Developing Country Studies
ISSN 2224-607X (Paper) ISSN 2225-0565 (Online)
Vol 2, No.5, 2012

Increasing Female Participation in Science and Technology Careers: Problems and suggested Interventions from Nigeria

Uchenna Udeani PhD
Department of Science & Technology Education,
University of Lagos, Lagos, Nigeria.
Tel: +234 8037860978 Email: uudeani@unilag.edu.ng

Abstract
The study utilized a modified adaptation of the Science Career Predictor Scale (SCPS) to assess eight factors involved with science career choices: Interest, Enrolment, Masculine image of science, Social barriers, Role Model, School factor, Teacher factor and Parental factor. The instrument was administered to a sample of 375 females enrolled in a general studies programme in the 2010/2011 academic session at the University of Lagos, Nigeria. The sample was then sub divided into female science major and female non-science major groups. A student's t-test was used to compare the responses of the two groups.
Result indicated that the group means were significant for enrolment, social barriers and role models. The group means for interest, masculine image of science, school, teacher and parental factors were found not to be significant.
The paper concludes that because females and males appear to possess equal potential to develop the skills required for the pursuit of science it is both a waste of talent and a deprivation to individuals that the two sexes do not participate equally in science.

Keywords: Female participation in science, Female underrepresentation in science, Science careers, Gender differences in science.

1. Introduction

In the second half of the 20th century resources have been allocated in many parts of the world for developing curricula in school science. While initially the rhetoric and practice of many of these developments were directed to the need for more scientists, an additional thrust toward the provision of "Science for All" has developed more recently. These directions reflect two of the overriding aims of science education:

- To educate students for careers in science and technology
- To create a scientifically and technologically literate population capable of looking critically at the development of science and technology and of contributing to democratic decisions about this development.

In the context of these aims, concern has been expressed since the early 1970s regarding the imbalance between female and male enrolment in science classes. The concern has focused progressively on the consequences of this imbalance for universal scientific literacy and for gender equity in the pursuit of science and technology. It is now widely acknowledged that by the end of schooling the number of females with the motivation and background to progress into further studies in sciences, into decision-making roles or careers in science and technology and into activities integral to the application of science and technology for development is much smaller than that of males with similar motivation and background. Clearly, if science education is to achieve the above aims, it must provide more equitably than in the past for the access and success of both females and males.

A summary of research findings pertaining to a number of aspects of sex-related differences in science career enrolment indicates a narrow participation of girls in secondary school subjects of science and technology as well as low numbers of women who hold a professional career in science or technology (e.g. NAEPT 1983, Lockheed et al. 1985). It also seems that girls who choose to learn science prefer subjects that are different from those favored by boys. In their studies, Entwisle and Duckworth (1977), Jungwirth (1973) and Tamir (1975) have shown that while boys are more oriented towards the so-called 'hard' sciences (physics, chemistry, etc), girls prefer the 'soft' subjects such as human physiology, plant life, zoology, etc.

In Nigeria, gender differences in enrolment in science, mathematics and technology careers show a lot of disparity, with females being underrepresented. Table 1a&b presents data on this disparity from two S&T faculties at the University of Lagos in Nigeria. (Source: University of Lagos, Academic Planning Unit, Enrolment Data for 2010/2011 academic year). The tables indicated that females constitute only 12.4% of the total enrolment in the Faculty of Engineering and 37.5% of the total enrolment in the Faculty of Science. The picture presented in these tables are typical of most S&T faculties in Nigeria.

The purpose of the present study, which was exploratory in nature, was to investigate the influence of some of these factors that have been identified over the years as barriers to female pursuit of science-related careers. The variables chosen for the study were:

- Interest
- Enrolment
- Masculine image of science
- Social barriers
- Role model
- School factors
- Teacher factors
- Parental influence.

2. Methodology

2.1 Sample and background of subjects.

The sample for the study was drawn from all the females enrolled in the general studies programme in the 2010/2011 session at the University of Lagos, Nigeria (this programme is offered to all students irrespective of their course of study). A total of 375 females constituted the research sample. The sample was then subdivided into female science major and female non-science major groups. The students in the faculties of arts, business studies, law and social sciences were grouped under the non-science major group, while those in the faculties of basic sciences, engineering and environmental sciences were put in the science major group (Table 2).

2.2 Instrumentation

A modified version of the Science Career Predictor Scale (SCPS) developed by Hill et al. (1990) was used to assess the relevant contributions of the eight variables in the study in influencing the pursuit of a science career at the university. The instrument consists of 48 attitude statements (6 statements for each of the 8 variables). A five-point Likert scale ranging from 'strongly agree' to 'strongly disagree' was used for the responses to the statements. The modified instrument was content revalidated by a panel of five science educators to rate the degree to which agreement with a particular statement was indicative of the presence of an attitude that could discriminate between someone pursuing a career in science and someone who was not. Their comments were used in modifying some of the statements before the final version of the questionnaire was produced for distribution.

In order to get more qualitative responses from the respondents, the same questionnaire without the Likert scale was used on about two-thirds of the respondents. Their responses were used to crosscheck previous responses and also to obtain more personal information.

2.3 Method of data collection and analysis

Copies of the questionnaire were distributed to all respondents during a class and collected soon after. A score for each subscale and scale was obtained by summing the scores assigned to each response to an item in a subscale. A student's t-test was used to compare the responses of those in the science major group with those in the non-science major group for each of the subscales.

3. Results, discussions and conclusions

3.1 Results

The results in Table 3 show that three subscale means were significant and five were not in respect of two groups of respondents.

3.2 Discussion

The discussion of the findings on each of the subscales is presented below.

3.2.1 Interest

The results from the science and non-science major groups on the interest subscale show that both groups of students were interested in science. The t-test showed no significant difference between the groups in this subscale. In all the six subscales items the two groups did not differ in their opinion on their interest in science. These results are interesting, as they do not corroborate previous research studies. For instance, after an extensive research study, Hill et al. (1990) found that general lack of interest in science was responsible for lack of participation of females in the field.

3.2.2 Enrolment

In 1981 Alison Kelly coined the term 'the missing half' to describe the under participation of girls in science. Also in 1981 the first GASAT (gender and science and technology) conference was held in Eindhoven in the Netherlands with participation of representatives from eight countries that shared the problem of low enrolment of girls in science. In the present study higher mean scores were recorded for the science major group; thus, the t-test was significant. One interesting result from the subscale items was that 38% of the non-science major group mentioned that they could not pursue a science career because they failed mathematics at 'O' levels. Universities in Nigeria require a credit pass in mathematics to study any course in science. Thus, it can be inferred from the results that mathematics proficiency is required to increase female enrolment in science careers. The subscale data on subjects taken for 'O' levels also show that 79% of all the females registered for biology, and 31% for chemistry. Lower percentages were recorded for physics.

3.2.3 Masculine Image of Science

Masculine image of science is the perception of math and science as masculine is a major barrier to females pursuing careers in science areas (Bossert 1981, Vockell and Lubonc 1981, Weinreich Haste 1981, Whyte and Kelly 1982) In the present study students in both science and non-science major groups agreed that science had a masculine image. There was no significant difference on the t-test for the subscale means. In Nigeria female scientists have had very low visibility. The masculine image of science is conveyed in the way in which the science curriculum is packaged, taught and assessed. Of equal importance is that science and math textbooks have helped project the masculine image of science in that until recently their illustrations were almost entirely male related and work problems generally dealt with male-oriented mechanical and outdoor examples. Where women were portrayed, they were usually shown in stereotypical roles such as housewives, helpers or spectators. Even though most publishers make a conscience effort to remove sexist stereotypes and references from their books, it will probably be years, even with efforts on all fronts, before this masculine image is changed.

3.2.4 Social barriers

This study viewed social barriers to female representation in science careers from three perspectives:

- Environmental (urban and rural setting)
- Socioeconomic status
- Societal expectations

Significant differences were found on the environmental and socioeconomic factors between the means of the science and non-science major groups. However no significant difference was found on the societal factor. With regard to the environmental subscale, 53% of the females who choose science lived in urban environments. Okebukola and Jegede (1990) found that the general environment in which the learner spends most of their time, i.e. whether it was predominantly manual or automated, and whether their reasoning pattern was empirical or superstitious, affected career choices in science. Most rural environments in Nigeria do not have electricity; consequently most activities are manual.

Another significant factor in female participation in science careers is the socioeconomic status of the family. In Nigeria, socioeconomic status classification would be more valid if based on the educational level of parents (Udeani, 1992). The findings from this study show that 66% of the females with educated parents chose science careers against 33% for their non-science counterparts.

It is generally believed that societal expectations are a major factor in female underrepresentation in science careers. The present study showed no significant difference in the means of the students in the science and non-science major groups in their opinion on societal expectations. The sociocultural forces at work tend to discourage girls from choosing science careers. The societal expectation of females is marriage oriented and few Nigerian men would wish to marry a female in the core engineering or science careers (there is a myth that too much education reduces chances of marriage!). For the females, especially those in the non-science (60%) group, the desire for marriage and children is more important than the attraction of a high-status career.

3.2.5 Role models

In the Nigerian society at large female scientists have had very low visibility. The study indicated a significant difference between the students in the science and non-science major groups on all role model subscales. Females in the science group indicated that their choice of career had been influenced by their interaction with female scientists such as parents, siblings, relatives or family friends. Researchers (Malcolm et al. 1976; Young and Young 1974) found that early exposure to and interactions with professional role models in the natural and technical sciences were critical for recruiting and retaining students' interest and participation in mathematics and science. The lack of role models has been suggested as yet another factor that inhibits enrolment of females in sciences (Hill 1983; Pearson 1985). Some 57% of the students in the non-science group had not been acquainted or interacted with a female scientist at secondary schools.

3.2.6 School factors

School factors in the context of this study were mainly construed as the packaging and presentation of curriculum materials. The instructional materials used in science classrooms are known to carry implicit messages about the relationship between gender and science. Research reported by Whyte (1986) demonstrated that, particularly in the physical sciences, illustrations, examples and applications presented in resource materials are more familiar in general to the experiences and interests of males than to those of females.

The present study agrees with previous research. The t-test for the subscale means shows no significant difference in the responses of the two groups. They recognize that the curriculum typically omits references to females. This researcher has established the deleterious effects of such omissions on female education in science and has contributed to the recommendations for major reforms (AAUW 1992).

3.2.7 Teacher factors

The predominant pattern of teacher interaction with female and male students is well established. As Kelly (1988) concludes from her meta-analysis of 81 studies of teachers-pupil interaction, it is now beyond dispute that girls receive less of the teacher's attention in class. Teacher-student interaction was explored in this study. The results show a non-significant t-test for opinions of the females in the two groups (Table 3). The respondents mentioned that they were under-involved in science lessons. Mahoney (1985) found that teachers unconsciously impede the progress of girls in science and math classes by encouraging girls to keep their contributions short. In addition Dweck et al. (1978) reported that boys received more praise and girls more criticism for the quality of their academic work. All the respondents in this study indicated that their physics teachers had always been male; 74% had male chemistry teachers, 66% male mathematics teachers, and 21% male biology teachers. These results indicate that most Nigerian secondary schools have male science teachers, and most are coeducational. Selective interaction patterns favoring the male student disadvantage the female student in science classes.

3.2.8 Parental factors

Results on parental factors could not be isolated easily due to the fact that most parents did not respond to the questions. However, the item on parental expectation produced adequate results for analysis. Both groups of females (81% of the total sample) mentioned that parents had different expectations for their female and male children irrespective of the children's demonstrated ability. Agreeing with Eccles (1989) studies, this study shows that parents expected sons to do better than daughters in mathematics, and they saw mathematics, physics and chemistry as more important for sons than for daughters. This state of affairs is prevalent in the Nigerian society were parents are likely to force their male children to study science even when they perform poorly in the subjects. On the other hand, female children are not encouraged to take science even if they show exceptional cognitive abilities in the subjects.

4. Intervention initiatives in Nigeria

Over the years, the Nigerian government has paid minimal attention to education. This lack of commitment prompted a lot of private sector investment in education. Science and technology education, in particular, suffered because of lack of funds to equip laboratories and workshops. This situation is not very encouraging for girls, since it makes the learning environment very competitive. Some initiatives have been introduced to facilitate girls' access to scientific and technological knowledge. The most prominent are described below:

- **Large, nationwide, government-funded projects** such as the Junior Engineers, Technologists and Scientists (JETS) initiative. This is a televised science quiz programme for science students in secondary schools starting at the zone level. Zonal winners proceed to the national level. The JETS programme had popularized science, but its effect on increasing female participation in science is yet to be established.

- **The establishment of Science, Maths and Technology (SMT)** clinics for girls in specified institutions and locations in Nigeria has reached an advanced stage. The clinics are a comprehensive multiphase intervention aimed at increasing the number of females prepared at school level to enter science and engineering studies. Private sector funding is being solicited for this project. The initiative has not taken off at present due to lack of funds.

- **Career counseling** is another area where professional associations have had great input. Career days are set aside periodically in schools to expose students to the career choices available in the many fields of human endeavour. However, these career days have not specifically targeted females and science. There is a growing need to expose girls to careers in science, because most girls are not able to relate the science they do in school to the courses available in tertiary institutions. In this area, role models become very important. Successful woman scientists in all spheres of life should be encouraged to address students during career days.

- **Information campaigns**. Many states in Nigeria organize information campaigns on scientific and technical occupations to familiarize students and their families with the range of careers and jobs in these fields. In a few states these campaigns have reached the broad public through intense media coverage.

- **Scientific awards and prizes** have been targeted at females by scientific professional associations in Nigeria to encourage greater participation of females in science. Of special mention is the initiative of the Association of Women Engineers of Nigeria.

- **Science fairs.** The Science Teachers' Association of Nigeria (STAN) organizes annual science fairs and quizzes at state and national levels. These fairs, although not specifically targeted at females, encourage the production of science projects. Prizes are awarded to winners of the best projects.

5. Conclusions

This paper began with the premise that all young people should be given the opportunity to be part of the pool of future scientists and technologists and to be scientifically literate citizens. Because females and males appear to possess equal potential to develop the skills required for the pursuit of science, it is both a waste of talent and a deprivation to individuals that the two sexes do not participate equally in science. Attempts to remedy the gender imbalance in participation in Nigeria must target primarily effective and sociocultural aspects. It is also important to note that unless these programmes are specifically targeted to assess the status, articulate goals and directly target educational problems of females, they are unlikely to be effective. Finally there is need for systemic support for equity initiatives. Consistent and sustainable support from the government and the educational system is necessary for both the implementation and continuance of intervention programmes.

References.

AAUW. (American Association of University Women). (1992). *How schools short changed girls.* Commissioned report prepared by the Wellesley College Centre for |Research on Women. Washington, DC: AAUW Educational Foundation/National Education Association.
Bosert S. 1981. Understanding sex differences in children's classroom experiences. *Elementary School Journal* 81, 254-266.
Dweck S. Davidson W. Nelson S. and Enna B. (1978). Sex differences in learned helplessness. II. The contingencies of evaluative feedback in the classroom. *Development Psychology* 14, 268-276.
Eccles J. (1989.) Bringing young women into math and science. In: Crawford M. and Gentry M.(eds) *Gender and thought: psychological perspectives*. Springer-Verlag, New York. 36-58.
Entwistle N. and Duckworth D. (1997). Choice of science courses in secondary school: trend and explanation. *Studies in Science Education* 4, 63-82.
Hill O.W., Pettus C. and Hedin B.A. (1990). Three studies of factors affecting the attitudes of blacks and females toward the pursuit of science and science-related careers. *Journal of Research in Science Teaching* 27, 4, 289-314.
Hell S.(1983). *Participation of black students in higher education: a statistical profile from 1970-71 to 1980-81*. National Center for Educational Statistics, Washington, DC.
Kelly A. (1981). Retrieving the missing half. In: Kelly A.,(ed). *The missing half.* Manchester University Press, Manchester, UK.
Kelly A.(1998). Gender differences in teacher-pupil interaction: a meta-analytic review. *Research in Education* 39, 1-23.
Lockheed M.E., Thorpe M., Brooks-Gunn J., Casserlym P. and Mc Aloon A. (1985). *Sex and ethnic differences in middle school mathematics, science and computer science: what do we know*? ERIC Document Reproduction Service No. ED 303 353. Educational testing Service. (ERIC Document Reproduction Service), Princeton, NJ.
Mahoney P. (1985). *School for boys*? Hutchinson, London.
Malcom S., Hall P. and Brown J (1976). *The double blind: the price of being a minority woman in science*. American Association for the Advancement of Science, Washington, DC.
Okebukola P.A.O. and Jegede O.J. (1990). Eco-cultural influences upon students' concept attainment in science. *Journal of Research in Science Teaching*, 27,7 ,661-669.
Pearson W. and Pearson L.(1985). Baccalaureate origins of black American scientists: a cohort analysis. *Journal of Negro Education* 54, 24-34
Udeani U.N. (1992). Learning outcomes in integrated science as related to teacher and student characteristics and interaction pattern. PhD thesis, University of Nigeria, Nsukka.
Vockell E. and Lubonr S. (1981). Sex role stereotyping by high school females in science. *Journal of Research in Science Teaching* 18,209-219.
Weinreich-Haste H.(1981). The image of science. In: Kelly A.,(ed). *The missing half.* Manchester University Press, Manchester: UK.
Whyte J. (1986). *Girls into science and technology: the story of a project*. Routledge and Kegan Paul, London.
Young H. and Young B. (1974*). Scientists in the black perspective*. The Lincoln Foundation, Louisville

TABLE 1
UNIVERSITY OF LAGOS
ACADEMIC YEAR: 2010/2011
TOTAL ENROLMENT OF FACULTY/DEPT., SEX AND LEVEL OF COURSES

Table 1a

FACULTY OF ENGINEERING	UNDERGRADUATE COURSES		PERCENTAGE OF FEMALES (%)	GRAND TOTAL (M&F)
	MALE	FEMALE		
CHEMICAL ENGINEERING	258	81	24.1	339
PET. & GAS ENGINEERING	175	27	7.1	377
CIVIL & ENV. ENGINEERING	250	25	9.1	275
ELECTRICAL ENGINEERING	367	45	11.0	412
COMPUTER ENGINEERING	136	24	15.0	160
MECHANICAL ENGINEERING	284	16	5.3	300
MET. & MAT. ENGINEERING	216	21	8.9	237
SURVEYING & GEOINFORMATICS	197	25	11.3	222
SYSTEMS ENGINEERING	195	30	13.3	223
SUB TOTAL	**2,078**	**294**	**12.4**	**2, 372**

Table 1b

FACULTY OF SCIENCE	UNDERGRADUATE COURSES		PERCENTAGE OF FEMALES (%)	GRAND TOTAL (M&F)
	MALE	FEMALE		
BIOCHEMISTRY	151	143	48.6	294
BOTANY	123	145	54.1	168
MICRO-BIOLOGY	133	195	59.5	328
CELL BIOLOGY & GENETICS	154	178	53.6	332
CHEMISTRY	233	125	34.9	358
COMPUTER SCIENCE	242	65	21.1	307
GEOPHYSICS	66	13	16.5	79
GEOLOGY	69	9	11.5	78
FISHERIES	18	17	48.6	35
MARINE BIOLOGY (SCIENCE)	171	147	46.2	318
MATHEMATICS/STATISTICS	370	111	23.1	481
PHYSICS	358	50	12.3	408
ZOOLOGY	103	117	53.2	220
SUB TOTAL	**2,191**	**1,315**	**37.5**	**3,506**

Table 2. Distribution of the students

Faculty	Females	
	Non-science major	Science major
Arts	85	-
Business Administration	68	-
Law	75	-
Social Sciences	46	-
Basic Sciences	-	43
Engineering	-	21
Environmental science	-	37
Total	**274**	**101**

Tables 3. Responses of the Students to Items on the SCPS.

Subscale	Means for science major	S.D	Means for non-science major	SD	df	t statistics	Critical value of t
Interest	33.26	8.32	32.02	9.03	373	0.82	1.960
Enrolment	29.44	7.81	24.10	8.43	373	2.43*	1.960
Masculine image of science	31.86	7.69	32.27	8.32	373	1.10	1.960
Social barriers	34.25	3.21	30.16	6.53	373	2.09*	1.960
Role model	28.59	9.30	23.31	9.30	373	2.54*	1.960
School factors	28.95	7.97	28.80	9.16	373	0.89	1.960
Teacher factor	25.75	8.62	25.16	8.68	373	0.79	1.960
Parental factor	32.32	7.50	32.61	8.90	373	0.81	1.960

*****(Significant at 0.05 level)
N for science major = 101
N for non-science major = 274