RELATIONSHIPS AMONG JAMAICAN NINTH-GRADERS' VARIABLES AND PERFORMANCE IN INTEGRATED SCIENCE

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This study assessed the level of integrated science performance of 200 Jamaican ninth-graders (100 boys, 100 girls), and determined if there were significant differences in their performance linked to their gender, attitudes to science, school location and student-type. A science achievement test and attitudes to science questionnaire were used for data collection. The subjects were selected from two rural and two urban schools in Jamaica. The results indicated that the students' level of science performance was barely 'average'; there were significant differences in their science performance based on the four variables in favour of females, students with highly positive attitudes to science, urban students and students in the Reform of Secondary Education (ROSE) schools; while the relationship between their science performance and gender (r = ,30, p < .01) and school location ($r = .13$, $p < .05$), was positive, statistically significant but weak respectively, the relationship between their performance and their attitudes to science ($r = .70$), and student-type ($r = .64$) was positive, statistically significant and 'strong' (Miller, 1991).

INTRODUCTION

Over the years, the Caribbean Examinations Council's (CXC) reports have indicated that Jamaican 11th graders' annual performances in the Secondary Education Certificate Examinations (SECE) at the General Proficiency (GP) level in biology, chemistry and physics were poor. For instance, Jamaican students' mean percentage passes in biology, chemistry and physics in CXC's SECE (GP) from 1990 to 1996 were 29.03, 42.25, and 35.49 respectively, and 49.60, 45, and 37.30 respectively from 1998 to 2000; their mean percentage pass in integrated science (single award) from 1990 to 1995 was 39.23 while it was 88 in 2001. This latest result represents a marked improvement in Jamaican 11th graders' performance in integrated science at the GP level.

Nonetheless, a search in the literature reveals that only relatively few studies have been conducted on Jamaican 7th-9th graders' performances in integrated science most of which indicated that the students' performances were poor. For example, Swire (1992) reported that the integrated science mean score of the 7th-graders she tested was low. Dobson (1994) found out that the understanding of nutrition and reproduction in animals and plants that Jamaican grade 9 students (n = 253) and Jamaican Grade 11 students (n = 269) exhibited was low while, the knowledge that the former displayed on each of the two concepts was significantly but not substantially lower than that of the latter. Soyibo (1992) and Beaumont-Walters and Soyibo (2001) rated Jamaican (a) 7th graders' performance on a test of six science process skills, and (b) 9th graders' (n = 146) and 10th graders' (n= 159) performance on five integrated science process skills, respectively, as barely "average". Clayton-Johnson (1993) reported that more than two-thirds of the 393 Jamaican 8th-graders she tested scored "average" marks in integrated science. Rainford (1997) discovered that 156 Jamaican Grade 7 students' performances on the science content and science process skills tests she administered to them were low. Both Soyibo and Johnson's (1998) investigation involving 1,008 Grade 7 and 992 Grade 8 Jamaican students, and Soyibo and Pinnock's (1998) study on the knowledge of 180 Jamaican 11-th-graders on six integrated science concepts revealed that the students' performances in both cases were dismal. Recently, Ugwu (2001) reported that 932 Jamaican grade 8 students he tested in 14 schools performed poorly on nutrition in animals and plants and plant reproduction. But, Soyibo and Evans (2002) reported that 80 Jamaican 9th-graders, who were taught human nutrition using Johnson and Johnson's (1999) 'Learning Together Model' (LTM) – a cooperative learning strategy – significantly out-achieved their counterparts (n = 76) taught with the lecture method.

Many variables have been associated with students' poor understanding of science and their low levels of performances in science examinations. Among the students' variables are their gender, attitudes to science, school location and student-type. But there are conflicting findings on the links among these variables and students' knowledge of science and performance in science.

Several studies have recorded gender differences in high school students' performances in mathematics and science tests in favour of males (e.g. Forrest, 1992 citing examination results for over 70 years in several countries and at different ages; Third International Mathematics and Science Study, TIMSS, 1997 in 45 nations), while a few studies have recorded no gender differences in students' science performance (e.g. Greenfield, 1996). Many studies carried out in Jamaica recorded no gender differences in students' integrated science performance (e.g. Beaumont-Walters & Soyibo, 2001; Clayton-Johnson, 1993; Hall-Gaynor, 1999; Rainford, 1997; Soyibo & Johnson, 1998; Soyibo & Pinnock, 1998; Ugwu, 2001). On the other hand, while Swire (1992) reported significant gender differences in Jamaican 7th-graders' science performance in the females' favour, Soyibo and Evans (2002) recorded a statistically significant gender difference in Jamaican Grade 9 students' performance on human nutrition in favour of the males. Nonetheless, Evans (2001) reported that, over the last 15 years, Jamaican female students markedly outperformed their male peers in all school subjects at all levels of education and that the inability of many Jamaican male primary and secondary school students to read materials written in the English language and the harsh treatment teachers meted out to them were among the major causes of their underachievement in schools. That this scenario is likely to be true of many other Anglophone-Caribbean countries was evident in Kutnick's (2000) similar findings about students' academic performance in selected primary and secondary schools in Barbados, St Vincent and Trinidad.

Whereas many studies have reported the existence of a low, positive relationship between students' attitudes to science and science achievement (e.g. Clayton-Johnson, 1993; Freedman, 1997; Ugwu, 2001), some have reported that there was no relationship between students' attitudes to science and their integrated science performance (e.g. Nneji, 1985; Soyibo & Pinnock, 1998). A growing body of research suggests that good teaching and an overall teacher quality are the major determinants of students' attitudes to science (e.g. Woolnough, 1994). In this context, Osborne and Simon (1996) stated that the likely effects of weak or inadequate teaching were the generation of negative attitudes to science of primary school students, which were enduring and very difficult to change.

Literature suggests that a great diversity is found in both the teachers' knowledge of subject matter and in teaching across districts (Good, 1987) and that urban schools are better equipped in terms of staff and teaching facilities than their rural counterparts (Rainford, 1997; Science Education Committee, 1999; Soyibo & Johnson, 1998). It is not surprising then that many studies have demonstrated that urban students significantly outperformed their rural peers in science tests (e.g. Rainford, 1997; Science Education Committee, 1999; Soyibo, 1992; Soyibo & Pinnock, 1998; Young, 1997) while a few studies have reported the reverse situation (e.g. Swire, 1992).

In this study, student-type refers to two groups of subjects: those who used the Reform of Secondary Education (ROSE) Grade 9 integrated science curriculum (called ROSE students) and those who used the traditional Grade 9 integrated science curriculum (called nonROSE students). As a part of the ROSE project, which was started in 34 Jamaican pilot schools in 1993, new curricula for grades 7-9 were developed in six subjects areas: mathematics, language arts, social studies, integrated science (IS), resource technology, and career education. Grades 7-9 ROSE and non-ROSE students use the same textbook and IS curricula that are identical in content and philosophy, but, in practice, the former are given the opportunity to perform practical tasks more than the latter (Soyibo & Johnson, 1998).

The few studies that have compared ROSE and non-ROSE students' science performance showed that the former significantly outperformed the latter. For example, a study that the Jamaican Ministry of Education conducted, revealed that ROSE students showed greater improvements in their post-test performance on science knowledge compared with the control students (Reform of Secondary Education Secretariat, 1996). Soyibo and Johnson (1998) reported that Jamaican Grades 7 and 8 students (n = 1,115) following the ROSE's IS curriculum, significantly outperformed their non-ROSE counterparts (n = 885) in a science test. Beaumont-Walters and Soyibo (2001) reported that Jamaican Grades 9 and 10 ROSE students (n = 164) significantly outperformed their non-ROSE peers (n = 141) on five integrated science process skills, while Wilson (1998) found out that Jamaican grade 9 ROSE students (n = 70) significantly outachieved their non-ROSE counterparts (n = 70) on a science test.

Note that while Soyibo and Johnson (1998) selected their sample from 23 all-age, comprehensive and traditional high schools, and

Beaumont-Walters and Soyibo's (2001) subjects were chosen from 4 comprehensive and four traditional high schools, Wilson (1998) selected her sample from four coeducational comprehensive high schools. In Jamaica, prior to the abolition of the common entrance examination (CEE) in 1998, 95% of the students who were admitted into the long-established 'traditional' high school (formerly called 'grammar schools') passed the CEE at age 10 or 11 years, while 5% were admitted on the school principals' discretion. But, only some of the students who were admitted to the comprehensive high schools (founded in the 1970s as junior secondary schools) passed the CEE, while the majority gained admission by 'age promotion from feeder schools' once they were 12 years old (UNESCO, 1983). In short, many Jamaican traditional high school students are generally cognitively superior to their all-age, and comprehensive high school counterparts. More information is provided about the all-age and junior high school students sampled in this study under *Sample* below.

PURPOSE OF THE STUDY

In light of the foregoing review, this study sought to find out (a) the level of performance of selected Jamaican 9th-graders on an integrated science test, (b) if there were significant differences in their performance linked to their gender, attitudes to science, school location, and student-type; and (c) if there were significant relationships among these four variables and the students' science performance.

SAMPLE

The main study's sample consisted of 200 students (100 boys and 100 girls) in Grade 9 (aged 14-15 years) selected from a parish in Jamaica. Fifty students per school were randomly selected from two junior high schools (one urban, one rural) using the ROSE integrated science curriculum and two all-age schools (one urban, one rural) that were not using the ROSE integrated science curriculum.

As stated earlier, the CEE was abolished in 1998. It was replaced with the grade-six achievement test (GSAT). The GSAT, like the CEE, is designed to select the more brilliant students into the traditional high schools with a strong bias towards academic education and the "academically weak ones" into other categories of high schools that do not focus primarily on students' academic education. In this study, the junior high school students were students who failed the CEE used to select students into the traditional high schools. The junior high school students in this study therefore had to spend a year in primary six before they were allowed to start the junior high school programme which is still in operation in Jamaica up till today. These students may stay in school until they reach grade 11 when they are expected to sit the Jamaican secondary school certificate examination, while some of them go into the technical high schools at age 15 years. Some of the holders of the Jamaican secondary school certificate, through private study, later sit for the CXC's SECE at the GP level and go for higher education, while many of them end up learning some trade skills that would enable them to earn a living. Similarly, all-age schools are post-primary schools to which students who failed the CEE or scored low grades in the GSAT are sent instead of the traditional high schools. At age 15, all-age school students sit the grade 9 achievement test at the end of which some of them go to learn specific crafts training skills that the Human Employment and Resources Training (HEART) Trust/NTA offers. For many of them, their Grade 9 education programme is the end of their formal education. Hence, some end up as apprentices to private trades persons like tailors, road-side motor mechanics, auto-electricians, barbers, cement block-makers or messengers.

Considering the foregoing scenarios, this study's subjects were cognitively less able than their traditional high school counterparts and seemed to be intellectually matched when they commenced their all-age and junior high school education programmes. Hence, any significant differences that were observed in their science performance in this study were likely to be partly attributable to the differences in their teachers' qualifications and teaching experience, science content knowledge and teaching styles, among other factors, which we could not manipulate or control.

All the four teachers who taught the students in the four schools sampled for this study were females. The two science teachers in the two junior high schools, had 7 and 8 years teaching experience and were holders of the Jamaican teachers' college diploma who were trained to teach biology, chemistry, and physics in grades 7-11. On the other hand, the two teachers of the all-age school students were untrained teachers each of whom had three years teaching experience. Whereas the teachers of the junior high school students were specialist science teachers, their all-age counterparts were generalists who taught their students all school subjects including science. In sum, the junior high school students in this study were taught by the more qualified and more experienced teachers than their all-age peers.

INSTRUMENTATION AND PROCEDURE

Two instruments were used for data collection. A 25-item attitudes to science questionnaire (ATSQ) adopted from Soyibo and Pinnock (1998) was used to measure the students' attitudes to science. Each item had five options. The 12 positively worded items were scored 5-1, while the 13 negatively worded items were scored 1-5. With a pilot sample of 30 students selected from two schools, the ATSQ's Cronbach alpha coefficient was 0.76, and a maximum score of 125. The pilot students' mean score was 95.43 and the standard deviation was 14.83.

To assess the students' understanding of six of the science concepts, which they had been taught, a science achievement test

(SAT) consisting of 42 multiple choice items was used. Each item had four options. The concepts tested were: sense organs, central nervous system, endocrine system, atoms and molecules, elements, mixtures and compounds, and chemicals in living things. Using a table of specifications, the items covered the knowledge, comprehension and application levels on Bloom's (1956) taxonomy of educational objectives in the cognitive domain. The SAT's difficulty / facility indices ranged from 0.30 to 0.70, and are regarded as acceptable in educational research (Ebel & Frisbie, 1991). It had a discrimination power of more than .40 and a maximum score of 42. The SAT yielded a Kuder-Richardson (KR-21) internal consistency reliability coefficient of .84 using Ebel and Frisbie's (1991) correction formula for underestimation. KR-21 formula was used because the SAT items were dichotomously scored (i.e. either "right" or "wrong" (Gay & Airasian, 2003, p. 144). We considered the ATSQ and SAT to highly reliable because Miller (1991) labelled test instruments with reliability coefficients of between .60 and .80 as having 'strong reliability' and those with reliability coefficients of between 0.80 and 1.0 as displaying 'very strong reliability'. Details about the instrumentation are available from the authors.

It took 20 minutes for the subjects to complete the ATSQ and 50 minutes to finish the SAT at the same sitting. The main study students were categorised into three attitudes to science groups shown in Table 1. The sample mean was 80, and SD was 16; the highest score was 121, while the lowest was 43. Students who scored between 88 and 121 (i.e. half of the SD above the mean) were labelled as showing 'highly positive' attitudes to science; those who scored between 68 and 87 (i.e. three-quarters of the SD below the mean) were considered as displaying 'moderate' attitudes; whilst those who scored below 68 were regarded as showing 'poor' attitudes to science.

RESULTS AND DISCUSSION

Table 1
Science Test Means and Standard Deviations By Gender, Attitudes to Science, School Location and Student-type

Variable	n	Mean	SD
Gender			
Males	100	22.76	5.92
Females	100	26.01	5.96
Attitudes to science			
High	68	27.26	6.32
Moderate	70	19.48	5.83
Poor	62	14.10	4.43
School location			
Urban	100	25.41	5.65
Rural	100	23.42	5.20
Student-type			
ROSE	100	26.99	6.52
NonROSE	100	21.83	4.93

Sample's science test Mean = 24.41 SD = 5.59

Table 1 suggests that the students' overall mean score (24.41 or 58.12%) is barely "average" because it is just above half (21 or 50%) of the maximum score (42) on the SAT. To find out if there were statistically significant differences in the students' mean scores based on the four variables in Table 1, a 4-way analysis of variance was computed (Table 2).

Table 2
A 4-way Analysis of Variance in Students' Means By Gender, School Location, Student-type and Attitudes to Science

Source of variation	SS	DF	MS	F
Gender	69.865	1	69.865	4.476*
Location	108.045	1	108.045	6.922**
Student-type	362.242	1	362.242	23.209***
Attitude	2097.198	2	1048.599	67.184***
2-Way Interactions				
Gender x Location	4.057	1	4.057	0.260
Gender x Student-type	8.665	1	8.665	0.555
Gender x Attitude	24.176	2	12.088	0.774
Location x Student-type	19.701	1	19.701	1.262
Location x Attitude	12.745	2	6.373	0.408
Student-type x Attitude	145.672	2	72.836	4.667**
3-Way Interactions				
Gender x Location x Student-type	4.828	1	4.828	0.309
Gender x Location x Attitude	11.203	2	5.602	0.359
Gender x Student-type x Attitude	9.313	2	4.657	0.298
Location x Student-type x Attitude	87.499	2	43.749	2.803
4-Way Interactions				
Gender x Location x Student-type x Attitude	29.392	2	14.696	0.942
Explained	4774.362	23	207.581	13.300***
Residual	2746.993	176	15.608	
Total	7521.355	199	37.796	

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

Table 2 indicates that there are significant differences in the students' performance linked to all the four variables. It is evident from Table 1 that these are in favour of (a) the females, (b) students with highly positive attitudes towards science followed by those with moderate attitudes and, lastly, those with poor attitudes, (c) urban students, and (d) ROSE students. These results imply that the females significantly outperformed the males; students with highly positive attitudes to science significantly outachieved those with moderate and poor attitudes respectively; the urban students performed significantly better than their rural peers while the ROSE students scored significantly higher than their non-ROSE counterparts. Table 2 also shows that there are statistically significant interactions between the subjects' attitudes to science and student-type. This suggests that students in the ROSE (junior high) schools who had highly positive attitudes to science did significantly better in the SAT than their counterparts in the nonROSE (all-age) schools.

The finding that the females statistically significantly outperformed the males in the science test was surprising. This is because it conflicts with many previous studies' findings (Beaumont-Walters & Soyibo, 2001; Clayton-Johnson, 1993; Forrest, 1992; Rainford, 1997; TIMSS, 1997; Soyibo & Johnson, 1998; Soyibo & Pinnock, 1998; Soyibo & Evans, 2002; Ugwu, 2001). It, however, receives an indirect support from Swire's (1992) finding in respect of Jamaican 7th graders' science performance and the findings of Evans (1999, 2001). The finding that students with highly positive attitudes to science significantly outscored their peers with moderate and poor attitudes was expected. But it is inconsistent with the findings of some previous studies which showed that there were no differences in students' performance in integrated science despite the differences in their attitudes to science (Nneji, 1985; Soyibo & Johnson, 1998; Soyibo & Pinnock, 1998).

That urban students performed significantly better than their rural counterparts in this study is not surprising. It is consistent with the findings of many previous studies (Rainford, 1997; Science Education Committee, 1999; Soyibo, 1992; Soyibo & Pinnock, 1998;

Young, 1997) all of which attributed the differential performance to the fact that urban schools, unlike rural schools, usually enjoyed the services of experienced and qualified teachers and better teaching facilities and resources. That ROSE students did significantly better than their non-ROSE peers was also expected. It is consistent with the findings of the few previous studies that compared ROSE and non-ROSE students' cognitive achievement in science tests (Beaumont-Walters & Soyibo, 2001; Reform of Secondary Education Secretariat, 1996; Soyibo & Johnson, 1998; Wilson, 1998). Among the probable reasons why ROSE students did much better than their non ROSE peers in this study are that ROSE science teachers usually undergo a two-week course designed to train them in the use of the project's student-driven methodologies and curriculum materials; five teacher educators supervise their lessons and give them feedback; and ROSE students are allowed to do more practical activities than non-ROSE students (Soyibo & Johnson, 1998). Moreover, as stated earlier, the junior high school students—who were the ROSE students in this study - were using the ROSE science curriculum, while their all-age counterparts, the nonROSE students, were not. Again, the ROSE students' teachers had a better teaching qualification and more teaching experience than the non-ROSE teachers.

Point bi-serial correlation coefficients were computed to find out if there were any significant relationships among the four independent variables and the students' science scores. The results indicated that there was a positive, statistically significant but weak relationship between the students' (a) gender and science performance ($r = .30$, $p < .01$), (b) school location and science performance ($r = .13$, $p < .05$), while the relationship between their science performance and (c) attitudes to science ($r = .70$, $p < .01$) , and (d) student-type ($r = .64$, $p < .01$) constitutes 'strong reliability' in each case, based on Miller's (1991) categorisation stated earlier. These findings support the data in Table 2 discussed earlier. The weak relationships suggest that there were other variables that were likely to have been strongly associated with the differences in the students' science performance besides the students' gender and school location which this study did not investigate. Such variables, which future studies on this topic should explore, may include differences in the students' cognitive abilities, subject preference, learning styles, teachers' qualifications, teaching experience and teaching styles.

CONCLUSIONS AND IMPLICATIONS

The finding that the females' science performance was significantly better than that of the males implies that Jamaican 9th grade science teachers in junior high and all-age schools need to find practical ways of motivating and encouraging their male students to develop highly positive attitudes to science so that they can perform well in the subject like their female counterparts. This suggestion is pertinent because as stated earlier, in this study, the girls had significantly better science performance and attitudes towards science than the boys. Moreover, Evans (1999) reported that boys underachieved than girls in many Jamaican primary and secondary schools because most boys were (a) in the low streamed classes and obtained low grades, (b) unable to read and so found school punishing, (c) not interested in academic work, (d) alienated by the teaching methods, (e) beaten and insulted by their teachers, and (f) treated harshly for violations of gender codes.

The results indicating that students with highly positive attitudes to science significantly outperformed their peers with moderate and poor attitudes to science and that urban students' science performance was significantly superior to that of their rural counterparts have implications for the training and distribution of science teachers and the provision of science teaching facilities in Jamaican high schools. To motivate more Jamaican 9th-graders in junior high and all-age schools to have highly positive attitudes to science so that they can perform well in the subject, the Jamaican Government needs to train more highly qualified science teachers who are competent in using effective teaching strategies that are likely to enable their students to have highly positive attitudes to science and perform well in the subject. In addition, there must be an equitable distribution of such teachers and the needed science teaching facilities and materials to urban and rural schools.

That ROSE students' performances in the science test was significantly better than that of their non-ROSE counterparts implies that the ROSE science curriculum and ROSE teacher training programme appeared to have had some salutary impacts on the ROSE students' performances. To improve Grade 9 ROSE and non-ROSE students' attitudes to science and science performance, Jamaican grade 9 science teachers need to give their students ample opportunities to carry out worthwhile hands-on and minds-on activities. This suggestion seems germane because some studies have implicated the predominant use of the lecture method in the teaching of science as one of the principal causes of students' low science performance at all levels of education in Jamaica (Evans, 2001; Science Education Committee, 1999; Soyibo & Johnson, 1998).

It should be noted that the independent variables were not assumed to be the real causes of the significant differences documented in the students' attitudes to science and science performance in this study. This is because relationship does not imply causality (Soyibo & Pinnock, 1998). Among the limitations of this study were the authors' inability to match the students sampled in terms of their cognitive abilities and school- type, or in terms of their teachers' qualifications and teaching experience, the small sample size, and the fact that the sample was not representative of either the Jamaican junior high school or the all-age school populations. Future studies on this topic should engage other types of high schools with a view to ensuring the representativeness of samples from each school type and other independent variables. Despite this study's limitations, its findings are likely to be true of a significant number of Jamaican junior high and all-age school students, who, as explained earlier, are generally academically weak

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