

## **CORRELATIONS AMONG FIVE VARIABLES AND THE BIOLOGY PERFORMANCE OF A SAMPLE OF JAMAICAN HIGH SCHOOL STUDENTS**

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*This study investigates whether or not (a) 252 Jamaican high school students (168 boys, 84 girls, 171 grade 10 and 81 grade 11 students) had favourable attitudes to biology, (b) their level of biology performance was satisfactory, (c) there were significant differences in their performance based on their gender, grade level, school-type, socioeconomic background (SEB), and attitudes to biology, and if there were significant correlations among the five variables and the students' performance in biology. The subjects were selected from four traditional high schools: two all-boys', one all-girls', and one coeducational school, all in Kingston, Jamaica. Two instruments—an attitudes to biology questionnaire and a biology performance test—were used for data collection. The findings indicated that many of the students had highly favourable attitudes to biology; their level of biology performance was fairly good and satisfactory; there were statistically significant differences in their performance related to their (a) gender in favour of the boys, (b) grade level in favour of the 11<sup>th</sup>-graders, (c) school-type in favour of all-girls' school, and (d) attitudes to biology, in favour of students with highly favourable attitudes to biology; and there were positive, statistically significant but weak correlations among the students' gender, grade level, and attitudes to biology and their biology performance.*

## INTRODUCTION

Several studies have focused on students' academic performance in science because, despite the best endeavours of good teachers, many students fail to understand many of the central concepts in the natural sciences (Pfundt & Duit, 1994). The Caribbean Examinations Council (CXC) (2002) reported that only 18.7% of the 3,779 Jamaican students who wrote the secondary education certificate general proficiency examination (SECGPE) in biology obtained the passing grades of I, II, and III. The CXC's biology examiners' reports (1987-2002) indicated that, annually, most Caribbean high school students who sat the biology examinations demonstrated a lack of understanding of many concepts in the biology syllabus, and resultantly perform poorly in the biology examinations. That this situation is not peculiar to the Caribbean receives some corroboration from the observation of the Corporation for Public Broadcasting (1996), cited in Pearsall, Skipper and Mintzes (1996), that even many students who graduated from the finest institutions in the USA experienced severe difficulties in understanding many biological concepts and consequently performed poorly in the discipline.

One of the justifications for this study was that many researchers (Andrade, 1997; Johnstone & Mahmoud, 1980; Friedler, Amir, & Tamir, 1987; Soyibo, 1981; Westbrook & Marek, 1991) have shown that cells, diffusion, osmosis, modes of feeding and photosynthesis were among the biology concepts that students found difficult to understand. From the authors' teaching experiences at the high school level, these are concepts that are taught at both the lower and higher grades in high schools, and, still present cognitive difficulties to many students. This situation is a cause for concern as these concepts form a part of the core concepts in the CXC's biology syllabus for grade 11 students.

The findings from several studies on learner variables that may be related to high school students' science performance are conflicting. These variables include the differences in students' gender, grade level, school type, SEB, and attitudes to science.

Although many studies have shown that male high school students significantly outperformed their female counterparts in science and mathematics tests (Forrest, 1992; Third International Mathematics and Science Study, TIMSS, 1997; Whiteley, 1995), there are inconclusive findings on gender differences in high school students' performance in biology. While Okeke and Ochuba (1986) found no gender differences in Nigerian 11<sup>th</sup>-graders' biology performance, Jegede and Okebukola (1991) reported that Nigerian 10<sup>th</sup> grade male students significantly outperformed their female peers in biology. With respect to Caribbean students, Soyibo (1999) reported that 11<sup>th</sup> grade female students in Barbados, Belize, Jamaica, Trinidad, St Lucia, and St Vincent, significantly outscored their male counterparts on a biology test, whereas Whiteley (1995) recorded statistically significant gender differences in the 1994 CXC's SECGPE in biology among Barbadian, Jamaican, and Trinidad and Tobago 11<sup>th</sup>-graders in favour of males. However, Clayton-Johnson (1999) and Field (1998) recorded no gender differences in Jamaican grades 10 and 11 students' biology performances.

It is expected that students' scientific conceptions and performance improve with their age (Trowbridge & Mintzes, 1985). Nonetheless, there are conflicting findings on the relationship between differences in students' ages or grade levels and their performance in biology. With 100 students each in their samples of 7<sup>th</sup>-grade life sciences students, 10<sup>th</sup>-grade biology and college zoology students, Westbrook and Marek (1992) reported that the students' understanding of the concept of homeostasis increased across the grade levels. On the other hand, Westbrook and Marek (1991), with 100 students each in their samples comprising 7<sup>th</sup>-

graders (of life sciences), 10<sup>th</sup>-grade biology students, and college zoology students, found that none of the answers that the students gave indicated a complete understanding of the concept of diffusion they explored. In a study involving 173 first, second and third year students in all Jamaican teachers' colleges, Soyibo (1997) discovered that while the first year students had significantly better knowledge of errors in biological haracte than the second and third year students, there was no significant difference in the knowledge of the second and third year students on the haracte test. One possible explanation for these conflicting findings relating to grade level differences in students' performance in biology could be that various biological concepts present different cognitive challenges to students regardless of their grade level.

In this study, school-type refers to single-sex high schools that only boys or only girls attended, and co-educational or mixed high schools were schools that both boys and girls attended. Though research findings on the science performance of students attending different types of schools suggest that school-type is linked to differences in students' science performance, the results are mixed. Jules and Kutnick (1990) discovered that 35% of variance in Trinidad and Tobago's students' science scores was attributable to school effects (i.e. school-type, school district and class level). Whilst Clayton-Johnson (1999) reported that Jamaican 11<sup>th</sup>-graders in mixed schools significantly outperformed their peers in all-girls' and all-boys schools on a biology test, Forrest (1992) revealed that in several countries and over a period of 70 years, all-girls' schools achieved significantly better science results than all-boys' schools. Again, Hamilton (1985) found that Jamaican 11<sup>th</sup>-graders in all-boys' and all-girls' schools performed significantly better on a science test than those in mixed schools. Yet, Field (1998) reported no significant difference in the biology performance of Jamaican 10<sup>th</sup>-graders she tested in all-boys', all-girls', and mixed schools. Many of the

Jamaican single-sex high schools are older than the co-educational ones. They had established the modus operandi of assisting students in their schools to obtain satisfactory results including the benefit of strong church and trust funds which provide them with the needed financial and technical support. In contrast, most of the mixed schools were government-aided and lacked many of the resources that could assist them in improving their students' academic performance. Research findings on school-type and students' performance are so conflicting that whereas some researchers have proposed single-sex teaching in mixed schools (Forrest, 1992; Harvey & Stables, 1986), the American Association of University Women (1992) posited that the separation, rather than removing inequity which existed in the school system, would make it worse.

Many studies have shown that students from a high socioeconomic background (SEB, i.e. those whose parents/guardians are relatively educated or are rich) tend to perform better in science than their counterparts from a low SEB (i.e. students whose parents/guardians are uneducated and have low income) (e.g. Fleming & Malone, 1983; Tamir, 1989). However, some studies have recorded mixed findings. While Field (1998) and Clayton-Johnson (1999) reported significant differences in Jamaican grades 10 and 11 students' biology performance in favour of those from a high SEB, Ugwu (2001) found no significant differences in the performance of Jamaican 8<sup>th</sup>-graders on nutrition and plant reproduction based on their SEB.

Many studies have documented the existence of a low, positive correlation between high school students' attitudes to biology and performance in biology (e.g. Clayton-Johnson, 1999; Field, 1998; Ugwu, 2001), while some have found no relationship between students' attitudes to biology and their biology performance (e.g. Dobson, 1994). Indeed, a growing body of research suggests that

good teaching and an overall teacher quality are the critical determinants of students' attitudes to science and science achievement (e.g. Woolnough, 1994).

## **RATIONALE FOR THE STUDY**

Considering the foregoing review of the literature, another justification for this study was to find out the extent to which there were any significant differences in selected Jamaican high school students' performance on a biology test linked to differences in their gender, grade level, school type, SEB and attitudes to biology. This decision was considered worthwhile because, as stated above, many studies have reported conflicting findings on differences in students' biology performance based on these five variables. However, we are not aware of any single study that had explored the five variables in respect of high school students' performance on a biology test that tested their understanding of the concepts of cells, diffusion, osmosis, photosynthesis and modes of feeding.

## **PURPOSE OF THE STUDY**

This study therefore sought to find out if (a) the level of performance of selected Jamaican grades 10 and 11 students' on these five concepts was satisfactory or not; (b) their attitudes to biology were favourable or not; (c) there were significant differences in their performance on the biology test linked to differences in their gender, grade level, school type, SEB and attitudes to biology; and there were significant correlations among the five independent variables and their biology performance.

## **METHODOLOGY**

### **Research Design**

As the study sought to determine if there were significant correlations among the students' gender, grade level, school-type, SEB and attitudes to biology (called the independent variables) and their performance on the biology test (the dependent variable) an *ex post facto* research design was employed (Weirisma, 1995).

### **Sample**

The main study's sample consisted of 252 students selected from four randomly traditional high schools in Kingston, Jamaica: two all-boys' schools, one all-girls' school, and one mixed school. Table 3 displays the detailed composition of the main study's sample based on the five variables. The mean age of the 10<sup>th</sup> graders was 15 years, while that of the 11<sup>th</sup> graders was 16 years.

## **INSTRUMENTATION AND PROCEDURE**

The Biology Performance Test (BPT) that we developed, and the Attitudes to Biology Questionnaire (ATBQ) that we adapted from Soyibo and Pinnock's (1998) attitudes to science questionnaire, were used to collect the study's data. The BPT consisted of 40 multiple choice items with four options per item. The items were based on the following five concepts: cells, diffusion, osmosis, photosynthesis and modes of feeding, selected from section B of the CXC's (1998) biology syllabus. Using a test table of specifications, the items tested not only the students' knowledge of the concepts but also their ability to comprehend, apply, and analyse based on Bloom's (1956) taxonomy of educational objectives in the cognitive domain. The ATBQ consisted of 25 items adapted from Soyibo and Pinnock's (1998) for measuring students' attitudes to science. The adaptation involved changing the word "science" in each of the original 25

items to “biology”. Each item had five options. Each of the 12 positive items was scored 5 to 1, while each of the remaining negative items was scored 1 to 5. The maximum score was 125. With a pilot sample of 38 grade 10 students and 12 grade 11 students, the Cronbach alpha coefficient of the ATBQ was .89, while the BPT yielded a Kuder-Richardson

KR-21 internal consistency reliability coefficient of .85. using Ebel and Frisbie’s (1991) correction formula for underestimation which may characterize KR-21. We considered the two instruments to have satisfactory reliability because Miller (1991) stated that reliability coefficients ranging from .80 to 1.0 depict ‘very strong reliability’. The BPT’s facility / difficulty indices ranged from 0.30 to 1.0 and are regarded as acceptable in educational research (Ebel & Frisbie, 1991). The pilot subjects’ BPT mean was 25.72 and SD = 6.56. These were similar to the main study’s subjects mean = 25.46, and SD = 6.32. Likewise, the pilot subjects’ ATBQ mean = 96.08, and SD = 15.90 are comparable to those of the main study’s mean = 94.43, and SD = 14.04 respectively. The ATSQ and, then, the BPT were administered at the same sitting to the main study’s subjects in January 2001 within 60 minutes. Grades 10 and 11 students were tested in this study because the five biology concepts explored in this study are usually taught formally in grade 10 in Jamaican high schools and are expected to be taught in fairly high depth.

Table 1  
*Frequency Distribution, Mean and Standard Deviation of Students’ Biology Test Scores*

Score	Frequency	%	Mean	SD
8 - 19	42	16.67		
20 - 32	178	70.63	25.46	6.32
33 - 39	32	12.70		

Maximum score = 40

## RESULTS AND DISCUSSION

The first purpose of this study was to determine whether or not the performance of the students on the biology test was satisfactory. Table 1 reveals that the students' raw scores range from 8 (20%) to 39 (98%) and that their mean score 25.46 (64%) could be considered as fairly good. In addition, because 210 (83%) of the students scored between 20(50%) and 39(98%), while 132 (52%) of them scored above the mean (i.e. between 27 and 39), their performance was deemed to be fairly good and satisfactory. This finding is not surprising although it is inconsistent with the findings of many local researchers (e.g. Andrade, 1997; Clayton-Johnson, 1999; Dobson, 1994) who reported that Jamaican high school students performed poorly in the biology tests they administered to them. Among the factors that could have contributed to the students' fairly satisfactory performance in this study was that many of them excelled in the common entrance examinations (CCE) that were used to select them into the traditional high schools in 1996 and 1997. It was the norm that primary school students who scored the highest marks were preferentially admitted into the traditional high schools while those who scored lower marks were sent to the new secondary schools now called upgraded secondary schools. Traditional high schools are "grammar school" type of secondary school where the curriculum emphases are on the mastery of academic subjects with less emphasis on technical and vocational education which receive fairly high emphasis in the upgraded secondary schools. Additionally, the sampled traditional high schools were located in the capital city where the more experienced and better qualified biology teachers were often found and many of the students had access to extra lesson programmes. These programmes are offered, after school hours and on Saturdays, to students whose parents/guardians can pay in addition to the official tuition fees that the Jamaican Government charges every student.

The study's second purpose was to find out if the students' attitudes to biology were favourable or not. An analysis of their ATBQ showed that their scores ranged from 46 (37%) to 120 (96%), their mean = 94.43 (75.54%) and standard deviation = 14.04; about 140 (56%) of them scored above the mean, while 247(98%) of the students scored between 63(50.40%) and 120 (98%). On the bases of these data, we inferred that the majority of the students had favourable attitudes to biology. The students were grouped into three attitudes categories: those whose raw scores were between 95 and 120 (i.e. above the mean) were regarded as having highly favourable attitudes to biology; those whose scores ranged between 80 and 94 (i.e. one standard deviation below the mean) were categorized as having 'moderately favourable' attitudes to biology; while the others (with scores between 46 and 79) were considered to have 'low' attitudes to biology (Table 2).

Table 2  
*Categorisation of Students Based on Their Attitudes to Biology*

Categories	n	Raw scores	%
High	140	95 - 120	55.55
Moderate	75	80 - 94	29.76
Low	37	46 - 79	14.68

Maximum score = 125

Table 2 further indicates that because 215 (85.32%) of the students' exhibited highly and moderately favourable attitudes to biology, it is sensible to conclude that the majority of them had favourable attitudes towards biology. This study's finding receives some indirect support from the findings of some local researchers (e.g. Andrade, 1997; Clayton-Johnson, 1999; Field, 1998) who reported that most of the Jamaican high school students they studied displayed favourable or positive attitudes towards biology. As many

of this study's subjects exhibited favourable attitudes towards biology, we expected them to perform fairly well in the BPT administered to them.

The third 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, grade level, school type, SEB, and attitudes to biology. Table 3 shows the means and standard deviations of the students based on the five variables.

Table 3  
*Means and Standard Deviations of Students' Biology Scores by Gender, Grade Level, School Type, Socioeconomic Background and Attitudes to Biology*

Variable	n	Mean	SD
<b>Gender</b>			
Males	168	26.03	6.42
Females	84	24.32	6.00
<b>Grade Level</b>			
10	171	24.46	6.31
11	81	27.58	5.84
<b>School type</b>			
All-boys'	127	25.65	6.66
All-girls'	43	25.86	6.01
Mixed	82	24.95	5.98
<b>Socioeconomic background</b>			
High	148	25.65	6.49
Low	91	25.68	5.84
<b>Attitudes to biology</b>			
High	140	26.02	6.02
Moderate	75	25.35	6.27
Low	37	23.57	7.44

Table 3 suggests that (a) the mean of the females is slightly lower than that of the males; (b) the mean of the 11-th-graders is much higher than that of the 10<sup>th</sup>-graders; (c) the mean of the all-girls' school is slightly higher than that of all-boys' and mixed school students; (d) the mean of students from a high SEB and those from a low SEB are similar; and (e) the mean of students with highly favourable attitudes to biology is slightly higher than that of students with moderately favourable and low attitudes respectively. The standard deviations are relatively high in all cases suggesting that there were fairly high variations in the scores of the high and low scorers on the ATSQ. To find out if there were statistically significant differences in the students' mean scores based on the five independent variables, a 5-way analysis of variance was computed (Table 4).

Table 4  
*Analysis of Variance in Students' Biology Performance by Gender, Grade Level, Socioeconomic Background, School Type and Attitudes to Biology*

Source of Variation	SS	df	MS	F
Gender	298.892	1	298.892	8.619**
Grade level	603.069	1	603.069	17.391***
SEB	2.755	1	2.755	0.079
School type	376.256	2	188.128	5.425**
Attitudes to biology	292.967	2	146.483	4.224*
Explained	1255.330	7	179.333	5.172
Residual	8010.219	231	43.676	
Total	9265.548	238	38.931	

\* p < .05    \*\* p < .01    \*\*\* p < .001

Table 4 indicates that there are significant differences in the students' performance on the biology test linked to their gender, grade level, school type, and attitudes to biology, while there is no significant difference in their performance based on their SEB. It is evident from Table 3 that the significant differences are in favour of the males, the 11<sup>th</sup>-graders, students from all-girls' schools followed by all-boys' and mixed schools, and students with highly favourable attitudes to biology.

We found the finding that the males significantly outperformed the females surprising. This was because from our high school biology teaching experiences and from research findings (e.g. Evans, 2001; Soyibo & Whiteley, 1996), Jamaican female students in the primary and secondary schools are, in general, much more conscientious in their school work than their male counterparts. Nevertheless, this study's finding is consistent with the findings of many previous studies (e.g. Soyibo & Akintola, 1985; Jegede & Okebukola, 1991; Whiteley, 1995) which had documented statistically significant gender differences in high school students' biology performance in Nigeria, and the Caribbean respectively, in the male students' favour in both cases. But the finding conflicts with the findings of some studies (e.g. Soyibo, 1999; Whiteley, 1994), which showed that Caribbean grade 11 female students significantly outperformed their male peers in biology, and a few studies (e.g. Clayton-Johnson, 1999; Field, 1998) which recorded no gender differences in Jamaican grades 10 and 11 students' biology performance.

The finding that the 11<sup>th</sup>-graders performed significantly better than the 10<sup>th</sup> graders was expected. This is because the former have had more exposure to the subject area than the latter and would have had other academic skills such as increased, cognate science vocabulary (e.g. Walker, 1989) which was likely to have given them an edge over the 10<sup>th</sup>-graders on the biology test. This study's

finding, therefore, supports the findings of some earlier studies (e.g. Dobson, 1994; McCulloch & Soyibo, 2003; Westbrook, 1992), but conflicts with the findings of Soyibo (1997) and Westbrook and Marek (1991a) reviewed earlier.

The finding that students in the all-girls' school performed significantly better than their counterparts in the all-boys', and mixed schools respectively, is not surprising. This is consistent with the finding of Forrest (1992) that, in several nations, and over a period of 70 years, all-girls' schools' students' science performances were superior to that of all-boys' schools. However, this study's finding contradicts the findings of Clayton-Johnson, (1999), and Ijatuyi and Babalola (1984), that students in mixed schools significantly outperformed their peers in all-boys' and all-girls' schools in biology. It is equally inconsistent with the finding of Field (1998) that there was no significant difference in the biology performance of Jamaican 10<sup>th</sup>-graders she tested in all-boys', all-girls', and mixed schools.

We expected the finding that students with highly favourable attitudes to biology performed significantly better than those with moderately favourable attitudes and low attitudes respectively. This was because many studies had recorded the existence of a low, positive correlation between high school students' attitudes to biology and performance in the subject (Clayton-Johnson, 1999; Field, 1998; Ugwu, 2001). It is, however, in conflict with some studies that found no relationship between students' attitudes to biology and their biology performance (e.g. Dobson, 1994).

The authors did not expect the absence of a statistically significant difference in the students' biology performance linked to their SEB recorded in this study. This was because we had expected the students from a high SEB to have done significantly better than their counterparts from a low SEB in accord with the findings of Clayton-Johnson (1999) and Field (1998) cited earlier regarding the

biology performance of Jamaican grades 10 and 11 students respectively. On the other hand, this study’s finding receives some indirect support from Thorpe and Soyibo’s (1999) finding that there was no significant difference in Jamaican preservice primary school teachers’ knowledge of science based on their SEB. One possible explanation for this study’s finding came from Thorpe and Soyibo (1999) who noted that, in Jamaica, there were cases where parents/ guardians with “poor” educational background and low income (low SEB) strove hard to invest in their children’s education so that they could achieve academic excellence like the children of highly educated and financially well-to-do parents/ guardians (high SEB). Such a scenario was likely to be the case in this study.

*Table 5  
Point-biserial Correlation Coefficients Relating Students’ Gender, Grade Level, School-type, Socioeconomic Background and Attitudes to Science to Biology*

	Gender	Grade Level	School-type	SEB	Attitudes
Biology Score	.13*	.23**	.05	.00	.13*

The fourth purpose of this study was to find out if there were significant correlations among the students’ gender, grade level, school-type, SEB, and attitudes to biology and their performance on the biology test. The point-biserial correlation coefficients computed (Table 5) indicated that there was a positive, statistically significant relationship between the students’ (a) gender and biology performance, (b) grade level and biology performance, and (c) attitudes to biology and biology performance, while there was no relationship between their (d) school-type, and (e) SEB and their biology performance in each case. The findings that there were significant relationships among the students’ gender, grade level and attitudes to biology and their biology performance are consistent with the findings in Table 4 discussed earlier.

Nonetheless, the findings that there was no relationship between the students' school-type and their biology performance conflicts with the data in Table 4, while the finding that there was no correlation between their SEB and their performance confirms the finding in Table 4 discussed above.

## **CONCLUSIONS AND EDUCATIONAL IMPLICATIONS**

The students' level of performance in the biology test was considered to be fairly good and satisfactory. This implies that many of them displayed a fairly good understanding of the five concepts tested. The students' satisfactory performance was likely to be attributable to the relative effectiveness of the instructional methods their teachers used to teach them. This finding is noteworthy because many previous studies (e.g. Andrade, 1997; Friedler, Amir, & Tamir, 1987; Soyibo, 1981; Westbrook & Marek, 1991b), have shown that many students tended not to perform well on the concepts tested (e.g. diffusion, osmosis and photosynthesis). We, therefore, recommend that Jamaican Grades 10 and 11 biology teachers (and their counterparts in other nations) should endeavour to use a variety of student-centred, practical-oriented instructional strategies to teach their students the five concepts tested in this study to enhance their students' understanding and performance on them. This is because some studies (e.g. Thompson & Soyibo, 2002; Ugwu, 2001) have shown that students taught science with student-centred or activity-based instructional strategies tended to do significantly better than those taught with the lecture method.

It was evident from this study that students who showed highly favourable attitudes to biology significantly outperformed their counterparts who displayed moderately favourable and low attitudes to biology respectively. Hence, Jamaican Grades 10 and 11 biology teachers should employ a variety of student-friendly teaching techniques to teach their students the subject so as to

nurture and sustain their favourable attitudes towards biology in order to improve their biology performance. This was because as shown in this study and the literature (e.g. Clayton-Johnson, 1999; Field, 1998; Ugwu, 2001), students who had highly favourable attitudes to biology tended to perform well in the subject than their peers who had less favourable attitudes.

As the male students significantly outperformed their female counterparts, the authors recommend that Jamaican grades 10 and 11 biology teachers in the coeducational schools should use gender-fair teaching strategies to ensure that both genders perform equally well in the subject.

The finding that the 11<sup>th</sup>-graders significantly outperformed their 10<sup>th</sup>-grade counterparts could be due to the fact the former were generally cognitively more mature and probably had more time to assimilate the concepts tested than the latter. This point seems pertinent because, as mentioned earlier, in Jamaica, the five topics tested in this study are usually taught in grade 10. Consequently, we recommend that biology concepts scheduled to be taught in grade 10 must be fully and thoroughly taught at this level because it may not be possible for biology teachers to teach them again in grade 11.

The differences in the students' SEB did not engender any significant difference in their biology performance. This suggests that if students from both low and high SEBs receive adequate academic stimulation and support in their homes, they are likely to do fairly well not only on the biology concepts tested in this study but on other related abstract biology concepts.

The findings that there were positive, statistically significant but with weak correlations among the students' gender, grade level and attitudes to biology and their biology performance suggest that there were other variables besides these three which could have accounted for the differences in the students' biology performance, but which

were not investigated in this study. Such variables, which should be identified and explored in future studies on this study's concepts, include the differences in the students' cognitive styles, cognitive abilities in biology and the English language, subject preference, self-esteem, school location, teachers' teaching qualifications and teaching experience.

Note that the independent variables were not presumed to be the actual causes of the significant differences recorded in the students' performance in this investigation. However, there seemed to be some links or relationships among the five independent variables and the students' biology performance. But relationship does not imply causality (Soyibo & Pinnock, 1998). The limitations of this study included the small sample size, and its unrepresentativeness, and our inability to match the subjects with respect to their intellectual abilities and learning styles or in terms of their teachers' qualifications, teaching experience and teaching strategies, and the non-inclusion of other school types such as technical and new secondary/upgraded high schools. These limitations notwithstanding, this study's findings are likely to be true of students in many of the other Jamaican traditional high schools.

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