RELATIONSHIPS AMONG SIX VARIABLES OF SOME JAMAICAN ELEVENTH-GRADERS AND THEIR PERFORMANCE IN BIOLOGY

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This study was designed to ascertain if (a) the level of biology performance of the selected 393 Jamaican 11th-graders (188 boys, 205 girls) - who constituted the main study's sample - was satisfactory or not; (b) there were statistically significant differences in their performance linked to their gender, attitudes towards biology, learning styles, school-type, school location, and socioeconomic background (SEB); and (c) there were significant relationships among the six independent variables and their performance on the test. Data were collected with three instruments. The participating students were selected from 15 rural and urban high schools. The results indicated that their biology mean score (21.61 or 45.02%) was unsatisfactory because it was below the conventional 50% pass mark of their schools; there were statistically significant differences in their biology performance based on their attitudes to biology, learning styles, school-type, school location, and SEB in favour of students (a) with highly positive attitudes to biology, (b) with convergent learning style, (c) in mixed schools, (d) in urban schools, and (e) from a high SEB respectively; there were positive, statistically significant but weak relationships among their biology performance and their attitudes to biology, SEB, learning styles, school-type and school location.

INTRODUCTION

Scientific literacy has received much attention in several nations including the USA (American Association for the Advancement of Science, 1989), Britain (Langksch & Spargo, 1996) and China (Wang, Wang, Zhang, Lang, & Mayer, 1996). In recognition of the importance of scientific literacy, the Jamaican Government, in its recent reform of primary school curriculum, has included science assessment as a part of the national assessment of primary school children (Lofters, 1998). Over the years, in many parts of the world, schools are expected to ensure that students acquire a high level of scientific literacy (the ability to use scientific knowledge to explain natural and artificial phenomena and everyday life experiences) with less emphasis on low scientific literacy (i.e. factual knowledge about natural and artificial phenomena). This is because traditionally, low level scientific literacy is used in educating the majority of the school population to prepare them for 'low-level' manual jobs, while high level scientific literacy is used to educate an elite minority group which qualifies those in this group for highly specialized, often exclusive careers. But, despite the worldwide emphasis on scientific literacy, evidence from several nations indicates that many high school students have a low knowledge of science and perform poorly in the subject (e.g., Forrest, 1992; Third International Mathematics and Science Study, TIMSS, 1997). In Jamaica, from 1990 to 1998, the majority of students who sat the Caribbean Examinations Council's (CXC) secondary education certificate general proficiency examinations (SECGPE) in biology, chemistry and physics failed the subjects. This was because the mean percentages of those who passed (i.e. obtained grades 1 and 2) in the subjects were 21, 36 and 34 respectively (The Planning Institute of Jamaica, 1998).

Among the numerous variables that are linked to high school students' low science knowledge and performance are their gender,

attitudes to science, learning styles, school-type, school location, and socioeconomic background (SEB). Yet, the findings of many studies conducted on the links among these variables and students' science performance are conflicting. For instance, while many studies have documented gender differences in high school students' performance in mathematics and science tests in favour of males (e.g., Edwards & Soyibo, 2003; Forrest,1992; TIMSS,1997), a few studies have recorded no gender differences in students' science performance (e.g., Beaumont-Walters & Soyibo, 2001; Clayton-Johnson, 1993; Edwards & Soyibo, 2003; Esiobu & Soyibo, 1995; Field,1998; Greenfield, 1996; McCulloch & Soyibo, 2003). Jegede and Okebukola (1991) found that Nigerian 10th grade male students statistically significantly outperformed their female peers in biology. Whiteley (1994) recorded statistically significant gender differences in the 1992-1993 CXC's SECGPE in biology among 11th grade Jamaican students in favour of male students, whereas Soyibo (1999) reported that 11th grade female students in Barbados, Belize, Jamaica, Trinidad, St Lucia and St Vincent statistically significantly outscored their male counterparts on a biology test. Furthermore, whilst Soyibo (1997) recorded statistically significant gender differences in some Jamaican preservice high school science teachers' biology performance in favour of the females, Bloomfield (2004) found not significant gender differences in the biology performance of Jamaican grade 12 (A-level) students (n = 360). However, Evans (1999, 2001) reported that over the last 15 years, Jamaican female students have markedly outperformed their male peers in all school subjects at the primary and secondary levels.

Whereas many studies (e.g., Keeves & Morgenstern, 1992; Freedman,1997), have reported, low, positive, but statistically insignificant relationship between students' attitudes to science and science achievement, some have recorded, positive, statistically significant relationship between students' attitudes to biology and biology achievement (e.g., Edwards & Soyibo, 2003, r = .51 Field,

1998, r = .46; Soyibo & Hudson, 2000, r = .43; Thorpe & Soyibo, 1999, r = .30), and students' attitudes to integrated science and performance in the subject (e.g., Stockhausen & Soyibo, 2004, r = .70). On the other hand, some studies have found no relationship between students' attitudes to biology and biology performance (e.g., Crooks & Soyibo, 2002; Dobson,1994; McCulloch & Soyibo, 2003), attitudes to chemistry and chemistry performance (e.g., Bucknor & Soyibo, 2001; Thompson, 2000), and attitudes to integrated science and their performance in the subject. (e.g., Soyibo & Pinnock,1998). Some studies (e.g., Holden & Yore, 1996) have shown that students who were taught science based on their cognitive or learning styles (i.e. preferred learning tendencies and strategies) achieved statistically significantly higher in science than those students who were mismatched with their learning styles. But other studies (e.g., Ahiakwo,1991) reported no significant relationship between secondary school students' learning styles and science achievement. That male and female students in single-sex high schools significantly outachieved male and female students in mixed schools in science tests had been reported in many studies (e.g., Field, 1998; Forrest, 1992). But some studies have reported that students in mixed high schools significantly outscored their peers in all-boys' and all-girls' schools in biology tests (e.g., Bloomfield, 2004; Soyibo, 1981) and in integrated science test (e.g., Soyibo & Pinnock ,1998). While many studies have demonstrated that urban students often significantly outperformed their rural counterparts in science (e.g., Dobson, 1994; Phinn, 2005; Science Education Committee, 1999; Soyibo, 1992; Stockhausen & Soyibo, 2004; Young, 1997), a few studies have reported the reverse situation (e.g., Field, 1998; Swire, 1992). Furthermore, several studies have shown that students from a high SEB significantly outperformed their counterparts from a low SEB in science (e.g., Fijgin, 1995; Phinn, 2005; Tamir, 1989; US Department of Education,1994), whereas a few studies found no significant differences in students' science

achievement linked to their SEB (e.g., Bloomfield, 2004; Houtz, 1995; Soyibo & Pinnock, 1998; Thorpe & Soyibo, 1999).

PURPOSE OF THE STUDY

Considering the foregoing review, this study sought to establish if (a) selected Jamaican 11th graders' level of performance on a biology test was satisfactory or not; (b) there were any statistically significant differences in the students' biology knowledge linked to their gender, attitudes towards biology, learning styles, school-type, school location, and SEB; and (c) significant relationships existed among these six independent variables and the students' biology performance.

The following are the specific research questions for this study.

1. Was the students' level of performance on a biology test satisfactory or not ?
2. Were there any statistically significant differences in the students' biology performance based on their gender, attitudes to biology, learning styles, school-type, school location, and SEB?
3. Were there any statistically significant relationships among the students' gender, attitudes to biology, learning styles, school-type, school location, and SEB and their biology performance?

METHODOLOGY

Research Design

As the study was aimed at finding out if there were significant differences in the students' performance on the biology test (the dependent variable) that might be linked to differences in their gender, attitudes to biology, learning styles, school-type, school

location, and SEB (the independent variables), an *ex post facto* research design was employed (Wiersma, 1995).

SAMPLE

The main study's sample comprised 393 students (188 boys, 205 girls) in grade 11 (mean age = 16 years 8 months) from intact classes in 15 randomly selected traditional high schools in Jamaica. Intact classes were engaged (a) so as not to disrupt the normal schedule of the classes and (b) because the numbers of students studying biology in some of the schools were so small that all of them had to be involved in this study. Of the students sampled, 205 were chosen from 7 urban schools (2 all-girls', 2 all-boys', and 3 mixed schools) and 188 were from 8 rural schools (2 all-girls', 2 all-boys', and 4 mixed schools). The pilot students were 123 eleventh-graders chosen from three (one rural and two urban) high schools. Traditional high schools in Jamaica are the long-established 'grammar-school-type' post-primary institutions offering primarily academic-oriented curricula although some technical/vocational subjects are offered as electives.

INSTRUMENTATION AND PROCEDURE

The three instruments used for data collection are described below.

Attitudes to Biology Questionnaire (ABQ) This consisted of 25 items, adapted from Soyibo and Pinnock (1998). The adaptation involved changing the term "integrated science" to "biology". Each item had 5 options while the instrument's maximum score was 125 with a Cronbach alpha coefficient of .85. The ABQ was used to measure the students' attitudes to biology. The main study students' mean score on the ABQ was 95.85 while their standard deviation was 12.16. Their lowest score was 58 while their highest score was 123. Using their mean and standard deviation, the main study's students were categorized into three groups as follows: those whose

raw scores ranged from 108 to 123 (i.e. those whose scores were 1 SD and over above the sample mean) were labelled as having highly positive attitudes to biology; those whose raw scores ranged from 84 to107 (i.e. from 1 SD below the mean) were regarded as having moderate attitudes, while those who scored below 84, were considered to have low or poor attitudes.

Learning Style Inventory (LSI) The LSI that Kolb (1984) developed, consisting of 12 items, was employed to categorize the students into four learning styles: diverger (imaginative; learns through observing and listening), assimilator (interested in abstract ideas; arranges information concisely and logically), converger (analytical; uses ideas and theories practically; can solve problems), and accommodator (learns through self-discovery; uses hands-on experience).

Biology Performance Test (BPT) This consisted of 48 multiple-choice items constructed on "living things and their environment" and " life processes" in the CXC's 1998 high school biology syllabus. It had difficulty indices of between .30 and .90, discriminating power of .50 and more, a maximum score of 48 and produced a Kuder-Richardson (KR-21) internal consistency reliability coefficient of .90, using Ebel and Frisbie's (1991) correction formula for underestimation that may characterize KR-21. The items covered the knowledge, comprehension and application levels on Bloom's (1956) taxonomy of educational objectives in the cognitive domain.

It took 75 minutes for the slowest students to complete the three instruments at a sitting during the pilot study with special attention given to the instructions on the LSI. Hence, the main study's students were allowed the same time to complete the instruments. One of the authors and four other teachers – who were specially chosen – administered the instruments as one instrument to the main study's subjects in their schools. Details of the instrumentation are available from the authors.

RESULTS AND DISCUSSION

Table 1
Students' Mean, Percentage Score and Standard Deviation on a Biology Test

Mean	Percentage	SD
21.61	45.02	9.19

Maximum score = 48 n = 393

Table 1 suggests that the students' mean score on the biology test (21.61 or 45.02%), is fairly "low". This is because it is less than 50%. Hence, the students' overall level of performance was considered as "relatively unsatisfactory". This was because in the Jamaican secondary school system, 50% is the minimum pass mark or grade C while scores from 80% and above are graded "A". The finding that the students' level of performance was low was expected as it is consistent with some previous studies' findings (e.g., Soyibo, 1999) which indicated that Jamaican high school students recorded low performances in biology in the CXC's SECGPE from 1990 to 1998 (e.g., The Planning Institute of Jamaica, 1998) and some local studies on Jamaican students' poor performance on biology tests (e.g., Bloomfield, 2004; Crooks & Soyibo, 2002; Soyibo, 1997; 1999).

Table 2
Students' Biology Means and Standard Deviations Linked to the Independent Variables

Variables		n	Mean	SD
Gender	Male	188	22.02	9.25
	Female	205	21.20	9.12
Attitudes	High	61	26.84	10.43
	Moderate	276	21.70	8.70
	Low	56	15.34	5.69
Learning styles	Convergent	151	23.92	9.60
	Assimilative	144	21.81	8.95
	Divergent	55	19.02	8.23
	Accommodative	43	16.00	6.05
School-type	All-girls	99	18.90	8.12
	All-boys	99	19.92	8.18
	Mixed	195	23.81	9.64
School location	Rural	188	20.28	8.65
	Urban	205	22.80	9.50
SEB	High	137	24.73	10.43
	Low	256	19.91	8.54

The second purpose of this study was to find out if there were statistically significant differences in the students' biology performance linked to differences in their gender, attitudes to biology, learning styles, school-type, school location, and SEB. Their means and standard deviations based on the six independent variables were computed (Table 2). The table's data indicate that the (a) means of the males and females are similar; (b) mean of students with highly positive attitudes to biology is higher than the means of students with moderate and low attitudes to biology; (c) mean of students using convergent learning style is the highest, followed by means of students using the assimilative and divergent

learning styles while the mean of students using the accommodative learning style was the lowest; (d) mean of students from the mixed schools is higher than the means of students from all-girls' and all-boys' schools; (e) mean of students in urban schools is slightly higher than that of those from rural schools; and (f) mean of students from a high SEB is slightly higher than that of their peers from a low SEB. To confirm if the differences in their means were statistically significantly different based on the six variables, a 6-way analysis of variance (ANOVA) was computed (Table 3).

Table 3
Summary of 6-Way Analysis of Variance in Students' Biology Performance Attributable to Six Variables

Source of Variation	df	MS	F
Gender	1	14.177	0.219
Attitudes	2	969.216	14.999***
Learning styles	3	277.167	4.289**
School-type	2	838.268	12.972***
School location	1	234.667	3.631*
SEB	1	1245.793	19.279***

*$p < .05$ **$p < .01$ ***$p < .001$

The data in Table 3 indicate that there are statistically significant differences in the students' biology performance linked to their attitudes to biology, learning styles, school-type, school location, and SEB, while there are no statistically significant gender differences in their performance. A close look at Table 2 suggests that the significant differences are in favour of (a) students with highly positive attitudes to biology, (b) students with the convergent learning style, followed by those with the assimilative, divergent and accommodative learning styles respectively, (c) students in the mixed schools, (d) students in urban schools, and (e) students from a high SEB. The absence of statistically significant gender differences

in the students' mean scores suggest the minor numerical difference in their means could have occurred by chance.

The absence of statistically significant gender differences in the students' performance in the biology test administered in this study was not surprising. This was because some local studies have reported the absence of significant gender differences in Jamaican students' performance in biology (e.g., Bloomfield, 2004; Field, 1998; McCulloch & Soyibo, 2003). This study's finding therefore conflicts with the findings of many previous studies which had documented gender differences in students' biology performance (e.g., Forrest, 1992; Jegede & Okebukola, 1991; Soyibo, 1997, 1999; TIMSS, 1997). The finding that students who displayed highly positive attitudes towards biology performed significantly better than their counterparts who showed moderate and low attitudes towards biology was expected. This is consistent with the findings of some previous local studies (e.g., Field, 1998; Soyibo & Hudson, 2000; Thorpe & Soyibo, 1999) and international studies' findings (e.g., George & Kaplan, 1998; Houtz, 1995) that students who displayed positive attitudes towards science significantly outperformed their counterparts with negative or mediocre attitudes. The finding that students using the convergent and assimilative learning styles did significantly better than their counterparts using the divergent and the accommodative learning styles receives some indirect support from Katz (1988) who suggested that biology students showed a preference for the convergent learning style and Willcoxson and Prosser's (1996) prediction that science students would display a preference for the convergent and assimilative learning styles. It, however, conflicts with Thorpe and Soyibo's (1999) finding that learning styles did not account for any significant difference in their subjects' science achievement.

That male and female students in the mixed schools significantly outperformed their peers in the single-sex schools supports the findings of some previous studies regarding students' biology performance (e.g., Ijatuyi & Babalola, 1984; Soyibo, 1981) and integrated science performance (e.g., Soyibo & Pinnock, 1998) but conflicts with the findings of some previous studies (e.g., Bloomfield, 2004; Edwards & Soyibo, 2003; Field, 1998; Forrest, 1992). The finding that the urban students performed significantly better than their rural peers is consistent with many previous studies' findings (e.g., Dobson, 1994; Phinn, 2005; Science Education Committee, 1999; Soyibo, 1992; Stockhausen & Soyibo, 2004; Young, 1997), but conflicts with the findings of a few local studies (e.g., Field, 1998; Swire, 1992). The finding that students from a high SEB significantly outperformed their counterparts from a low SEB supports the findings of several previous studies (e.g., Fijgin, 1995; Tamir, 1989; US Department of Education, 1994).

The third purpose of this study was to establish if there were statistically significant relationships among the six independent variables and the students' biology performance. Poin-biserial correlation test was utilised in this study as the six independent variables belong to nominal or categorical scale. Three of the variables (gender, school location and SEB) show genuine dichotomies, while the remaining three variables (attitudes to biology, school type and learning types) had three, three and four categories respectively (Guilford & Fruchter, 1978: 308). Table 4 displays the computed point-biserial coefficients.

Table 4
Point-biserial Correlation Coefficients Relating Students' Biology Performance to Gender, Attitudes to Biology, Learning Styles, School-Type, School Location, and Socioeconomic Background

	Gender	Attitudes	Learning styles	School type	School location	Socio economic background
Biology score	.04	.34*	.21*	.24*	.14*	.25*

*$p < .01$

Table 4 data indicate that there is a positive, statistically significant but weak relationship between the students' biology performance and their (a) attitudes to biology, (b) learning styles, (c) school-type, (d) school location, and (e) SEB. The table also shows that there is no relationship between the students' gender and their biology performance. These findings confirm the data in Tables 2 and 3 discussed earlier. The weak relationships suggest that there were other variables apart from the students' attitudes to biology, learning styles, school-type, school location, and SEB which could have accounted for the differences in their biology performance that were not investigated in this study. Such variables - which should be identified and explored in future studies on this topic -include the differences in the students' cognitive abilities, subject preference, and their teachers' qualifications, teaching experience and teaching styles.

CONCLUSIONS AND IMPLICATIONS

This study is significant because we are not aware of any previous studies that had investigated the links among the six independent variables and 11th graders' performance in biology either in the Anglophone-Caribbean or elsewhere. As the students' biology test mean score was 21.61 (45.02%), their performance was considered

to be relatively low or poor. This was in spite of the fact that the test was based on two relatively "simple" introductory sections of their biology syllabus that they had been taught in grade 10. But as expected, students with highly positive attitudes to biology statistically significantly outscored those with "moderately" positive and poor attitudes to biology. This finding suggests that Jamaican 11th graders' biology teachers should endeavour to foster and sustain their students' "highly positive" attitudes to biology to improve their "poor" and "moderately positive" attitudes to the subject in order to motivate and inspire their students to make concerted efforts to learn biology thoroughly. To attain these goals, the biology teachers of the likes of this study's students need to use a variety of student-centred instructional strategies (including hands-on, inquiry-based approaches, e.g., Bucknor & Soyibo, 2001; Freedman, 1997, and the constructivist learning model, e.g., Yager, 1992), which these researchers and others had employed to facilitate and improve students' attitudes to science and science achievement. This suggestion is pertinent because the lecture method is the principal method of science instruction in most Jamaican high schools (Science Education Committee, 1999; Soyibo, 1998).

The finding that students who exhibited the convergent learning style statistically significantly outscored their counterparts who displayed the assimilative, divergent and accommodative learning styles, implies that Jamaican 11th graders' biology teachers should be aware of and pay attention to the differences in their students' learning styles. These teachers need to utilize a variety of teaching and learning modes (including the constructivist learning model) to cater for their students' different learning styles. For example, while the use of the lecture and teacher demonstration methods might be effective in teaching students using the diverging and assimilatory learning styles, the use of hands-on, inquiry-oriented teaching approaches may be suitable for students using the converging and accommodative learning styles.

The finding that students in the mixed schools statistically significantly outperformed their counterparts in all-boys' and all-girls' schools is not surprising. This is because this study's finding is consistent with the finding of some previous studies (e.g., Soyibo, 1981; Soyibo & Pinnock, 1998) but conflicts with the findings of many previous studies (e.g., Field, 1998; Forrest, 1992) that males and females in single-sex high schools tended to significantly outscore their male and female counterparts in mixed schools in science. But the probable reasons for the superior performance of the mixed schools' students in this study were not evident from this study's data. For example, further analyses showed that the mixed schools' boys' and girls' mean scores were not statistically significantly different.

The finding that the urban students performed significantly better than their rural peers was expected. This might be due to the fact that urban high schools in Jamaica, unlike rural high schools, are usually more equipped for science teaching and enjoy the services of the more experienced and better qualified science teachers (Science Education Committee,1999; Soyibo & Johnson, 1998). Hence, to enable rural Jamaican 11th graders to perform as well as their urban counterparts in biology, the Jamaican Ministry of Education and Culture should ensure the equitable distribution of science teachers and science teaching facilities in both its urban and rural high schools, while their biology teachers should endeavour to use a variety of student-friendly teaching approaches mentioned earlier. This point is crucial because as stated earlier, the lecture method is commonly used to teach science in most Jamaican high schools. Yet, many studies have shown that the use of activity-based instructional strategies not only improved students' attitudes to science but also their science achievement (e.g., Bucknor & Soyibo, 2001; Soyibo & Hudson, 2000; Thompson, 2000; Yager, 1992).

The finding that students from a high SEB did significantly better than those from a low SEB implies that the parents/guardians of the former might have been more supportive of their children/ward than the latter (e.g., Tamir, 1989). Consequently, the parents/guardians of both type of students need to provide their children/ward with the necessary educational materials, academic stimulation and generally suitable home milieu that are likely to motivate them to study biology and other school subjects at home so that they could do well not only in biology but also in other subjects. The finding that there were no statistically significant gender differences in the students' biology performance implies that Jamaican female 11th- graders could perform as well as their male peers on the biology topics tested in this study. To improve the performance of the likes of this study's students on the biology topics investigated regardless of their gender, attitudes to biology, learning styles, school-type, school location, and SEB, their biology teachers need to use different student-friendly instructional strategies mentioned earlier that are likely to encourage their students to be responsible for their own learning (e.g., Bucknor & Soyibo, 2001; Freedman, 1997; Yager, 1992).

Note that relationship does not imply causality in this study. Consequently, five of the six variables in respect of which there were significant differences in the students' biology performance were not assumed to be the actual causes of the observed differences. Another limitation of this study was its relatively small sample size. Although the study's sample was not representative of the entire Jamaican grade 11 biology students even in all the traditional high schools, we are of the view that the main findings of this study are likely to be true of significant numbers of 11th-grade biology students in many other Jamaican traditional high schools who could not be sampled for this investigation. Hence, future studies on this topic should try to engage representative samples so that their findings could be generalised to the relevant entire populations.

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