phone: +233 267777741 E-mail: ibuabeng@ucc.edu.gh

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especially those whose education has an impact on a nation's progress and development. Sad is that in spite of many career opportunities that the study of physics can avail to students and the country , females' education in physics lags far behind, as available statistics show (Kwame Nkrumah University of Science and Technology [KNUST], 2008; National Science Foundation [NSF], 2002; UCC, 2008). Even though there is now an increase in the number of females in higher education, there are still great disciplinary disparities especially in the sciences.

Many educational researchers have explored the attitudes of students to science as a whole–their views about the science curriculum, their opinions of how science is taught and their perceptions of scientists. However, such researchers have not often distinguished between the different subjects within science (Christopher et al., 2003; Woolnough, 1995). Nevertheless, many studies in the Western world have attributed low females' participation in physics to a number of reasons such as: females have a natural tendency to be more concerned with 'people science' (e.g. biology) (Hazari & Potvin, 2005); females do not see physics as able to contribute to solutions of environmental or medical problems, but rather see physics as requiring a lot of mathematical ability (Fennema et al., 1988; Bhatia, 1991); females do not succeed in physics because of prejudice, discrimination and unfriendly attitudes towards them (Wenneras & Wold, 1997); females greatly perceive biology as interesting and physics as boring (Donnellan, 2003).

Buabeng and Ntow (2010) presented reasons of 208 female undergraduate students at UCC (reading biology -127, chemistry - 53 and physics - 28) as to why they chose or did not choose to study physics at the university. They indicated that the main reason why biology and chemistry students did not select physics was the perceived lack of career opportunities in physics. Majority of the biology students (79%) and all the chemistry students stated this as the major reason. Difficulty of the subject (physics) was the next popular reason chosen by 30 % of the biology students and 38% of the chemistry students. Other reasons given were: weak mathematics background, lecturer factor, and lack of motivation. Lips (2004) reported that in US high school girls were more likely to than undergraduate females to see a future possible self in the physical sciences. The findings of the study, as cited by Murphy and Whitelegg (2006), indicate that the increasing divergence between males and females is not a simple matter of interest but a more fundamental difference about students' beliefs concerning what social identities are manageable and appropriate. There is enough evidence that females as well as males can learn about physics in purposeful and meaningful ways (Murphy & Whitelegg, 2006). This study therefore sought to answer the question: What ways/methods could be employed to make physics more appealing to female students?

Theoretical Framework

It has been observed that teachers form the single strong fundamental factor in defining the quality of education in schools (Golla & Guzman, 1998). Accordingly, it cannot be shorn of that the physics tutors form the strongest force to shape the students particularly female students so that they become knowledgeable and skillful in understanding physics concepts and the natural world. Physics tutors have vital role to play when it comes to students' acquisition of creative and critical thinking abilities needed to face the realities of life. The physics tutor is therefore required to design teaching sequences with appropriate teaching styles that will develop students' interest for the subject and their abilities to properly respond to situations that confront them in their world of life. The teaching strategies of university and high school physics teachers and its relationship with female students' preference for physics were put into focus in this study. Thus, the study was guided by three viewpoints: inherent differences viewpoint; socialized differences viewpoint and culture bias of physics (Hazari &

Potvin, 2005), which are believed to be the cause of female under representation in physics studies.

Inherent Differences Viewpoint

According Hazari and Potvin (2005), inherent differences viewpoint suggests that inherent differences between males and females lead them to have different interests. In other words, females are less inclined towards physics than males due to some natural tendency. Inherent differences in males and females are transmitted through genes and those genetic differences result in males and females responding differently to the same external conditions, for example, enjoying physics and opting to study it.

The physicist or science educator who assigns weight to the inherent differences argument believes that, females have genetic influences that make them not interested in physics. These people (those who assign weight to inherent differences) often believe that females have a natural tendency to be more concerned with 'people science'. This would be their (those who assign weight to inherent differences) explanation for why there has been consistent evidence across the world for girls being more interested in biology programmes than in physical science programmes. For instance, Lie and Bryhni (1983) stated that females' interests are characterized by a close connection of science to the human being, to society, and to ethic and aesthetic aspects. Holden (2000), a social scientist also stated that wherever you go, you will find females far less likely than males to see what is so fascinating about ohms, carburetors, or quarks.

Socialized Differences Viewpoint

The socialized differences viewpoint suggests that males and females are socialized to have different interests. In this case, females are less inclined towards physics than males due to values and behavioural dispositions that are transmitted by society, family, education, and other influences surrounding them. Early in the study of socialized behaviour, researchers believed that these patterns may be transmitted through direct socialization where children adopt actions that are typical or valued for their own sex when sex-appropriate actions are positively reinforced by parents, teachers, or other children and when actions associated with the opposite sex are negatively reinforced (Maccoby, 2000).

Those who give weight to the socialized differences viewpoint believe that females are either trained directly to feel that physics is not for them or are trained toward behaviours that indirectly lead them away from interest in studying physics. This training occurs through the influence of two major social arenas: the education system (teachers, professors, peers, curriculum, etc.) and everything else outside the education system (such as parents, television, or society) (Hazari & Potvin, 2005). One example of direct training from the non-educational arena, according to Hazari and Potvin, is the social stereotype which deters females from the physical sciences particularly physics by portraying the physicist as male.

Culture Bias of Physics

The culture bias viewpoint is different from the inherent and socialized differences viewpoints in the sense that it focuses on problems in the community of physics that causes females to lose interest or opt out rather than the differences between sexes that cause their interest in physics to be different. The culture bias viewpoint suggests that physics is not a gender neutral subject but rather is tightly bound by masculine tendencies and preferences. Females and/or males that lack such tendencies might feel disinclined to the subject and/or alienated within the field (Baker, 2002). In contributing to this issue of culture bias of physics, Hazari and Potvin (2005) asserted that culture bias of physics is transmitted in three ways:-

pedagogically, by transmitting a narrow message about what it means to do physics rather than allowing for individuals to define it for themselves; academically, by defining what is acceptable physics research and what is not, primarily through various peer review processes; and socially, through the structure, interactions, and treatment in the field. An example of the pedagogical transmission of culture bias, according to Hazari and Potvin is that undergraduate physics is taught in a way that is often more unrealistic and abstract than necessary.

Researchers who assign weight to the culture bias viewpoint believe that females face active and passive discrimination and have little or no role in defining the field. Thus, there is an intrinsic bias in the field favouring males. Lederman (2003) sums it up by saying that practitioners of science as we know it have traditionally been white, male, and western and it is they who define the rules, methods, instrumentation, descriptions of results, and criteria for knowledge production. Lederman continued to say that it is the white, male and western who define what counts as science, both theoretically and in practice and again it is they who are the gatekeepers for access to, and definers of, a life in science. This bias according to Lederman is transmitted when physics is taught and studied at all educational levels and through all other interactions within the field.

What a female child and male child can do and should do is basically defined in the context of social and cultural beliefs and upbringing. This goes a long to influence what a female child want to do and also become. This dispositional trends which are transmitted by the family as the female child's first point of social interaction tends to train the female child to feel that physics is not for her to offer hence affects her interest in studying physics. However, the cultural bias viewpoint also goes to state that the content of the physics course itself makes females to lose interest in studying physics hence the teaching of physics. The content which explains that physics is bound by masculine tendencies and preferences tend to make females feel disinclined to the subject physics because they lack these tendencies. Some researchers believe the course favours males whilst it discriminates the active and passive participation by females. This study intends to explore more on the socio-cultural perspectives with specific reference to the teaching of physics at both senior high schools and the university levels.

Methodology

Sample

The population of the study comprised female undergraduate students offering biology, chemistry and physics, SHS final year female science students, university physics lecturers and SHS physics tutors. The sample size for the study comprised 208 undergraduate female students reading biology, chemistry and physics; 201 SHS final year female science and 11 physics lecturers and teachers respectively. Out of the 208 undergraduate female students, 127 representing 61.1% were biology students, 53 representing 25.5% were chemistry students and 28 representing 13.4% were physics students. The researcher applied for the list of female students reading biology, chemistry and physics from Students Record and Information Management Unit (SRIMU) at UCC. From the list that was provided, the females in their respective subject areas for the various levels were selected accordingly. The female biology and chemistry students were randomly selected using computer generated random numbers whereas in the case of physics, all the females, from year one to year four were selected.

Also, four SHS offering all three elective science subjects (biology, chemistry and physics) in Cape Coast Metropolis were purposefully selected from a list of SHS obtained from Cape Coast Metro Educational Office. Purposefully sampling technique was used because the other SHS in the Metropolis offering all three elective science subjects were only male institutions. The four schools comprised two female institutions and two co-educational (mixed) institutions respectively. In each of the co-educational schools all the final year female science students were selected. This yielded a total of 60 female students from these two schools, 35 from school A and 25 from school B respectively. In the case of the two female institutions, computer generated random numbers were used to select 83 (out of 165 from school C) and 58 (out of 116 from school D) final year science students according to the number of the final year science students in each school, making a total of 141 students from the two female institutions. In each institution (UCC and SHS), all physics lecturers and physics teachers at post at the time of the study numbering 11 formed the sample of lecturers (7) and teachers (4) for the study.

Instrument

Semi structured questionnaires and interview protocols were developed for the study. The semi structured questionnaire was made available to experts in the field to determine its validity after which it was pilot-tested. The pilot study was conducted with sample size of 150 subjects in four institutions in Kumasi Metropolis having the same characteristics as the institutions in Cape Coast Metropolis that were used in the main study. The responses from the pilot study indicated that the wording was appropriate to the participants concerned.

Procedure

Data were collected in two stages. The first stage involved data collection from female undergraduate students offering biology, chemistry and physics at UCC, female final year science students from four selected SHS, physics lecturers from UCC and physics teachers from the selected SHS. The researcher met the female undergraduate (biology, chemistry and physics) students in their respective lecture halls to administer the questionnaires. The questionnaire for female undergraduate students was administered to the selected students after the purpose of the study was explained to them. Nearly all questionnaire administered to female undergraduate students were collected by the researcher on the same day. The researcher also visited the selected SHS to administer the questionnaires. In each of the school, the purpose of the study was explained to the female students before questionnaires were administered. Questionnaires were administered with assistance from the physics teachers at post at the time of the research. A different questionnaire was administered to physics lecturers and teachers. Questionnaires administered to lecturers and teachers were collected back the third day. However, there were cases of non responses which were abandoned by the researcher after several attempts to get back these questionnaires failed.

In the second stage, the researcher conducted individual interviews with a smaller number of the respondents. The researcher personally conducted the interviews with the selected female students, lecturers and teachers. The purpose of this interview was to delve deeper into issues which came up from analysis of responses to female students' questionnaires and physics lecturers and teachers' questionnaires. It was also meant to allow respondents who might not have had the chance to expand on, or react verbally to a question of particular interest or importance to do so. All interviews were conducted using semi-structured interview guide. At the beginning of each interview session, interviewees were assured that their responses would be treated confidentially and would be used for research purposes only. All the interviews were recorded with an audio tape-recorder with the permission of interviewees. Notes were also taken to supplement what were recorded.

Data Analysis

The data obtained from the questionnaires on participants ways of making physics more appealing to female students were organized and shown in tabular forms containing frequencies/percentages, mean, mode and median. Qualitative data gathered during interviews were used to substantiate findings from the survey data. All responses were transcribed and interpreted as presented by the respondents.

Results and Discussion

The study was designed with the aim of determining methods/ways by which physics can be made more appealing to female students. The methods were evolved based on some inputs of three significant stakeholders of the study: female undergraduate non-physics students (biology and chemistry) students, female undergraduate physics students and physics lecturers and teachers. Responses offered by female non-physics students and female physics students are shown in Table 1.

It can be seen from Table 1 that good tuition and career awareness in physics were the main concerns of biology and chemistry female students. In fact, these were the main reasons why biology and chemistry female undergraduate students did not select physics as a course of study. It is therefore in line for biology and chemistry female students to suggest that, job opportunities in physics should be made known to students together with good tuition of the subject in order to make the subject (physics) more appealing to female students.

About 9% of the biology and chemistry female students also indicated that scholarship schemes should be instituted in the universities for females who pursue physics to motivate and encourage others to pursue the subject to the higher level as far as possible. Very few of them (3.9%) indicated that regular counseling services should be instituted to help clarify misconceptions and perceptions most females had conceded to about the subject.

Table 1. Non-Physics and Physics Students' Suggestions of Practical Ways to make Physics more appealing to Female Students (N = 208)

Practical way	Non-Physics Students (N=180)		Physics Students (N=28)	
	No.	%	No.	%
Good tuition	57	31.7	8	28.6
Career awareness in physics	49	27.2	10	35.7
Making physics more practical	18	10. 0	3	10.7
Scholarship schemes	16	8.9	5	17.9
Change of perception about the subject	13	7.2	0	0
Restructure of content	12	6.7	0	0
Role models and mentors	8	4.4	2	7.1
Counseling services	7	3.9	0	0

Practical ways suggested by female physics undergraduate students were not different from those given by female biology and chemistry undergraduate students since they were also much concerned about career awareness in physics and good tuition as shown in Table 1 above.

It is undeniable fact that females in general would not like to be found in a limited job opportunity environment, and since to them little is known about job/career avenues in physics, female students especially, should be exposed to the job avenues in physics so that physics would be seen as equally important as biology or chemistry. Indeed, majority of females pursuing biology, chemistry and physics at University of Cape Coast are not aware of the many prospects in the subject (physics). Physics lecturers are therefore entreated to disseminate amongst students, especially female students, information on job avenues in physics. By this means, females' perception about limited job opportunities in physics can be placed under curb if not eliminated completely.

As indicated in Table 2, 45.5% of physics lecturers and teachers were also concerned about good tuition as a major tool for making physics more appealing to female students.

Table 2. Physics Lecturers and Teachers' Suggestions of Practical Ways to make Physics more appealing to Female Students (N = 11)

Practical way	No.	%
Good tuition	5	45.5
Counseling services	4	36.4
Role models and mentors	2	18.1

When asked to throw more light on good tuition as a way to make physics more attractive to females, physics lecturers who were interviewed mentioned that physics should be taught by using practical examples to explain physics concepts and phenomena. They also advised that, lecturers and teachers must take their time to ensure that students, especially female students grasp the concepts being presented. In addition, they emphasized that, if need be, special attention should be given to (some) female students after lectures so as to help them understand some (key) concepts that were unclear to them during scheduled teaching periods.

SHS physics teachers who were also interviewed added that mathematics and physics concepts should be taught well at JHS level in order to encourage more females to study both mathematics and physics at SHS. To them, if basic terminologies and concepts are explained very well with examples, and encouraged female students' involvement during class discussions when the subject is being taught, more females would be interested to pursue physics to the higher level.

Another strategy which physics lecturers and teachers placed much emphasis on was counseling. They suggested that counseling services should be provided for female students for two main reasons: one, to renew their minds and dispel the notion that physics was a difficult subject and two, to bring to their knowledge the many prospects in the subject which cut across all fields of study. The lecturers who were interviewed conceded that much had not been done to project the subject in terms of its numerous job opportunities hence there was the need therefore to educate students on job opportunities in the subject. One lecturer stated: "As a matter of fact, most physics tutors only teach the subject without discussing its numerous careers with their students" (Physics Lecturer).

Practical ways which were suggested by both biology and chemistry female students, physics female students and lectures/teachers are in line with the strategies offered in the literature. For example, Doherty, as cited in Taber (1991) suggested that physics teachers should provide good teaching by changing the way topics and concepts are taught to capitalize on girls' interest. Ivie and Guo (2000) were of the view that physics career path should be made more predictable to students. Also in IUPAP's (2002) resolution directed to National Government and Granting Agencies, proposed that female physics education should be supported with grants and scholarship schemes.

However, single-sex classroom environment which has been tested and reported in the literature as a successful strategy (Kelly, 1981; Peltz, 1990; Pollina, 1995; Stowe, 1991) was not found in this study to be an important strategy that could encourage greater female participation in physics. Nevertheless, physics lecturers and teachers suggested that female students should be given special attention after lectures to help clarify issues that did not go down well with them (female students) in the classroom. It can, however, be speculated that if the above strategies were considered and implemented appropriately, low female participation in physics at University of Cape Coast, where the study was conducted, and other institutions would be improved.

When the SHS female students were asked to describe ways that could encourage them to study physics beyond SHS level, Table 3 shows that job opportunities in physics, practicality of the subject, good tuition, motivation and role models and mentors were among the pertinent issues that must to be addressed so as to develop and sustain the interest of these females to study physics beyond SHS level. These concerns by the SHS females support the concerns raised by their colleague-participants in the university pursuing biology, chemistry and physics programs. This explains further, the need for awareness programs to sensitize students, especially female students about the numerous opportunities in physics and the need to study the subject. This might help students to be psychologically prepared to pursue physics at higher level.

Table 3. Responses by SHS Female Students of ways to encourage them to Study Physics beyond SHS Level (N = 201)

Category	**No.**	**%**
Good tuition	46	22.9
Career opportunities made known	44	22.0
Practicality of physics	42	20.9
Given more motivation	23	11.4
No option	21	10.4
Role model and mentors	13	6.5
Change of perception	12	6.0

Examples of the categories given by the students are listed in Table 4.

Table 4. Category and Examples by SHS Female Students of ways to encourage them to Study Physics beyond SHS Level (N = 201)

Category	**Example of category**
Career opportunities in physics	If I am convinced that I'll easily find employment other than teaching after graduation.
Given motivation	If I get more encouragement from teachers, parents and friends.
Change of perception	If people stop making the pronouncements that physics is difficult at the university.
Practicality of physics	When physics made more practical than just the theory and the assumptions.
Role model and mentors	If I see females in physics who are known to be doing well in life.
Good tuition	If physics teachers will adopt new strategies of teaching the subject to enhance better understanding.
No option	I'll only study physics if I have no other option

In a similar situation, when all the female undergraduate students and teachers were asked to rank other methods that were provided, Table 5 shows that, methods related to career opportunities in physics and relevance of physics, among other methods were ranked medium/high (see Table 6 for the basis for the ranks). This goes to buttress the need for physics educators to create awareness of job/career avenues in physics so as to make physics more appealing to female students in particular.

Table 5. Female Undergraduate Students and Physics Teachers' Ranking for Practical Ways to make Physics more Appealing to Females (N = 219)

Statement	Rank
Career opportunities in physics should be made known to students in the lecture room.	Medium/high
Lecturers should stress the relevance of physics by relating it to social and environmental issues.	Medium/high
Counselors should be encouraging girls in mathematics and science.	Medium/high
Lecturers must find ways to encourage females to study physics to highest level as far as possible.	Medium
Females should be supported by providing them with mentors and role models.	Medium/high
Lecturers should occasionally invite female scientists and technologists into the lecture room.	Medium/Low
Lecturers should provide information on female scientists and technologists in the lecture room.	Low/medium

Table 6. Results of Female Undergraduate Students and Teachers' Ranking of Ways to Make Physics More Appealing to Females

Statement	Mean	Median	Mode	Rank
Females should be supported by providing them with mentors and role models.	2	2	1	Medium/high
Counselors should be encouraging girls in mathematics and science.	2	2	1	Medium/high
Lecturers must find ways to encourage females to study physics to highest level as far as possible.	3	3	3	Medium
Career opportunities in physics should be made known to students in the lecture room.	2	2	1	Medium/high
Lecturers should stress the relevance of physics by relating it to social and environmental issues.	2	2	1	Medium/high
Lecturers should provide information on female scientists and technologists in the lecture room.	3	4	4	Medium/low
Lecturers should occasionally invite female scientists and technologists into the lecture room.	3	3	4	Medium/low

In compiling this table all the responses were brought together and average values were worked out. Mean, mode and median values for each of the statement were compared, since each of the methods had a tendency to obscure some aspect of the data. The values were placed as an order (order of mean, order of modes, and order of medians). All three orders were then considered in allocating a high (1), medium (2-3) or low (4) rank for each statement (Ampiah, 2004, p. 257). Thus high denotes that all three averaging methods gave a higher rank, medium/high that there were two medium and one high and so on. This was used to determine the rankings presented in Table 5.

Conclusion

Physics lecturers/teachers and science educators would agree that female students are not 'ill-assorted' with physics. This study has discussed in some details female students' suggestions on how to ensure greater female participation in physics studies. It is logical that they will tend to be less interested in the subject if the strategies suggested for enhancing greater female participation are not adopted and implemented. Thus physics lecturers and teachers as well as science educators who are interested in greater female participation in physics studies should seek to understand the concerns of the female students and incorporate these concerns in the interventions/strategies they develop.

Recommendations

From the study, it is recommended that effort must be made by physics educators, physics departments and institutions and other stakeholders who are interested in enhancing greater female participation in physics studies to create awareness of the career opportunities in physics, which cut across all fields, so as to make the subject more appealing to female students. Physics lecturers and teachers should also make it a point to encourage female students to study the subject since they (lecturers) always have direct contact and interactions with the students.

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