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CONTENTS

BOYS AND GIRLS IN SCIENCE: DOES THE GENDER COMPOSITION OF THE SCHOOL MATTER?

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ABSTRACT

The study was designed to find out the influence of the gender composition of the schools students attend on their selection of the physical and applied sciences for their college majors. Consistent with several previous studies, this study also shows that boys are more likely than girls to choose their majors from these subject areas. Furthermore, the boys in the single-sex schools are more likely than any other group to choose physical or applied science majors in Ghana. Contrary to previous studies, however, girls in mixed-sex schools appear to be slightly more likely than their counterparts in single-sex schools to choose physical and applied science majors. The implications of the findings are discussed.

Introduction

Development theorists in economics and sociology see the level of a society's scientific and technological development as the underlying factor accounting for its socioeconomic development. These theorists believe that the key to socioeconomic development is the ability to generate scientific and technological capacity, as well as the capacity to absorb scientific and technological knowledge (Romer, 1990). This generative and receptive capacity, and the capacity to produce are thought to be a function of formal education (Nelson, 1990). In the light of this, developing countries have been urged to try and generate their own indigenous scientific and technological potential (Giddens, 1982).

In view of the important role of education in building the capacity for science and technology, the persistently low enrolments in science, particularly the physical and applied sciences, in the secondary and tertiary levels of education have aroused the concern of science educators, researchers, and policy-makers the world over (Hardin, Hilderbrand and Klainin, 1988). Of even greater concern has been the underrepresentation of females in scientific studies and careers (Brush, 1991). This concern about females stems from the realisation that the underrepresentation translates into underutilisation of female talent, which in turn exacerbates the bottleneck in the development of science and technology capacity-building. Accordingly, efforts have been made to investigate various dimensions of the problem. One major finding emerging from the studies is that single-sex schooling facilitates girls' participation in science (Rennie and Parker, 1987). Other findings, however, indicate that such a relationship is spurious (Harvey, 1985). Since both single-sex and mixed-sex schooling are typical of the educational systems of Ghana and some other African countries, this paper will focus on gender and school context influences of Ghanaian secondary school students' intentions to choose the physical and applied sciences as their college major.

Previous Research

In response to the challenges posed by the generally low enrolments in the physical sciences, and the persistently low participation of females in science courses and scientific careers, a great deal of effort has been sunk into investigations into different dimensions of the problem. The studies have focused mainly on gender differences in participation and achievement in science (Steinkamp and Maehr, 1983). Others have been focused on either the school's sex-compositional effect on female participation and achievement in science or the determinants of students' enrolment in science courses (Crawley and Coe, 1990; Myeong and Crawley, 1993).

In the study of gender differences in achievement in science, results from different parts of the world indicate little consistent pattern of boys' relative superiority over girls at the lower levels of education. In Africa, a

study of Kenya reported by Hardin and her associates (1988) indicates that the gender factor vanished when school-context factors were controlled. A difference does emerge, however, at the secondary and tertiary levels (Steinkamp and Maehr, 1983).

Most of the literature on gender differences in subject preference show, however, that with reference to science, boys tend to be predisposed to the physical sciences whereas girls tend to be predisposed to the biological sciences (Amon-Nikoi, 1978). The aspect of science education that has generated the greatest controversy, however, has been the sex composition of the schools students attend. Results of the studies do suggest that mixed-sex schooling is detrimental to girls' participation and achievement in science (Rennie and Parker, 1987). The argument has been that in mixed-sex schools, the boys tend to choose science, considered a masculine subject, whereas the girls tend to choose subjects considered feminine. Single-sex schooling is, therefore, considered to be more beneficial to girls' participation in science. However, using classroom and school-based experiments to determine sex-compositional effects on girls' participation and achievement in science, Harvey (1985) found that single-sex schooling did not increase girls' participation in science. This controversy over sex-compositional effects has not been resolved hitherto.

In other analytical studies, one factor that consistently emerges as a predictor of the intention to choose a science major has been encouragement and support received from parents, teachers, and peers (Myeong and Crawley, 1993). Others are previous grades in science and mathematics as well as self-concept of ability in science, self-concept of ability in mathematics, and self-concept of general academic ability (Koballa, 1988). The studies suggest that previous grades in science and mathematics boost self-concept of ability in science, which in turn, influences the intention to major in science (Deboer, 1987).

The literature thus suggests that an interplay of social structural and social psychological factors explain and predict both males' and females' participation in science at the secondary and tertiary levels. The salient

social structural factors include family background and the economy, while the social psychological factors include the self concept and social support. Given the persistent bottlenecks in human resource development in science and technology, and the persistently low enrolments in the physical sciences in many African countries, it is imperative that African scientists themselves come to grips with these salient social structural and social psychological factors that influence students' selection of the physical and applied sciences as their college major.

This Ghanaian study extends previous research by examining the school-context factor, which in juxtaposition with social psychological and social structural factors, do influence students' intentions to choose their college majors from the physical and applied sciences. Ghana provides an example of a good setting for such a study because, first, it is one African country that has set up the infrastructure for science and technology human resource development (Smillie, 1986). Second, it is a good example of an African country where, in spite of the facilities provided enrolments in the physical and applied sciences have always lagged behind expected levels (UNDP, 1994). This paper is therefore designed to answer two main questions, namely:

1. Are Ghanaian secondary school boys and girls equally predisposed to the physical and applied sciences?
2. Does the sex-composition of the schools students attend make a difference in their intentions to major in the physical and applied sciences?

Data and Method

Data for the study were collected between June and August 1994 from a random sample of 624 final year senior secondary school students drawn from a Ghanaian school district. The study focused on this cohort because they were boys and girls about to select their college subject areas. As such, they constituted the ideal target group for a study of this nature.

The district has nine senior secondary schools. Since students all over the country are not restricted in their selection of senior secondary schools to attend, these nine schools, like those in other parts of the country, recruit students from all parts of the country. Therefore, in terms of curriculum, organisation, students' social and academic background, these schools do not differ very much from schools in other parts of the country.

Four of the nine schools are mixed-sex, whereas the remaining five are single-sex. Two of the five single-sex schools are for girls, whereas the remaining three are for boys. To ensure equitable representation, all the nine schools were purposefully included in the survey. Conditions in one of the all-male schools, however, did not make data collection there possible. Systematic random sampling techniques were employed at the school level to select samples from the final year classes. Three hundred and ten boys and 314 girls were selected through this process. This method also yielded a total of 106 subjects from the all-female schools, and 111 from the all-male schools. The sample selected from the mixed-sex schools was made up of 199 boys and 208 girls. In all, a sample of 217 was drawn from the single-sex schools, and 407 from the mixed-sex schools. A larger sample of students were selected from the mixed-sex schools because of their larger numbers.

The data were collected with precoded pen and paper questionnaires which included items such as sex of respondent, the type of school the respondent was attending, and parents' education. Others were the self-concept, social support, and previous grades. Previous grades were obtained from official school records. In each school, with the permission of the authorities, students in the sample were assembled and the purpose of the exercise was explained to them. Item by item, the questionnaire was explained to them. They were allowed to ask questions if they did not clearly understand something. They were assured of confidentiality and advised not to write their names on the questionnaires. They were then dismissed with the instruction that they should independently respond to the questionnaires at their own pace.

The dependent variable is the intention to choose a physical or an applied science major in college. A physical or an applied science choice was coded *1*, whereas any other choice was coded *0*. The main predictor variables are gender and sex composition of the school the student attends. Males were coded *1*, and females, *0*. Single-sex schools were coded *1*, whereas mixed-sex schools were coded *0*. For analytical convenience, school and gender were combined in later stages of the analysis, into a four-category variable – *school*. The all-male schools were coded *1*, and all-female schools, *2*. Categories 3 and 4 were created for males and females respectively, in the mixed-sex schools.

The control variables are self-concept of ability in the physical sciences and Mathematics, and self-concept of general academic ability. These were all measured on a five-point scale on which a score of 5 is the highest. Others are previous grades in mathematics and science, social support, mother's education, and father's education. Previous grades were coded from percentages into a five-point scale on which a score of 5 was the highest. Father's and mother's education were also measured in number of years, and then recoded into five-point scale. Social support in the form of parents', teachers' and peers' support and encouragement for sciences choice, were also measured on a five-point scale. The last two control variables are the students' own rating of the status of science in their schools, and their own appraisal of the chances of job opportunities that will be available for those who major in the physical and applied sciences in college. The response categories for the rating of science were *excellent* (5), *very good* (4), *good* (3), *fairly good* (2), and *poor* (1). The response categories for the appraisal of the chances for job opportunities were *extremely promising* (5), *very promising* (4), *promising* (3), *fairly promising* (2), and *not promising* (1).

Data Analysis and Results

For the bivariate analysis, first, a cross-tabular analysis was done to determine the percentage of the different groups of students intending to choose physical or applied science majors. Second, the means and standard deviations of the variables in the equation were run to form the

basis for a series of t-tests. Logistic regression procedures were employed in the multivariate analyses. Table 1 presents the cross-tabulation showing the relationship between type of student and the choice of a physical or an applied science major.

Table 1

Percentage Distribution of the Intention to Choose a Physical or an Applied Science by Category of Student

Group	No. Choosing	% Choosing	N
Entire Population	296	47.4	624
Single-sex schools	141	65.0	217
Mixed-sex schools	155	38.1	407
All-male schools	106	95.5	111
All-female schools	35	33.0	106
Boys in the mixed-sex schools	101	50.8	199
Girls in the mixed sex schools	54	26.0	208
Boys	207	66.8	310
Girls	89	28.3	314

The distribution shows that more boys and girls intend choosing physical and applied science majors. This is statistically significant ($\chi^2 = 92.40$, df $= 1$, $p < .01$). Furthermore, compared with the other categories of students, those in the all-male schools are overwhelmingly the most inclined towards the subjects under study ($\chi^2 = 151.01$, df $= 1$, $p < .01$). The means and standard deviations of the control variables are presented in Table 2.

Table 2

Means and Standard Deviations of the Variables Predicting the Intention to Choose a Physical or an Applied Science Major (Standard Errors in Parentheses)

Variable	Entire Population 624	Male Only 111	Female Only 106	Male mixed 199	Female mixed 208
Science self-concept	3.14	3.93	2.90	3.26	2.73
	(1.03)	(0.70)	(0.80)	(1.05)	(1.02)
Math self-concept	3.13	3.80	3.03	3.25	2.70
	(1.01)	(0.72)	(0.95)	(1.02)	(0.95)
General self-concept	2.39	2.03	2.55	2.25	2.65
	(0.76)	(0.64)	(0.62)	(0.77)	(0.76)
School's science status	3.26	3.77	3.33	3.13	3.08
	(0.92)	(0.84)	(0.85)	(0.93)	(0.89)
Peer influence	3.50	4.09	3.34	3.55	3.22
	(1.07)	(0.75)	(0.88)	(1.09)	(1.16)
Teachers' influence	3.88	3.75	3.88	3.60	3.62
	(1.27)	(1.08)	(1.05)	(1.33)	(1.40)
Parents' support	3.55	3.75	3.79	3.57	3.30
	(1.39)	(1.19)	(1.19)	(1.44)	(1.50)
Father's education in yrs	15.9	16.8	17.0	15.2	15.5
	(4.74)	(3.98)	(4.52)	(5.01)	(4.81)
Mother's education in yrs	12.5	13.2	13.2	11.9	12.3
	(5.16)	(4.79)	(4.65)	(5.58)	(5.13)
Science grade	4.20	4.60	4.49	4.16	3.88
	(0.84)	(0.72)	(0.56)	(0.84)	(0.87)
Previous math grade	3.46	4.25	3.22	3.67	2.62
	(1.38)	(0.97)	(1.26)	(1.36)	(1.26)
Previous science grade	3.69	4.51	3.95	3.89	2.93
	(1.33)	(0.72)	(1.17)	(1.26)	(1.21)
Job certain	3.47	3.36	3.13	3.75	3.43
	(1.21)	(1.19)	(1.18)	(1.18)	(1.21)

The t-test confirms the result of the cross-tabular analysis which shows that the boys in general are more inclined towards the physical and applied sciences than are the girls and that the boys in the all-male schools are the most inclined towards the subjects under study. The t-tests reveal many more interesting facts. The tests reveal no difference between boys and girls in terms of parents' and teachers' support for science choice. The boys, particularly those in the all-male schools, tend to experience more peer influence for choosing physical and applied science majors.

Though the boys display higher self-concept of ability in mathematics and the physical sciences than the girls do, the latter tend to display a higher self-concept of general academic ability. It is understandable, however, that the boys rate the status of science in their schools higher than the girls do. The boys also show more optimism about the chances of job opportunities for physical and applied science majors. This probably explains why they are more likely than the girls to choose these subjects for their major. The tests further show that though the boys in general had performed better than the girls on teacher-made tests in science and mathematics, the boys in the all-male schools had performed the best. Finally, the t-tests show that the boys and the girls do not differ significantly in terms of parents' education. The fathers of students in the single-sex schools, however, tend to be more educated than the fathers of those in the mixed-sex schools. The same is true with mother's education. These indicate that students from the single-sex school come from higher-status backgrounds.

The multivariate analysis was done in two phases. Phase 1 involved the construction of three models. These are summarised in Table 3.

Table 3

Logistic Regression Coefficients of Predictors of the Intention to Choose a Physical or an Applied Science Major.

Variable	Model 1 Beta	Model 2 Beta	Model 3 Beta
Sex (dummy) (male = 1; female = 0)	1.63***(.17)	1.74***(.18)	1.15***(.30)
School (dummy) (single-sex = 1; mixed-sex = 0)		1.27***(.19)	.95***(.31)
Science self-concept			1.51***(.26)
Math self-concept			08***(.22)
General self-concept			.97***(.25)
Sch science status			.06 (.17)
Peer influence			.66***(.16)
Teacher's influence			.36***(.14)
Parents' suppot			.27**(.12)
Father's education in years			.18 (.15)
Mother's education in years			.31* (.17)
Science grade			25 (.19)
Previous grade in Math			.73***(.17)
Previous grade in Science			.78***(.18)
Job certainty			.39**(.13)
Constant	-0.93	-1.43	-22.03
-2 Log Likelihood			
	768.57	722.6	347.83
	df = 1	df = 2	df = 15
N = 824			

Note: (1) *p< .10; **p< .05; ***p< .01

(2) Standard errors are in parentheses

Model 1 shows the bivariate relationship between gender and the intention to choose a physical or an applied science major. In model 2, the type of school the student attends is introduced. This answers the question

whether the sex composition of the school attended has an influence on science-track choice. Model 3 includes the full set of variables in the equation.

The direction of the coefficients in model 1 shows that the boys are more likely than the girls to choose physical and applied science majors. Model 2 also suggests that students in the single-sex schools are more likely than their mixed-sex counterparts to choose the majors in question. In model 3 the background variables lead to a shrinkage of the coefficients of the gender and school variables. Indeed, with the introduction of the background variables, the effects of the gender and school variables shrink by almost 34% and 25% respectively. These findings suggest that the predictive value of gender and school type are shared with the socio-structural and socio-psychological factors in the background. In other words, gender and sex composition of the school do not adequately explain the intention to choose a physical or an applied science unless the socio-structural and socio-psychological factors are examined closely.

Consistent with the results of previous research, the three dimensions of the self-concept, together with previous grades, social support, and optimism about the chances of job opportunities for physical and applied science majors, are all predictive of the intention to major in the subjects in question. One interesting finding is that consistent with previous research that mother's education facilitates children's education (King and Bellew, 1991), the results of this study show that mother's education, rather than father's education, is a significant predictor of the intention to choose the majors in question.

The information in Table 3 indicates that it is not only being a boy that is predictive of one's intention to choose a physical or an applied science major; rather , it is being a boy in a single-sex school. The information, however, does not show clearly whether or not single-sex schooling favours both boys and girls in the question of science choice. What is more, the information does not show whether or not the girls in both school contexts are less inclined to choose the majors in question. To address these issues, the second phase of the multivariate analysis was introduced.

The second phase also involved the construction of three models. The results of these are presented in Table 4.

Table 4

Difference in Gender and School Effects on the Intention to Choose a Physical or an Applied Science Major.

Variable	Model 1 Beta	Model 2 Beta	Model 3 Beta
Sex (dummy) (Male = 1; Female = 0)	-.18(.37)		
School (dummy) (Single-sex = 1;Mixed-sex = 0)	-.90***(.45)		
Sex*School (interaction)	4.58***(.54)		
Boys in the single-sex schs (ref. category)			
Boys in the mixed-sex schs		-3.68***(.68)	
Girls in the single-sex schs		-4.40***(.74)	
Girls in the mixed-sex schs		-3.50***(.68)	
Differences due to school (girls)			.90***(.45)
Differences due to school (boys)			3.68***(.68)
Sex differences in the mixed-sex schs			-.18 (.37)
Constant	-23.57	-22.96	
-2 Log Likelihood	307.37	307.37	
	df = 16	df = 16	

Note: (1) Standard errors are in parentheses

(2) ***p.01

(3) Models 1,2, and 3 include controls for background factors.

Model 1 tests the significance of the interaction term. Model 2 shows the unique effect of each of the four school contexts. Model 3 indicates the school and gender differences between different categories of students under study. Model 1 shows that the interaction is significant. It fails, however, to show clearly the unique effect of each of the four different school contexts. Therefore, in model 2 the extent to which the sex composition of the school affects the dependent variable was examined.

With the all-male group serving as the reference category, and controlling for the background factors, it comes as no surprise that each of the three categories of school contexts is less likely to induce the desire to choose a physical or an applied science major. The category least likely to do so is the all-female group. Strangely enough, the boys and girls in the mixed-sex schools do not differ significantly in their intentions to major in the subjects in question.

In Models 3 the difference between boys in the different school contexts and girls in the different school contexts, as well as between boys and girls in the mixed-sex schools, were determined. The results show that the difference between girls in the all-female schools and those in the mixed-sex schools is slight but statistically significant. The difference is in favour of those in the mixed-sex schools. This indicates that though girls in general are less likely than boys to choose science majors, those in all-female schools are much less likely to do so than those in mixed-sex schools, when the socio-structural and socio-psychological background is held constant. The difference between the boys in the different school contexts is large and statistically significant. This difference, however, is in favour of those in the single-sex schools. This also goes to confirm the result of the bivariate analysis which depicts boys in the single-sex schools as those most likely to choose physical or applied science majors. Controlling for social structural and social psychological background factors, no difference between boys and girls in the mixed-sex schools is noticed.

Summary and Conclusion

The first question this research was designed to seek an answer to was whether boys and girls are equally likely to choose physical and applied science majors. The result shows that the answer is simply "No". Both the bivariate and multivariate analyses show that boys are more likely than girls to choose the subjects in question for their college major, probably because boys have higher self-concept of ability in mathematics and physical sciences, and are more optimistic about the chances of securing jobs related to these majors.

I am inclined to believe that there is no biological explanation for gender differences in the interest, or lack thereof, in science. I am inclined to believe that a social structural factor, stratification by gender, is manifested in such a social psychological factor as differential gender socialisation. This, I believe, influences girls so much that they invariably tend to see the sciences, particularly the physical and applied sciences, as male subjects. It is therefore suggested that in future research on the relationship between gender/school-context and students' science choice, stratification by gender, manifested in differential socialisation, be given a close look.

The second question was whether the sex composition of the schools students attend can, and do made a difference in the likelihood that they will choose their majors from the physical and applied sciences. The answer is partially yes, and partially no. The present study, contrary to previous ones, shows that girls in the mixed-sex schools are slightly but significantly more likely than their single-sex counterparts to choose the majors in question. The study shows further that though boys are generally well disposed to the physical and applied sciences, those in the single-sex schools are more inclined to be so. Thus, so far as this sample is concerned, single-sex schooling tends to predispose boys to the physical and applied sciences, whereas in the case of girls, mixed-sex schooling is the case.

The results of this study suggest an element of curricular specialisation in the schools. Whereas the all-male schools appear to concentrate on the sciences, the all-female schools appear to concentrate on non-science subjects. The mixed-sex schools appear to lie in-between.

I am inclined to suspect that owing to apparent curricular biases in the schools, able boys who believe in their science ability, and who are optimistic that they will find science-related jobs, tend to be encouraged by parents and teachers to choose the apparently selective all-male schools, whereas less able boys interested in science tend to be encouraged to choose mixed-sex schools. Similarly, since all-female schools apparently tend to be non-science biased, girls wishing to choose science tend to choose mixed-sex schools.

I am of the view that there is no inevitable or universal effect of the sex composition of the school on students' selection of colleges majors, since this obviously depends on the context and content of the schooling. Surely, given a liberal curriculum, a good number of female science teachers to serve as role models, and more importantly, an equitable distribution of the facilities for science teaching and learning, gender and sex-compositional effects will hardly be relevant. Thus, if Ghana, and for that matter other African countries, are to increase their human resource development in the area of science and technology, then they must do well to follow more liberal curricula, so as to enable boys and girls to avail themselves of the opportunities for studies in science and technology.

Slightly linked to the above is the fact, as shown by this study, that the fathers of those students in the single-sex schools are better educated than the fathers of those in the mixed-sex schools. This suggests that students in the single-sex schools come from higher-status backgrounds. This is not surprising. Through Western education, the basis of the stratification system in many African countries has been education credentials. Those who had the initial advantage of this new education thus became the elite, and to reproduce themselves as a class, they had to educate their children to acquire skills and abilities required for an effective elite cloning.

In a dynamic society, however, some skills and talents tend to lose their relative importance over time. Naturally, therefore, the elite have to adapt themselves to social change by sending their children to schools with curricula leading to placement in influential positions in the economy. This is because their children's attendance in such schools, and their participation in such curricula, are the guarantees of elite-cloning. I am inclined to believe that this explains the large representation of children of well educated parents in the single-sex schools. Thus, as already pointed out, the pursuance of more liberal curricula, coupled with a fair distribution of resources for the teaching and learning of science, are the surest means of ensuring that all boys and girls, irrespective of the sex composition of the schools they attend, and irrespective of their family background, can study science if they have interest in it.

Consistent with previous studies, this study shows that self-concept of ability, previous grades, social support, and mother's education are reliable predictors of the intention to choose physical and applied science majors. One unique factor that previous studies in Africa have failed to touch on, however, is students' appraisal of the chances of obtaining jobs in the fields of science and technology, as a condition for their intention to choose their majors from these subjects areas. This study shows that as a rational actor, a student will decide to choose a major if he or she is certain that job opportunities in the field are, or will be available. This underscores Blaug's (1972) maxim that, far from being irrational in their educational decisions, African students correctly appraise the actual job opportunities available. The message conveyed in this finding is that as they make efforts to accelerate human resources development in science and technology, African countries must at the same time, do well to create the avenues for job generation in these areas. Thus, unless the economies of African countries are diversified to create suitable jobs for those majoring in the sciences and applied sciences, students' apparent lack of interest in the sciences may persist and the human resource development bottlenecks in the field of science and technology will also persist. Furthermore, unless more females are encouraged to participate in science, human resource development in science and technology will continue to lack the right male-female mix.

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