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Affective Domain Progression in Single-Sex and Coeducational Schools

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Abstract Students who study science in single-sex and coeducational schools have attracted lots of attention from the education community. However, changes to students' attitudes toward science as they progress to higher grades in these schools are not clearly understood. The aim of this study was to compare the changes in attitudes toward science among lower secondary students (Grade 7 to Grade 9) in single-sex and coeducational schools in Brunei. A cross-sectional survey design was used to collect data from 1,034 students. Despite a significant nonlinear decline in attitudes toward science from Grade 7 to Grade 9, the attitudes remained positive. This decline in attitudes toward science was at a minimum for students in the coeducational school, and it followed the following order: single-sex boys > single-sex girls > coeducational students. The decline was independent of the initial perceived values of the students' attitudes, and it followed different trends when the data of the same-sex students from single-sex and coeducational schools were compared. Male students from the SSB school had more chances for significant decline as they progressed from Year 7 to Year 9. Brunei and countries with similar intentions to expand single-sex and coeducation school systems can target communication between single-sex and coeducation schools so they may learn from each other to improve the effectiveness of science teaching and learning processes. We expect that academics and administrators can benefit from the results of this study to guide their secondary science education policies, curriculum reforms, and teaching practices.

Keywords Attitudes · Gender education · Science · Secondary single-sex education

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Single-sex versus coeducation education has been debated from various angles for over a decade now. The majority of research is based on the effect of school type on students' achievement, including the minimization of gender differences in achievement, and has produced mixed results (Demers & Bennett, 2007; Younger & Warrington, 2002). George (2000), after reviewing the literature, reported a dearth of longitudinal studies on attitudes toward science. Our literature review supports that this dearth of research is true for both single-sex and coeducational schools. Research has concentrated on the advantages and disadvantages of these schools and their impacts on students attitudes toward science (George, 2000; Kaplan, 2009; Scantlebury & Baker, 2007); however, the long-term impact of attending these schools on students' attitudes toward science has not attracted a lot of attention.

Research on the advantages and disadvantages of single-sex education suggests that single-sex schools provide learning environments with reduced opposite-sex interference, gender bias in teachers' attention during instruction, student diversity, intergender communication and socialization, and variations in learning styles. Intragender communications within single-sex schools have been found to improve group work, friendship between students of the same sex, and student attention during learning. Moreover, these pros and cons are mostly reversed in the coeducational environment (Scantlebury & Baker, 2007; Younger & Warrington, 2002), where students are sensitive to these differences, which have the potential to influence their attitudes toward science differently. For example, research has shown that single-sex environments are intimidation free and provide girls as well as students from underprivileged groups with a sense of empowerment and confidence to ask questions in class (Scantlebury & Baker, 2007), which improves students' attitudes toward science. It is unknown, however, whether such improvements in students' attitudes toward science are maintained as students progress to higher grades in schools that have single-sex education and coeducation schools.

In addition to school learning environment, other variables, such as culture, ability, maturity, and family (e.g., Feingold, 1994; Orbay, Gokdere, Tereci, & Aydin, 2010; Osman & Halim, 2004); curriculum design (e.g., Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008); initial attitudes (e.g., George, 2000; Kaplan, 2009); and teacher, parent, and peer role models (e.g., Ewing-Cooper & Parker, 2013) influence students' attitudes toward science. Ewing-Cooper and Parker (2013) reported that role models play an important role in influencing the opinions of others; therefore, science teachers', parents', and peers' perceptions of and attitudes toward science could influence students' own attitudes toward the subject. Studies support the idea that differences in school curricula, social structure, student ability, and intake profiles between single-sex and coeducational schools could also create differences in students' attitudes toward science (e.g., Patterson, & Pahlke, 2011; Salomone, 2006).

Thus, a number of factors influence students' attitudes toward science in schools, and further research in this area would require a significant control over them. To account for the impacts of such variables on attitudes, psychologists have developed a number of theories (Cacioppo, Petty, & Crites, 1994) to explain the formation of and change in attitudes. In the present study, the theory of reasoned action (Fishbein & Ajzen, 1975), motivational approach (or balance theory; Heider, 1958), self-persuasion approach (or information-processing model; Bem, 1972), and judgmental approach (or the theory of prior experience; Hovland & Sherif, 1980) are considered and discussed with regard to

their accounts of the variations in students' attitudes toward science over time in schools that offer single-sex education or coeducation.

The limited research available in this area has revealed that the attitudes toward science of Bruneian Year 9 (age 14 years) girls and boys in single-sex schools were moderately and marginally better than those of girls and boys in coeducational school (Dhindsa & Chung, 2003). Diaconu (2010) analyzed TIMMS data and reported that New Zealand boys' and girls' attitudes toward science did not change from 1995 to 1999, but thereafter had improved by 2003 for both single-sex and coeducation schools. While accounting for school type differences in the 1999 data from New Zealand, she reported nonsignificant and significant differences for male and female students, respectively. However, for Hong Kong, none of these differences were significant. These studies represent an unclear picture of changes in attitudes toward science in these schools and lack real longitudinal research designs. However, they do support prior published research that has shown that students from different countries and cultures interact differently in single-sex and coeducational environments (Osman & Halim, 2004).

Researchers studying the association between grade level (age) and attitudes toward science have noted a decline in enthusiasm and attitudes toward science with age in coeducational schools (Pell & Jarvis, 2001; Reiss, 2004; Sorge, 2007). A decline in attitudes depends upon the initial level of the attitudes—for example, the higher the attitude, the less the decline, and vice versa (George, 2000; Kaplan, 2009). The decline in attitudes and enthusiasm with age seems particularly prevalent at the transition between elementary and middle school (Sorge, 2007). Osborne, Simon, and Collins (2003) reviewed the published research and concluded that attitudes toward science decline from age 11 onward, which is from the point of entry to secondary school. Other studies have suggested that attitudes toward science also decline during primary school (Pell & Jarvis, 2001). Contrary to the findings above, Dhindsa and Khadijah-Mohd-Salleh (2006) reported comparable attitudes toward science of Form 3 and Form 4 (14- to 15-year-old) students. Hadden and Johnstone (1983) reported that attitudes toward science did not change for students 9 years of age or older. Cheung (2009) reported that female students' attitudes toward chemistry did not decline as they progressed to higher grades. These studies suggest that (1) research indicates an inconclusive picture about the change in attitudes toward science among students as they progress to higher grades; (2) little is known about the nature of decline in attitudes toward science in single-sex schools; and (3) a sample of lower secondary science students may be more suitable to investigate changes in attitudes toward science in single-sex and coeducational schools. It is important to see what the literature says about the extent and nature of the expected changes in attitudes toward science.

The nature and extent of the changes in attitudes toward science over time have also been of concern to researchers (e.g., Barmby, Kind, & Jones, 2008; Dhindsa & Khadijah-Mohd-Salleh, 2006; Osborne et al., 2003; Yasushi, 2009). Dhindsa and Khadijah-Mohd-Salleh reported the attitudes toward science of 14- and 15-year-old students to be nonsignificantly different. Hadden and Johnstone (1983) reported no improvement in attitudes toward science from the age of 9 onward. Cheung (2009) reported a decline in attitudes toward chemistry among male students with increases in grade level, but not among female students. Girls become more mature earlier than boys, tend to have higher standards, evaluate their performance more critically, and get higher grades in science (Dhindsa & Shahrizal-Emran, 2007; Dwyer & Johnson, 1997;

Feingold, 1994). These differences between genders could be the reasons why the rates of change of attitudes toward science are different between boys and girls. Curebal (2004) reported no effect of grade level on attitudes toward science among gifted students. Osborne et al. (2003) used TIMSS data on liking of science in different countries and concluded that students' declines in their attitudes toward science may be nonlinear and accelerate rapidly after age 14 in secondary school. These studies are inconclusive and support that the nature of the decline in attitudes toward science as students increase in their grade level in single-sex schools is also not fully understood. To better understand this decline in attitudes among students in single-sex schools, at least three variables need to be investigated within a longitudinal research design. More specifically, students' attitudes toward science, the nature and extent of the decline in these attitudes, and any gender differences are worth investigating over time among students in single-sex and coeducational schools.

The above literature guided us to compare the nature and the extent of changes in attitudes toward science among lower secondary students as they progressed from Grades 7 to 9 in single-sex and coeducational schools. We selected single-sex and coeducational schools that were comparable in terms of student characteristics, school curriculum and resources, social structure, geographic location, the socio-economic backgrounds of parents and peers, and teachers' levels of teaching experience, for the purpose of minimizing the impacts of these variables, as mentioned earlier.

The objective of this study was to investigate changes in attitudes toward science among students in lower secondary single-sex versus coeducational schools. The study was intended to answer the following research questions:

1. Was the questionnaire used in this study valid and reliable to evaluate lower secondary students' attitudes toward science?
2. Did students' attitudes toward science change from Year 7 to Year 9, and what was the nature of the change?
3. How did the changes in attitudes toward science among students in single-sex schools differ from the overall change in attitudes among students in coeducation schools?
4. How did these changes compare for students of the same sex from single-sex and coeducation schools?

Method

Sample

The participants in this study consisted of 1,034 lower secondary (Year 7–Year 9) students from three schools: one single-sex boys' (SSB; $n = 283$) school, one single-sex girls' (SSG; $n = 300$) school, and one coeducational (Coed; $n = 451$: 243 male, 208 female) school. The median ages for the Year 7 ($n = 332$), 8 ($n = 365$), and 9 ($n = 337$) students were 12, 13, and 14 years, respectively. Additional details are provided in the tables as needed. The number of students selected from the Coed school was higher than the numbers of boys and girls from single-sex schools. The students in all of the schools were from families who had medium socio-economic backgrounds and lived in

the proximity of the schools. Most of these students were from Malay culture, and English was their second or third language. Each of the schools classified the students into three categories, separated into three different classes: low, medium, and high ability. A stratified sampling technique with random selection was used to select equal numbers from the low-, medium-, and high-ability classes at each grade level in each school. The students' participation in the project was voluntary.

School Characteristics

The three schools that participated in this study were government schools. The schools provided students with a free education, taught the same curriculum, and had the same admission requirements. These similarities minimized the impact of school curriculum differences and economic differences on the families of the students in these schools. The single-sex boys' and single-sex girls' schools admitted boys and girls, respectively, whereas the coeducational school admitted both genders. The daily class instructional time, numbers of science classes taught per week, holidays celebrated, and lengths of the school semesters were the same for all three schools. The entry requirements for all three schools are based only on the parents' choice of which school they wanted their child to attend. The schools were in the capital city, and each school shared its geographical boundary with the other two schools. The buildings of the schools are within a distance of about 100 m from each other, are well established, and are equally resourced. All of the science teachers were well trained and experienced.

Instrument

A number of instruments are available in literature; however, on the basis of our previous experience with using questionnaires on attitudes toward science among students 14 years of age (Dhindsa & Chung, 2003), we selected the instrument originally developed by Aiken (1979) to study attitudes toward mathematics among Iranian secondary students. Moreover, this instrument covered six dimensions of attitudes that are influenced by teaching and learning environments. The items of this instrument are written in language that is simple for students to understand and have proven to be valid and reliable in previous research (Dhindsa & Chung, 2003). In our study, this instrument was pilot tested among 146 students from another coeducational school to evaluate the suitability of its use among students in Years 7, 8, and 9. Each statement item of this instrument was presented in English with a Malay translation. The quality of the Malay translation was ensured through back-translation as well as by approval from an officially recognized translator at the national library.

The instrument covers six dimensions of attitudes toward science: enjoyment, anxiety, importance, interest, confidence, and motivation. Responses to items for each scale are measured using a 5-point Likert-type scale format (*strongly agree*, *agree*, *not sure*, *disagree*, and *strongly disagree*). *Strongly agree* was coded as 5, and *Strongly disagree* was coded as 1. The minimum score of 1 was interpreted as being highly negative and 5 as being highly positive for all scales except for anxiety toward science: Because of the nature of the anxiety items, a score of 1 was interpreted as *high anxiety* and 5 as *low anxiety*. Descriptions of the scales and representative items are reported in Table 1.

Table 1 Scale, description, and sample test items from the attitude instrument

Scale	Description	Sample Item
Enjoyment	Extent to which student enjoys a science lesson	Science is fun.
Anxiety	Extent to which student is anxious about science lesson	I am scared of science.
Importance	Extent to which student perceived science is important to everyday life and activities are worthwhile	Science is especially important in everyday life.
Interest	Extent to which student develops interest in science and its related activities	I am interest in learning science.
Motivation	Extent to which student is motivated to learn and pursue science in future	I am looking forward to doing science.
Confidence	Extent to which student is confident and successful when doing science	I am confident when doing science.

The Flesch–Kincaid Reading Ease score and grade level for the instrument are 77.9 and 4.7, respectively. These coefficients were standardized using data from native English-speaking students. Our sample consisted of students in Year 7 to Year 9 for whom English was second or third language, and the coefficient of 4.7 suggested that the instrument had a grade level more than two years below those of our students, which provided evidence that they should be able to cope with reading and understanding the statements. However, the local research suggested that the English standard for our sample was seven years below that of native speakers (Heppner, Heppner, & Leong, 1997). Therefore, it was decided to provide Malay translations alongside the English items.

Research Design and Data Collection

Two types of data collection designs have been used for evaluating a change in attitudes toward science with increased age (or grade level): longitudinal (Cheung, 2009; George, 2000; Reiss, 2004; Yasushi, 2009) and cross-sectional (Dhindsa & Khadijah-Mohd-Salleh, 2006; George, 2006). The longitudinal studies followed the same students over time, whereas the cross-sectional studies investigated the exiting students in various grades. Both types of designs have advantages and disadvantages and have produced similar results. After considering financial and time constraints, it was decided to use a cross-sectional design to collect data using our survey technique.

The questionnaires in our study were administered to the sample students by their classroom or science teacher, who was briefed by one of the researchers. The students rated each item from 1 to 5. The questionnaires were then collected by the classroom or science teacher and returned to the researchers. On the basis of the sample selection, a total of 1,178 questionnaires were distributed, and only 1,034 questionnaires (88 %) were returned to the researchers.

Data Analysis

The data were coded into an SPSS spreadsheet and analyzed to compute the scale item mean, standard deviation, t value, analysis of variance (ANOVA) results (including

post-hoc analyses), partial correlation coefficient (discriminant validity), and alpha reliability coefficient. The scale item mean was computed by averaging a student's responses to the scale items and then averaging the data for participants in the group. Effect size data (Cohen's *d*) were computed for significant differences only. We used the following criteria, from Cohen (1969), for evaluating our effect size data for this study: Below 0.20 as very low, above 0.50 as medium and above 0.80 as large.

Results and Discussion

The Cronbach's alpha of .95 for the complete attitude instrument was well above the recommended criterion of $\alpha = .70$ (Gable, 1986). The alpha coefficient values for the assessed scales in this study ranged from .78 to .84 (enjoyment, .84; anxiety, .78; importance, .83; interest, .84; motivation, .81; confidence, .84). Similar values have been reported in the literature: .68 to .81 (Dhindsa, 2005) and .61 to .90 (Jegede & Fraser, 1989), for various scales. These data support the argument that the overall instrument and its scales had satisfactory, reliable, and adequate internal consistency among the small number of items for each scale.

The mean of the absolute partial correlation coefficients of a scale with other scales was used as a convenient measure of the discriminant validity of the attitude questionnaire. The values ranged from .12 to .25 (enjoyment, .17; anxiety, .19; importance, .12; interest, .25; motivation, .21; confidence, .16). Similar values, from .12 to .22 (Dhindsa & Chung, 2003) and from 0.10 to 0.14 (Dhindsa & Fraser, 2011), have been reported in literature. The low values of discriminant validity suggest that the scales were distinct in nature, although somewhat overlapping. The results of data analyses for the instrument variables suggest that the instrument was valid and reliable for the collection of quality data to answer the research questions.

Attitude Progression in Single-sex and Coeducation Schools

The scale item mean scores on attitude scales for sample students in Year 7, Year 8, and Year 9 in all three schools are reported in Table 2. The data suggest a significant decrease in enjoyment of science in the order of Year 7 (4.36), Year 8 (4.24), and Year 9 (3.83). Similar trends were also seen in anxiety, importance, interest, motivation, and confidence toward science, suggesting that Year 7 students had more positive attitudes toward science than Year 8 and Year 9 students.

A one-way ANOVA of the overall sample data from each of the three grades indicated that the scale item mean scores for the Year 7, 8, and 9 students were significantly different ($p < .001$) for all scales. This means that at least one of the three possible comparisons for each scale (18 overall comparisons: six scales and three grade levels) should be significantly different. Post-hoc analyses using Scheffé's test revealed significant differences in the mean values of Year 7 and Year 8 students for enjoyment ($p = .01$) and anxiety ($p = .02$), and nonsignificant differences for importance ($p = .19$), interest ($p = .21$), motivation ($p = .06$), and confidence ($p = .07$). These data suggest that Year 7 and Year 8 students showed equal levels of importance, interest, motivation, and confidence toward science, whereas a significant decrease in enjoyment in learning science and an increase in science anxiety were observed from Year 7 to Year 8. The low effect sizes of 0.22 for both

Table 2 Scale item mean scores on the attitude scales for all Year 7, Year 8, and Year 9 students

Scale	Level	*N*	Mean ± *SD*	*F* Value	*p* Value	Scheffé's test		
						p7 vs. p8	p7 vs. p9	p8 vs. p9
Enjoyment	Year 7	332	4.36 ± 0.52	81.22	<.001	.01	<.001	<.001
	Year 8	363	4.24 ± 0.57			(0.22)	(0.94)	(0.70)
	Year 9	337	3.83 ± 0.60					
Anxiety	Year 7	332	3.91 ± 0.58	94.12	<.001	.02	<.001	<.001
	Year 8	362	3.78 ± 0.62			(0.22)	(1.03)	(0.78)
	Year 9	336	3.31 ± 0.58					
Importance	Year 7	332	4.26 ± 0.61	15.89	<.001	.19	<.001	<.001
	Year 8	361	4.18 ± 0.58				(0.42)	(0.30)
	Year 9	334	4.00 ± 0.63					
Interest	Year 7	332	4.06 ± 0.64	70.85	<.001	.21	<.001	<.001
	Year 8	361	3.97 ± 0.64				(0.86)	(0.71)
	Year 9	332	3.52 ± 0.62					
Motivation	Year 7	332	4.05 ± 0.62	57.43	<.001	.06	<.001	<.001
	Year 8	360	3.94 ± 0.62				(0.79)	(0.61)
	Year 9	332	3.57 ± 0.60					
Confidence	Year 7	330	4.03 ± 0.67	100.09	<.001	.07	<.001	<.001
	Year 8	359	3.91 ± 0.62				(1.02)	(0.86)
	Year 9	328	3.37 ± 0.63					

N = Number of subjects in each level. Effect sizes (Cohen's *d*) are shown in parentheses p7 vs P8 under Scheffe's test column signifies p-value for comparison between Year 7 and Year 8 data

of the significant comparisons suggest that these differences are of little educational importance. Moreover, only two out of six comparisons were significant. Hence, we concluded that the Year 8 students' attitudes toward science were statistically nonsignificantly lower than (i.e., were comparable to) those of Year 7 students. Similar analysis using Scheffé's test for the Year 8 and Year 9 data as well as for the Year 7 and Year 9 data revealed statistically significant decreases in scale item mean scores for all of the scales ($p < .001$). This means that the attitudes toward science of Year 9 students were significantly lower than those of Year 7 and Year 8 students. These data support a significant increase in anxiety and decreases in enjoyment, importance, interest, motivation, and confidence regarding science for Year 9 students as compared to Year 7 and Year 8 students, and the decrease was of educational value, as marked by medium and high effect size values. Was this trend repeated in the single-sex and coeducational schools? An answer to this question is shown in the results reported in the next section.

Coeducational School

The scale item mean scores for attitude scales for Years 7 to 9 from the coeducational school are reported in Table 3. ANOVA of the scale item mean scores for Year 7 to Year 9 students produced significant *p* values ($p < .001$) for all the scales. The significant *p* values suggest that at least one of the three possible comparisons for each scale (18

Table 3 Average scale item mean scores on the attitude scales for Year 7, Year 8, and Year 9 students in the coeducational school

Scale	Level	*N*	Mean ± *SD*	*F* Value	*p* Value	Scheffé's Test		
						p7 vs. p8	p7 vs. p9	p8 vs. p9
Enjoyment	Year 7	140	4.27 ± 0.54	28.64	<.001	.43	<.001	<.001
	Year 8	163	4.36 ± 0.57				(0.67)	(0.81)
	Year 9	146	3.89 ± 0.59					
Anxiety	Year 7	140	3.81 ± 0.61	33.70	<.001	.49	<.001	<.001
	Year 8	163	3.90 ± 0.61				(0.74)	(0.89)
	Year 9	146	3.36 ± 0.61					
Importance	Year 7	140	4.19 ± 0.57	5.78	<.001	.86	.59	<.001
	Year 8	163	4.23 ± 0.58					(0.36)
	Year 9	146	4.01 ± 0.65					
Interest	Year 7	140	3.95 ± 0.70	21.98	<.001	.40	<.001	<.001
	Year 8	163	4.05 ± 0.63				(0.56)	(0.75)
	Year 9	146	3.58 ± 0.62					
Motivation	Year 7	140	3.95 ± 0.61	16.02	<.001	.67	<.001	<.001
	Year 8	163	4.01 ± 0.60				(0.50)	(0.61)
	Year 9	146	3.64 ± 0.62					
Confidence	Year 7	140	4.01 ± 0.62	37.51	<.001	1.00	<.001	<.001
	Year 8	163	4.01 ± 0.60				(0.88)	(0.89)
	Year 9	143	3.48 ± 0.59					

N = Number of subjects in each level. Effect sizes (Cohen's *d*) are shown in parentheses p7 vs P8 under Scheffe's test column signifies p-value for comparison between Year 7 and Year 8 data

comparisons overall: six scales and three school types) should have significantly different scale item mean values. Post-hoc analyses using Scheffé's test revealed 11 out of 18 possible comparisons for the six scales were significantly different. A comparison of the scale item means in Year 7 and Year 8 for all six scales produced *p* values greater than .05. These data suggest that the scale item mean values for Year 7 and Year 8 students for all six scales were nonsignificantly different. This means the students' attitudes represented by the six scales in the coeducation school did not decrease from Year 7 to Year 8. Interestingly, the scale item mean values for Year 8 students were either equal to or larger than those for Year 7. Hence, the attitudes of Year 7 and Year 8 students represented by the six scales were comparable.

The post-hoc analysis data in Table 3 do reveal significant differences in the scale item mean values for Year 8 and Year 9 ($p < .001$). This means that the scale item mean values for Year 9 students were significantly lower than those for Year 8 students. These data suggest (a) a significant decrease in students' enjoyment, importance, interest, motivation, and confidence toward science and (b) a significant increase in anxiety. The moderate to high values of the effect sizes for all of the significant differences (except for importance in Year 8 vs. Year 9, at 0.36) suggest that these differences are of educational importance. These data reveal that students' attitudes toward science deteriorated significantly from Year 8 to Year 9. This trend was also observed for all scales (except for the importance scale) when Year 7 and

Year 9 data were compared. The scale item mean values for the importance scale were nonsignificantly different. On the basis of these data, we concluded that the students' attitudes toward science in the coeducational school did not decrease significantly from Year 7 to Year 8, but did decline significantly from Year 8 to Year 9.

Single-Sex Girls' School

The ANOVA results and scale item mean data for the six attitude scales for Years 7–9 in a single-sex girls' school are reported in Table 4. It is clear from the data that there was a decrease in enjoyment toward science from Year 7 ($M = 4.35$) to Year 8 ($M = 4.04$) to Year 9 ($M = 3.89$). Similar trends were also observed in anxiety, importance, interest, motivation, and confidence toward science. ANOVAs of the data computed $p < .001$ for all of the scales except the importance scale ($p = .24$). This means that at least one of the three possible grade-based comparisons for each of the five scales should be significantly different, whereas the importance of science data should remain comparable for all grades. Post-hoc analyses of the data using Scheffé's test produced p values less than .05 for 12 out of the 18 possible comparisons.

The effect size values for these significant differences ranged from 0.35 to 0.95, which indicated that these differences are educationally important. These data reveal a significant

Table 4 Average scale item mean scores on the attitude scales for Year 7, Year 8, and Year 9 students in a single-sex girls' school

Scale	Level	*N*	Mean ± *SD*	*F* Value	*p* Value	Scheffé's Test		
						p7 vs. p8	p7 vs. p9	p8 vs. p9
Enjoyment	Year 7	100	4.35 ± 0.53	15.47	<.001	.001	<.001	.21
	Year 8	103	4.04 ± 0.58			(0.56)	(0.76)	
	Year 9	97	3.89 ± 0.67					
Anxiety	Year 7	100	3.87 ± 0.60	20.51	<.001	.001	<.001	.04
	Year 8	103	3.54 ± 0.58			(0.56)	(0.89)	(0.35)
	Year 9	97	3.33 ± 0.62					
Importance	Year 7	100	4.20 ± 0.73	1.43	.24	.76	.62	.24
	Year 8	103	4.13 ± 0.60					
	Year 9	97	4.04 ± 0.63					
Interest	Year 7	100	4.11 ± 0.62	17.23	<.001	.04	<.001	<.001
	Year 8	103	3.87 ± 0.66			(0.38)	(0.84)	(0.46)
	Year 9	97	3.56 ± 0.69					
Motivation	Year 7	100	4.08 ± 0.67	13.43	<.001	.09	<.001	.01
	Year 8	103	3.88 ± 0.64				(0.74)	(0.44)
	Year 9	97	3.61 ± 0.60					
Confidence	Year 7	99	3.99 ± 0.63	25.57	<.001	.09	<.001	<.001
	Year 8	102	3.79 ± 0.61				(0.95)	(0.67)
	Year 9	97	3.35 ± 0.71					

N = Number of subjects in each level. Effect sizes (Cohen's *d*) are shown in parentheses p7 vs P8 under Scheffe's test column signifies p-value for comparison between Year 7 and Year 8 data

decrease in interest and increase in anxiety from Year 7 to Year 9 at each stage, whereas students' motivation and confidence were comparable for Years 7 and 8, but declined significantly from Year 8 to Year 9. Also, enjoyment of science decreased significantly from Year 7 to Year 8, but from Year 8 to Year 9 this attitude did not significantly decrease.

Single-Sex Boys' School

The scale item mean data for the six attitude scales for Years 7 to 9 in the single-sex boys' school are reported in Table 5. It is clear from the data that there was a decrease in enjoyment of science from Year 7 ($M = 4.51$), through Year 8 ($M = 4.24$), to Year 9 ($M = 3.67$). Similar trends were also seen in anxiety, importance, interest, motivation, and confidence toward science. ANOVAs of the data computed $p < .001$ for all scales. This means that at least one of the three possible comparisons for each of the six the scales (18 comparisons overall) should be significantly different.

Post-hoc analyses of the data computed p values less than .03 for 16 out of the 18 possible comparisons. The effect size values for these significant differences ranged from 0.38 to 1.85, which indicated that these differences are educationally important. These data support significant decreases in enjoyment, interest, and motivation, and an increase in anxiety from Year 7 to Year 9 at each stage, whereas no significant decrease

Table 5 Average scale item mean scores on the attitude scales for Year 7, Year 8, and Year 9 students in a single-sex boys' school

Scale	Level	*N*	Mean ± *SD*	*F* Value	*p* Value	Scheffé's Test		
						p7 vs. p8	p7 vs. p9	p8 vs. p9
Enjoyment	Year 7	92	4.51 ± 0.43	69.88	<.001	<.001	<.001	<.001
	Year 8	97	4.24 ± 0.53			(0.56)	(1.76)	(1.09)
	Year 9	94	3.67 ± 0.52					
Anxiety	Year 7	92	4.10 ± 0.48	67.66	<.001	.004	<.001	<.001
	Year 8	96	3.84 ± 0.62			(0.47)	(1.85)	(1.13)
	Year 9	93	3.21 ± 0.48					
Importance	Year 7	92	4.44 ± 0.51	18.06	<.001	.001	.07	<.001
	Year 8	95	4.14 ± 0.55			(0.57)	–	(0.89)
	Year 9	91	3.95 ± 0.59					
Interest	Year 7	92	4.17 ± 0.55	48.87	<.001	.03	<.001	<.001
	Year 8	95	3.95 ± 0.62			(0.38)	(1.50)	(1.02)
	Year 9	89	3.36 ± 0.53					
Motivation	Year 7	92	4.17 ± 0.54	42.76	<.001	.002	<.001	<.001
	Year 8	94	3.88 ± 0.62			(0.50)	(1.44)	(0.84)
	Year 9	89	3.39 ± 0.54					
Confidence	Year 7	91	4.09 ± 0.77	41.44	<.001	.09	<.001	<.001
	Year 8	94	3.87 ± 0.63			–	(1.29)	(1.09)
	Year 9	88	3.22 ± 0.56					

N = Number of subjects in each level. Effect sizes (Cohen's *d*) are shown in parentheses p7 vs P8 under Scheffe's test column signifies p-value for comparison between Year 7 and Year 8 data

was found in Year 7 and Year 8 students' confidence, but this attitude did decline significantly (and with a large effect size = 1.09) from Year 8 to Year 9. Conversely, students' view of the importance of science declined significantly (with a moderate effect size of 0.57) from Year 7 to Year 8, but not between Years 7 and 9 ($p = .07$).

Gender and Decline in Attitudes

A comparison of the significance of the declines for male students revealed significant and nonsignificant declines in enjoyment from Year 7 to Year 8 among the students in SSB and coeducational schools, respectively. These declines were significant for girls from both school types. When the results for the 18 possible comparisons (Year 7 to Year 8, Year 8 to Year 9, and Year 7 to Year 9) for each school type among the same-sex students were considered, for male students from SSB there were 16 significantly different and two nonsignificantly different comparisons, and for those from coeducational school, there were eight significantly different and ten nonsignificantly different comparisons. However, for females students from SSG there were 12 significantly different and six nonsignificantly different comparisons, and for those from the coeducational school there were 13 significantly different and five nonsignificantly different comparisons. Moreover, there were eight mismatches (significant declines for SSB/SSG vs. nonsignificant for Coed, or vice versa) among male students, as compared to five among the female students. These results suggest that declines in attitudes toward science were different for students of the same sex from single-sex and coeducational schools. This difference was more pronounced for male students.

Comparison of Changes

The effect size data for all significantly different mean values for Year 7 to Year 9 students from SSB, SSG, and Coed schools for all six attitude-toward-science scales are reported in Table 6. The data in Table 6 show that the mean effect size values for five scales at the Coed school ranged from 0.50 to 0.88, for an overall mean of 0.67 ± 0.13; the effect size values for five scales at the SSG school ranged from 0.74 to 0.95, or 0.84 ± 0.08 overall; and the effect size values for all six scales at the SSB school ranged from 0.89 to 1.85, or 1.46 ± 0.32 overall. The overall mean effect size data results are indicators of the sizes of change in the mean values that are compared, and in this report they refer to the amounts of decline in attitudes toward science from Year 7 to Year 9. The mean effect size values for the students in the Coed school were less than those for the students in the SSG school, and the mean effect size values for the students in the SSG school were less than those for the students in the SSB school. These differences in effect size values among the students in these three schools were also observed for all scales in this study. These differences in effect size values support the extents of declines in attitudes for three groups of students. This trend gets further support from the magnitudes of the effect size values given in the Table 6. There, ten out of 18 effect size values are greater than 0.8 (large effect size). These included one, three, and six measures for students from the Coed, SSG, and SSB schools, respectively. Thus, there were one, three, and six large declines in attitudes toward science for students from the Coed, SSG, and SSB schools. In other words, the declines in attitudes from Year 7 to Year 9 were large for all scales in the SSB, whereas a large decline was

Table 6 Effect size data for all mean attitude changes from Year 7 to Year 9

Scale	Year 7–9		
	Coed	SSG	SSB
Enjoyment	0.67	0.76	1.76
Anxiety	0.74	0.89	1.85
Importance	–	–	0.89
Interest	0.56	0.84	1.50
Motivation	0.50	0.74	1.44
Confidence	0.88	0.95	1.29
Mean	0.67	0.84	1.46

observed only for the confidence scale in the Coed school. These results also indicate that the nonlinear declines in attitudes toward science were different in the three types of schools assessed in this study.

Discussion and Future Research Directions

In this study we have reported that students' attitudes toward science in all three schools were positive and similar in degree in Year 7. These results are in line with previously published research on 7th grade students (Akpınara, Yıldıza, Tatarb, & Ergina, 2009). The influence of role models on students has also been well documented (Ewing-Cooper & Parker, 2013). The public in general (including parents, teachers, and students) perceives science learning to be associated with the availability of decent jobs that lead to a better future (National Foundation of Education Research, 2011). The role models (parents, teachers, and peers) encourage students to learn science to get a good job. Students' motives for learning science to get good job, as well as their encouragement from role models, appear to have contributed to high positive attitudes toward science, as explained by the combinatory approach of the theory of reasoned action (Cacioppo et al., 1994; Fishbein & Ajzen, 1975). The theory states that attitudes are a function of personal intention (motive) and subjective norms (support from role models). This theory can also explain the similar levels of the attitudes of students at the start of their academic careers. The students in our three school types come from a neighborhood with average socio-economic status and with very similar societal educational exposure. Thus, the expectations of teachers and parents and the opinions of peers would be very similar in their influences as role models. These factors appear to have contributed to similar levels of attitudes. Moreover, in Brunei the Curriculum Development Department decides how science syllabi are designed and what resources (the stimulus) and sequences of teaching (organization) are to be used. This approach is in line with balance theory, which states that attitude formation and change are associated with the quality of information about the stimulus and its organization (Heider, 1958). The discussion above explains the similar and positive initial attitudes toward science in our three school types. However, the reader should consider that high positive attitudes of students are based on the information received from teachers, parents, and peers (the influence of role models) without substantial experience in

learning the advanced science that is essential to fulfill students' perceived motivations for learning science. Hence, students' attitudes toward science are unstable in Year 7 and are likely to change as they learn science.

The decline in attitudes from Year 7 to Year 9 among the students in this study is consistent with the results previously reported in the literature (George, 2006; Reiss, 2004; Sorge, 2007; Yasushi, 2009). Our results support the argument that decline in students' attitudes toward science from Years 7 to 9 occurs irrespective of their single-sex or coeducational learning environment. This decline in attitudes toward science from Years 7 to 9 can be explained using the self-persuasion approach (the information-processing model—i.e., the natures of the experience and the outcome influence attitudes; Bem, 1972). After students' transition from primary school to secondary school, they learn a tremendous amount of new abstract scientific vocabulary and information from different teaching and learning styles. Under such conditions, the information-processing rate and connectivity of learned knowledge are compromised. Students attempt to process much of this information at a superficial level of experience and find they have problems with learning advanced abstract science concepts, as is reflected by their poor performance on tests and exams. These conditions generate unpleasant experiences for the students and lead to negative attitude outcomes. The role of teachers in minimizing the unpleasant experiences and poor performance outcomes is important and can contribute to changing students' attitudes toward science. However, in this study these effects of teachers' influence are assumed to be low, as the number of participating teachers in each school was small.

We have reported that the decline in students' attitudes toward science in three school types was nonlinear. This decline is consistent with reports from investigations that were mostly conducted in coeducational schools (e.g., George, 2000; Sorge, 2007). George's data (Year 7–Year 11) showed a nonlinear decline in students' attitudes toward science. This decline was sharp from Year 7 to Year 9, and reduced from Year 9 to Year 11. A nonlinear decline in students' attitudes toward science was also observed among students 9–11 years of age in primary school and among students 12–14 years of age in lower secondary school (Sorge, 2007). Sorge's findings appear to suggest a linear decline among female students' attitudes toward science, and a nonlinear decline among male students. Contrary to Sorge's report, our data show a steeper decline for male students from a single-sex school than for students from SSG and Coed schools. We did not find a Bruneian study to support these results. However, Brunei's culture and trends in its students' science achievement have revealed that girls outperform boys in learning science, which is also close to the performance of Malaysian girls and boys in learning science (see, e.g., Jelas & Dahan, 2010). Lim and Abdullah (2012) reported that Malaysian boys are less sensitive than girls to school environment and that their level of satisfaction with the school environment is lower. Therefore, boys make less use of the benefits offered by a single-sex educational environment. Russell (2007) reported that boys become less competitive in the absence of girls. These factors appear to have contributed to the steeper decline in male students' attitudes toward science in SSB schools. Further investigations into such differences under local cultural contexts will be needed.

Regarding the difference in the declines in attitudes toward science among different school types, our data show that SSB students showed the largest decline and Coed students showed the smallest decline in attitudes toward science. We have not come

across a study to support or contradict these findings. Research has shown that the personality traits for Malaysian male and female students were comparable, with the exception of neuroticism (Lim & Abdullah, 2012), which often contributes to low achievement. Girls have a significantly higher level of neuroticism than boys (Lim & Abdullah, 2012). This higher level of neuroticism among girls did not correlate to their achievement. Since achievement in and attitudes toward science show significant correlations, personality traits cannot explain variations in declines in attitudes. However, Jelas and Dahan (2010) reported that, relative to boys, girls feel more satisfied with their school environment, and that the impact of this satisfaction is significantly higher for girls than for boys. Moreover, Russell (2007) reported that girls are more outspoken and competitive when boys are not around to tease them. This may be the reason why Bruneian girls are more satisfied with and competitive in a single-sex school environment than in a Coed school environment and may explain the differences in attitudes toward science between girl and boy students among the types of schools in this study. Moreover, it is well known that girls mature earlier than boys and that maturity enhances the information-processing rate. Therefore, girls are able to process science information more meaningfully than boys. Enhanced processing of information has the potential to improve performance and lessen unpleasant learning experiences. Hence, according to the self-persuasion theory (information-processing model; Bem, 1972), the attitude deterioration has the potential to be lower among females than among males.

Kaplan (2009) reported that a strong correlation between initial science attitude value and its change over time, which suggests that the higher the initial attitudes, the lower the change in these attitudes over the time. Contrary to this idea, in our data the male students from the SSB school had the highest initial attitude scores, as compared to the female students from SSG and Coed schools. The extent of the decline in attitudes toward science among male students in the SSB school was higher than among female students in the SSG school from Year 7 to Year 9. Russell (2007) reported that boys benefit less from a single-sex education because of they feel less competitive in an environment without girls. Therefore, boys' advantage in attitude toward science levels could not be supported by the negative impacts of a lack of competitiveness in learning science, which could lead to a chain of events such as low achievement, higher anxiety, inferiority complex, emotional sensitivity, and unhappiness (Dzulkifli & Alias, 2012). Hence, attitudes toward science tend to decline faster among boys than among girls in single-sex schools. A coeducation environment provides rich student diversity, intergender communication, and socialization in class and learning styles. These characteristics are highly useful in cooperative learning environments (Scantlebury & Baker, 2007). In such an environment, both genders benefit from each other. For example, the maturity of the girls supports boys' need to be first, and as boys develop in their maturity they are able to support girls in their learning of science. Future research on the impact of girls' maturity on their attitudes is warranted.

A lot of research has reported significant associations between exposure to the subject of science and attitudes toward science (e.g., Allum et al., 2008; Evans & Durant, 1995). Therefore, attitudes toward science should improve from Year 7 to Year 9, as is predicted by the theory of prior experience (i.e., the judgmental approach), which posits that students' prior knowledge in and exposure to the field of science can

influence their attitudes toward science (Hovland & Sherif, 1980). The decline in the results of our mean data is not consistent with the above research. Research reports on gender variations in interest in some scientific and technological topics that pose risks to society have had a negative impact on students' attitudes toward science (e.g., Allum et al., 2008; Evans & Durant, 1995; Haste, 2004). Such a negative impact is explained by the Yale attitude change model (see the modifications by Bauer, 2008). An evaluation of the lower secondary science curriculum for such topics/examples is therefore warranted.

Implications and Future Research Directions

In Brunei, the concept of single-sex government schools has had a major impact on how students attend school. The schools that participated in this study were early single-sex and coeducational schools situated in the capital city of Bandar Seri Begawan. The expansion of the concept of single-sex schools has been slow. During the last decade of the 20th century, the Brunei Ministry of Education extended the concept of single-sex education to Tutong district in order to improve students' engagement and performance in science. The Brunei government or other governments that have plans to expand single-sex education in their countries in order to achieve improved science learning and teaching can use the results of this study to guide their policies on single-sex education.

We have reported that the largest and smallest declines in attitudes toward science were found among SSB and Coed students, respectively. Cooperation between science teachers from the three school types to minimize the declines of students' attitudes toward science will be useful to society. Staff development workshops and seminars for science teachers from these schools are warranted, so that science teachers can be trained how to teach science in a single-sex environment, one aspect that is lacking in current teacher training programs in Brunei. Moreover, in this age of technology, teachers in these schools should mutually cooperate to develop technology-enriched science teaching methodologies that are equally effective in single-sex and coeducational environments.

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