Eurasia Journal of Mathematics, Science & Technology Education, 2009, **5**(1), 35-45

The Effectiveness of Smart Schooling on Students' Attitudes Towards Science

Eng-Tek Ong
Sultan Idris University of Education, Perak, MALAYSIA

Kenneth Ruthven
University of Cambridge, Cambridge, UK

Received 13 February 2008; accepted 27April 2008

This article reports the relative effect of Smart and Mainstream schooling on students' attitudes towards science which was measured using ATSSA(M) -- the Malay version of the Germann's (1988) Attitudes Towards Science in School Assessment (ATSSA) instrument. The participants comprised 775 Form 3 (15-year-old) students from two Smart Schools and two Mainstream Schools. Using students' Standardised National Examination (SNE) primary-school science achievement results as covariate, the attitudinal data collected were analysed using analysis of covariance (ANCOVA). The results indicated that the level of attitudes towards science of Form 3 students who had participated in the Smart Schools is statistically significantly higher than the level of attitudes towards science of Form 3 students who had participated in the Mainstream Schools. A "statistical triangulation" was provided by performing two further analyses, namely (i) ANCOVA by school and (ii) like-for-like comparison through independent t-tests for each entry grade of students, so as to make a convincing case that the main result from the ANCOVA by group was truly the outcome of differences between Smart and Mainstream schooling. The article discusses the findings in terms of parallel impact comparison within the available literature and recommends that future studies should look into isolating specific elements of the Smart Schools Initiative that have direct impact on students' attitudes towards science.

Keywords: Academic Success, School Organization, Science Education, Student Perceptions, Teacher Behavior.

INTRODUCTIION: THE MALAYSIAN SMART SCHOOLS

The Malaysian Smart School -- conceptualised in 1996, documented in "The Malaysian Smart School: A Conceptual Blueprint" (Smart School Project Team, 1997a), and subsequently began its 3-year pilot phase with 87 schools in 1999 -- is defined as "…a learning institution that has been systematically reinvented in terms of teaching-learning practices and school management in order to prepare children for the Information Age" (p.10). This innovative project aims to transform the Malaysian educational system so that it is parallel with, and in support of, the nation's drive to realise Vision 2020. The Vision calls for sustained, productivity-driven growth that will be achievable only with a scientifically and technologically literate, critical thinking work force prepared to participate fully in the global economy for the 21st Century. Such transformation of educational system is within the aspiration of the Malaysian National Philosophy of Education that aims towards "developing the potential

Correspondence to: Eng-Tek Ong, Faculty of Science and Technology, Sultan Idris University of Education, 35900 Tanjung Malim, Perak, MALAYSIA.
E-mail: ong.engtek@fst.upsi.edu.my

E-ISSN: 1305-8223

of individuals in a holistic and integrated manner, so as to produce individuals who are intellectually, spiritually, emotionally and physically balanced and harmonious" (Ministry of Education, 1997, p.2). This on-going transformation takes account of the ever evolving world of education in that "the Smart School concept itself is still a work in progress and remains open to evolutionary refinement, including advances in pedagogy and improvement in information technology" (Smart School Project Team, 1997a, p.9). Additionally, the term 'Smart' is expected to be redundant by 2010 when all Malaysian primary and secondary schools would have been transformed to Smart Schools (Smart School Project Team, 1997b).

The most distinctive feature of the Smart School is the teaching and learning environment that builds on best practices from around the world. This includes the mutually reinforcing and coherent alignment of four different dimensions, namely the curriculum, pedagogy, assessment and teaching-learning materials. These dimensions are briefly described in the subsequent paragraphs.

The Smart School curriculum encompasses the four levels of knowledge, namely "content knowledge, problem solving knowledge, epistemic knowledge, and inquiry knowledge" (Smart School Project Team, 1997a, p. 31) alongside the integration of Malaysian cherished values such as "compassion, self-reliance, respect, love, freedom, courage, physical and mental cleanliness, co-operation, diligence, moderation, gratitude, rationality, public spiritedness, humility, honesty, and justice" (Smart School Project Team, 1997a, p.32). These values were not idiosyncratic to the Smart Schools. Rather, these values echoed similar ones stipulated in the Mainstream science curriculum, in particular, and across all other subject curricula, in general. At operational levels, a three-step approach was recommended, namely "being aware of the importance and the need for … noble values; giving emphasis to these …values; [and] practising and internalising these … noble values" (Curriculum Development Centre, 1999, p.11; Curriculum Development Centre, 2002, p.11). Nevertheless, in actual classroom implementation, it was left to the discretion of a science teacher in that continuous and effective inculcation of noble values could be done "casually or systematically" (Curriculum Development Centre, 1999, p.11),

Smart School pedagogy is to be 'student-centred' with the following characteristics (Smart School Project Team, 1997a, p.39): "(1) appropriate mix of learning strategies to ensure mastery of basic competencies and promotion of holistic development, (2) allowance for individual differences in learning styles to boost performance, and (3) classroom atmosphere compatible with different teaching-learning strategies". However, the pedagogy advocated does not propose that student-centred teaching should prevail all the time. Instead, it should be "increase[d] in age and maturity" (ibid., p.39), implying the notion of a "centredness" continuum with teacher-centred at one extreme and student-centred at the other and teacher as mentor and model, and teacher as coach or facilitator in between.

The Smart School assessment system (Smart School Project Team, 1997a) shall be "criterion-referenced" (p.51), "learner-centred" (p.52), "on-line" (p.53), and "conducted in various forms: classroom assessment, school-based assessment and centralised assessment … [so as] to allow different demonstrations of strengths, abilities, and knowledge" (p.54) using "multiple approaches and instruments to perform authentic, alternative, and performance assessments" (p.55). Nevertheless, these aspirations are far from reality when students from the Smart Schools are taking similar school-based and centralised assessments as their counterparts in the Mainstream Schools.

Teaching-learning materials are designed to support teaching-learning strategies for Smart Schools, and have these characteristics: "(1) meet curricular and instructional needs, is cost effective, as well as cosmetically and technically adequate; (2) cognitively challenging, attractive, motivates students to learn, and encourages active participation; [and] (3) combine the best of network-based, teacher-based and courseware materials" (ibid., p.58). These resources, acquired within and beyond schools, are purported to have the benefits of "accommodat[ing] students' different needs and abilities resulting in the fuller realisation of students' capabilities and potential, [and] students tak[ing] responsibility for managing and directing their own learning" (ibid., p.58).

In summary, three key differences in the teaching and learning process of Smart Schools as compared to the Mainstream Schools are self-accessed, self-paced, and self-directed learning. Self-accessed learning means the students learn how to access and use relevant learning materials. Self-directed learning means that students learn how to direct, manage and plan their learning. Self-paced learning means that a student learns at his/her own pace, with enough challenging materials to help him/her achieve a certain competency level. Hence, when a student's role is switched from a relatively dependent and passive one towards self-accessed, self-paced, and self-directed learning, the teacher's role undergoes, in tandem, an evolution from 'sage on the stage' to 'guide on the side'.

Purpose of the Study

For decades, science educators have been interested in understanding students' academic achievement. Research in academic achievement reveals that there is a strong association between science achievement and attitudes towards science (e.g., Nuttall, 1971; Oliver & Simpson, 1998). In TIMSS 1999 International Science Report (Martin et al., 2000), students' attitudes towards science was one of the ways to elicit information that could provide an educational context for interpreting the science achievement results. Therefore, the development of positive attitudes towards science is one of the legitimate goals of science education globally. Gray (1996) points out that it is a mistake to omit attitudinal measures in any comparison of schools. Accordingly, it is important to monitor students' attitudes and ascertain whether or not, the Smart Schools Initiative has the effect on students' attitudes towards science.

Research Question

Inasmuch as the purpose of the study is to establish the comparative effect of Smart Schools and Mainstream Schools on students' attitudes towards science, this study addresses the following question:

What is the effect of science teaching in Smart Schools as compared to the Mainstream Schools on students' attitudes towards science?

LITERATURE REVIEW

Attitudes towards Science

Gardner (1975) acknowledges the broad nature of the term attitude that takes on different meanings in discussions about science education. He distinguishes two broad categories of attitude. The first category, "attitudes towards science" (e.g., interest in science, attitudes towards scientist, attitudes towards social responsibility in science) shows some distinct attitude object such as science or scientist, to which the respondent is invited to react favourably or otherwise. The second category, "scientific attitudes" (e.g., open-mindedness, objectivity, honesty, and scepticism), by contrast, are best described as styles of thinking which scientists are presumed to display. Osborne, Simon, and Collins (2003) subscribe to Gardner's distinction between "attitudes towards science" and "scientific attitudes", reckoning such distinction as not only clear, but "fundamental and basic" (p.1053) in an otherwise "nebulous, …poorly articulated and not well understood" (p. 1049) concept of attitudes in science educational research.

The first of Gardner's (1975) two categories concentrates on the emotional reaction of students. It is on these emotional responses rather than the second set of category which are more intellectual aspects developed through the study of science that was investigated in this study. In this respect, Gardner regards attitudes to science as "learned disposition to evaluate in certain ways objects, actions, situations or propositions involved in the learning of science" (ibid., p.2).

Research on Attitudes towards Science

The science literature search conducted failed to identify any previous study that examines the impact of the Smart Schools Initiative on students' attitudes towards science. Accordingly, this section revisits studies on "attitudes towards science", and unless otherwise specified, these attitudes refer to students' attitudes to school science that are a product of students' experience of school science.

A clear feature of the research is the decline in attitudes towards science from age 11 onwards. Yager and Penick (1984, 1986) found that students in elementary schools perceived science to be enjoyable, interesting and useful. However, a decline in attitude occurs throughout junior high and high school, resulting in young adults who do not feel positive about their school science. Osborne, Driver, and Simon (1998) noted that positive attitudes towards school science appear to peak at, or before, the age of 11 and decline thereafter by quite significant amounts, especially for girls. This claim is supported by the findings of Institute of Electrical Engineers [IEE] (1994) that show a decline in the level of interest in England from +40 to +20 (on a scale of -100 [totally negative] to +100 [totally positive]) between the ages of 10 and 14. Lowery (1967) found that at the age of 10 to 11, science in children's mind was associated with difficult words, monsters, precious metals and jewels, and that science was unsafe.

Another clear feature of the research, supported by meta-analyses of Schibeci (1984), Becker (1989), and Weinburgh (1995), is that boys have a consistently more positive attitude towards school science than girls. The predominant thesis offered to explain this finding is that it is a consequence of cultural socialization that offers girls considerably less hands-on opportunity to manipulate scientific and technological devices (Johnson, 1987; Kahle & Lakes, 1983). Jovanovic and King (1998) have a similar thesis, arguing that girls' antipathy towards science is explained by their own comparative judgements across academic domains, perceiving that they are better at other subjects (i.e., English) and, therefore, not as good at science. However, while boys' attitudes towards science are significantly more positive than girls, the effect is stronger in physics than in biology. Such a bifurcation of interest in physical and biological science between boys and girls (i.e., Harvey & Edwards, 1980) has been given additional salience by the work of Ormerod, Rutherford, and Wood (1989) where boys were found to be far more interested in "space" and girls far more interested in "nature study".

In a meta-analysis study of the effect of computer-based instruction, Kulik and Kulik (1991) found that the scores in attitudes towards instruction (i.e., students liked their classes more when they received computer help in school) and attitudes towards computer (i.e., students developed more positive attitudes towards computers when they received help in school) were raised by 0.28 and 0.34 standard deviations respectively. However, the average effect of computer-based instruction in 34 studies of attitudes towards subject matter was near zero. In a more recent meta-analytic review of six controlled studies of computer-based instruction, Kulik (2003) found a median effect size of 1.10 for attitudinal outcomes. This means that computer-based instruction contributed to the development of favourable attitudes towards instruction (Bain, Houghton, Sah, & Carroll, 1992), towards computers (Jegede, Okebukola, & Ajewole, 1991), and towards subject matter such as chemistry (Yalcinalp, Geban, & Ozkan, 1995).

Studies reviewed in this section support four conclusions of research on attitudes towards science. Firstly, age is related to attitude (i.e., as a student advances to higher levels of schooling, attitude declines). Secondly, gender is related to attitude (i.e., boys have more positive attitudes towards science than girls). Thirdly, gender is also related to biological science relative to physical science (i.e., boys are more interested in physical science while girls are more interested in biological science). Finally, using computer-based instruction affects attitudes (i.e., computer-based science instruction promotes favourable attitudes towards science).

METHODOLOGY

Research Design

Given the research question that aimed to establish the effect of science teaching in the Smart Schools and the science teaching in the Mainstream Schools on students' attitudes towards science, a quasi-experimental design was deemed appropriate in a realistic school setting (Styles, 2006) where it was not possible to randomly assign students to the experimental treatment (experiencing science in the Smart Schools Initiative) and to the control treatment (experiencing science in the Mainstream Programme).

Instrumentation

The parsimonious Malay version of Attitudes Towards Science in School Assessment (see appendix) or ATSSA(M), which is a translation from the instrument developed by Germann (1988), was used in this study. Parsimonious because the initial 14-item Malay translated version of German's (1988) ATSSA was reduced to 11 items based on the psychometric evidence (Ong & Ruthven, 2002). Results from the initial principal component factor analysis show that, while all the 14 items load on Factor 1 with factor loadings (or correlations) greater than 0.4, the pattern of loadings of items 4, 5 and 10 suggests that these items are 'noisy' in that they all load relatively weakly on the first factor but strongly on the second factor. With the removal of the three items, the results from the subsequent principal component factor analysis indicated that these 11 items seem to cohere into one factor solution with an eigenvalue of 5.91 which accounted for 53.73 per cent of the total variance. This supports the unidimentionality of the ATSSA(M). Furthermore, its test-retest and Cronbach's alpha reliabilities were found to be at 0.93 and 0.90 respectively. Accordingly, the use of the 11-item ATSSA(M) justifies the use of summated-ratings procedure to measure students' attitudes towards science.

Sampling

The subjects were 186 male and 201 female students from two Smart Schools and 184 male and 204 female students from two Mainstream Schools in Malaysia. Table 1 shows the detailed breakdown of students by school. By means of purposive sampling, the choice of the two Smart Schools was a function of three predetermined criteria: (i) high implementation of smart schooling as gleaned from the monitoring report of the School Division (2002) of the Malaysian Ministry of Education, (ii) among Mainstream Schools which were turned into Smart Schools, and (iii) in the two states of Penang and Perak. Meanwhile, the two Mainstream Schools chosen were roughly parallel in terms of location, race composition, gender, proximity and socio economic status (SES).

Data Collection Procedures

Prior to the commencement of the study, permission was sought from the Educational Planning and Research Division (EPRD) of the Malaysian Ministry of

Table 1. Distribution of participating students by school.

	Male	Female	Total
Smart School 1	111	123	234
Smart School 2	75	78	153
Mainstream School 1	105	139	244
Mainstream School 2	79	65	144
Total	370	405	775

Education (MoE) as mandated by the MoE General Circular 112/86 on 'Ministry of Education Research Coordination'. Upon gaining the approval, further approvals at State Level, a hierarchy below the Ministerial Level, were sought. In this regard, letters for permission were forwarded to the two state education departments, namely the Perak and Penang State Education Departments, given our sampling of four schools from the two states. Finally, the principals of the schools were contacted and they permitted the conduct of the research at their respective schools. Students' Year 6 science achievement results in the Standardised National Examination (SNE) was accessed from the school records. This serves as the entry grade level, or covariate in further data analysis. Students in the Smart Schools received their 3-year lower secondary science instruction which, on the basis of the observation of 25 science lessons, was very much ICT-based than their counterparts in the Mainstream Schools (Ong, 2004). In each school, the administration of the ATSSA(M) was done simultaneously for all the classes under the supervision of teachers in school time.

Data Analysis Procedures

With the significance level set at 0.05, the scores on ATSSA(M) for the Smart Schools group and Mainstream Schools group were compared using the analysis of covariance (ANCOVA) with Year 6 Standardised National Examination science achievement as covariate. The dataset was initially screened for normality, linear relationship between covariate and dependent variable, and homogeneity of regression slopes. If any of the necessary assumptions was not met, other appropriate statistical technique(s), data transformation, or outlier deletion were performed accordingly.

RESULTS

Entry Profile Screening

The students' Year 6 Standardised National Examination science achievement results (henceforth referred to as UPSR science achievement, where UPSR is a Malay acronym for *Ujian Pencapaian Sekolah Rendah*, which literally means Primary School Attainment Test) were used as the entry level (covariate) in ANCOVA. Table 2 shows the distribution of entry grades by group and school.

As shown in Table 2, the initial difference between the Smart and Mainstream Schools in terms of students' entry grades favours the former. Although such initial difference, according to statisticians (e.g., Ferguson & Takane, 1989; Glass & Hopkins, 1996; Hinkle, Wiersma, & Jurs, 1998) has been taken into account in ANCOVA by making compensating adjustments to the posttest means of the two groups, it is understandable for critics to be sceptical of the results presented. However, two further analyses are performed to dispel the suspicion.

It is the entry profile of SS2 which is primarily responsible for the differences between groups; the profile of SS1 is much more similar to those of MS1 and MS2. First, then, in order to make a convincing case that the results from the ANCOVA for the dependent variable (i.e., attitudes towards science) are truly the outcome of differences between Smart and Mainstream science teaching, a further analysis of covariance by school is performed.

The entry profile of SS2 lacks students graded D or E, and this produces a corresponding imbalance in the grade profiles of the two groups. Second, then, independent t-tests for each entry (covariate) grade of student are performed so as to establish a like-for-like comparison in which the scores obtained in ATSSA(M) for students in Smart Schools are compared to those students in Mainstream Schools with identical entry grades.

As observed in Table 2, there is a very small sample size at E entry grade. According to Kraemer and Thiemann (1987), the number of participants is directly related to power, where power is the ability to detect "real" differences (i.e., correctly reject the null, when an alternate hypothesis is true). Furthermore, Cohen (1988) recommends 80% power achievable through having 30 participants per cell, as the minimum power for an ordinary study. Therefore, the independent t-test for students at E entry grade should be given little weight.

These complexities arise because the data are drawn from a real-world situation. However, by analysing the data in these different ways, it should be possible to draw firmer conclusions.

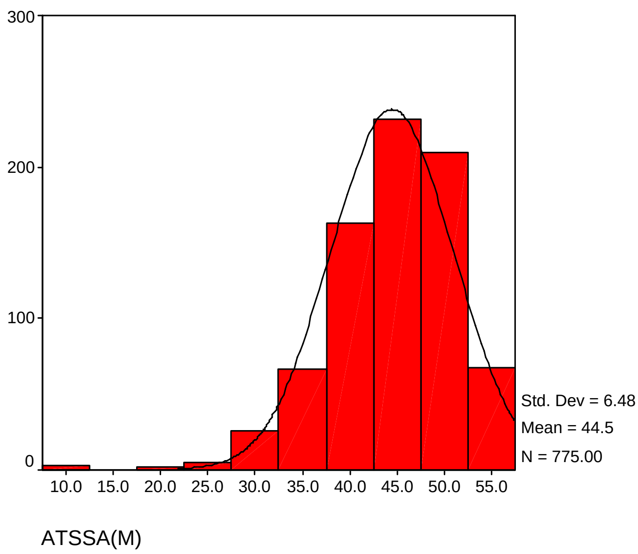

Figure 1. Histogram for distribution of scores on ATSSA(M).

ATSSA (M) Data Screening

The distribution of scores on ATSSA(M) was not normally distributed, assessed by its skewness and kurtosis values which were measured at –1.04 and 2.47 respectively. There are ways of getting round this problem of non-normal distribution, such as through a suitable variable transformation, or resorting to the use of non-parametric alternatives. However, by inspecting the shape of the histogram (see Figure 1), a handful of cases with much lower scores were observed. They tailed off from the normal distribution curve and 'sat' on their own, out on the extremes.

Through the exploration in which the most extreme cases were successively deleted, it was found that by deleting the 5 most extreme cases, the skewness and kurtosis values improved to that of –0.57 and 0.28, suggesting a normal distribution for the scores on ATSSA(M) (see Figure 2). Table 3 gives information on the five deleted extreme cases.

Given the normal distribution for ATSSA(M), it was intended that ANCOVA be used to test the research hypothesis. First, however, the data were analysed to see if (1) there was a linear relationship between the covariate and the dependent variable; and (2) the assumption of homogeneity of regression slopes was not violated. The former was checked graphically using scatterplots, while the latter was established graphically and tested in the "Custom General Factorial Model" for interaction between group and covariate.

The scatterplots in Figure 3 show that there was a linear (straight-line) relationship between the covariate (i.e., UPSR science achievement) and dependent variable (i.e., students' scores on ATSSA(M)) for each of the

Table 2.Distribution of entry grades by group and school for attitudes towards science analysis

Entry Grade	Smart Schools			Mainstream Schools		
	SS1	SS2	Total	MS1	MS2	Total
A	24	26	50	15	4	19
B	52	102	154	60	34	94
C	106	26	132	141	73	214
D	42	0	42	24	28	52
E	10	0	10	4	5	9
Total	234	153	387	244	144	388

Table 3.Information on five deleted extreme cases

Case	ATSSA(M) Score	Gender	School	UPSR Science achievement
165	11	F	SS2	B
521	11	M	MS1	C
530	11	M	MS1	C
539	20	M	MS1	C
543	21	M	MS1	C

Table 4.Results obtained from Analysis of Covariance by group for attitudes towards science Analysis of Covariance

Source	Sum of Squares	df	Mean Squares	F	p
Group	844.12	1	844.12	27.13	.000
Covariate	2565.12	1	2565.12	82.44	.000
Error	23866.47	767	31.12		

Mean

Group	N	Covariate Mean	Covariate SD	ATSSA(M) Mean	ATSSA(M) SD	Adjusted Mean	Δ*
Smart	386	3.49	0.94	46.07	5.04	47.72	0.68
Mainstream	384	3.16	0.80	43.24	6.59	43.59	
Total	770	3.33	0.89	44.66	6.03		

* Δ , effect size (ES) = (Smart adjusted mean – Mainstream adjusted mean)/(pooled SD of 6.03)

groups (i.e., Smart and Mainstream). Additionally, the R-squared value of approximately 0.10 for both Smart and Mainstream Schools indicate that 10% of variance in attitudes scores could be predicted from UPSR science achievement.

Furthermore, the slopes of regression lines were 'roughly' parallel, consistent with homogeneity of regression slopes. This was confirmed by the interaction testing for homogeneity of regression slopes in which the group and covariate interaction effect was found to be non significant [$F_{(1, 766)} = 3.64$, $p > .05$].

Therefore, the use of ANCOVA was justified given that there was a linear relationship between the covariate and dependent variable, and that there was homogeneity of regression.

Hypothesis Testing

Null Hypothesis, H_0: There is no statistically significant difference in attitudes towards science between Form 3 students from Smart and Mainstream Schools, as measured by the 11-item Attitudes Towards Science in School Assessment [ATSSA(M)].

Research Hypothesis, H_A: There is a statistically significant difference in attitudes towards science of Form 3 students who have participated in the Smart schooling and the attitudes of Form 3 students who have participated in the Mainstream schooling.

As shown in Table 4, the analysis of covariance yielded an F-ratio of 27.13 that was statistically significant ($p = .000 < .001$) and an effect size of +0.68 that was educationally significant. The adjusted mean obtained for the Smart Schools (47.72) was statistically significantly higher than the adjusted mean obtained for the Mainstream Schools (43.59). Therefore, the research hypothesis is accepted.

The level of attitudes towards science of Form 3 students who had participated in the Smart Schools is statistically significantly higher than the level of attitudes towards science of Form 3 students who had participated in the Mainstream Schools. Indeed, inasmuch as the obtained effect size ($\Delta = +0.68$) was equivalent to approximately two thirds of a standard deviation, it can also be argued that the difference favouring Form 3 students who participated in the Smart Schools is also educationally significant.

While five extreme cases (i.e., one in Smart Schools, and four in Mainstream Schools) were deleted, the deletion had a negligible impact on the overall mean. The deleted case in Smart Schools only incurred a difference of 0.1 point [i.e., $\{(46.07 \times 386) + 11\} \div 387$] from the mean score of 46.07, and the four deleted cases in Mainstream Schools, taken together, only incurred a difference of 0.3 points [i.e., $\{(43.24 \times 384) + (11 + 11 + 20 + 21)\} \div 388$] from the mean score of

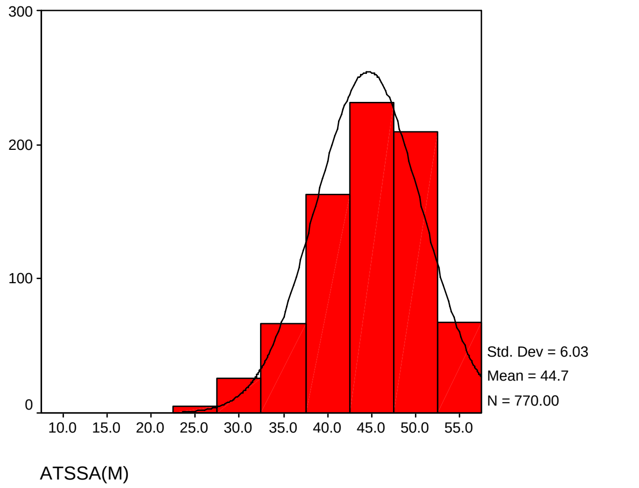

Figure 2. Histogram for distribution of scores on ATSSA(M) after deletion of extreme cases

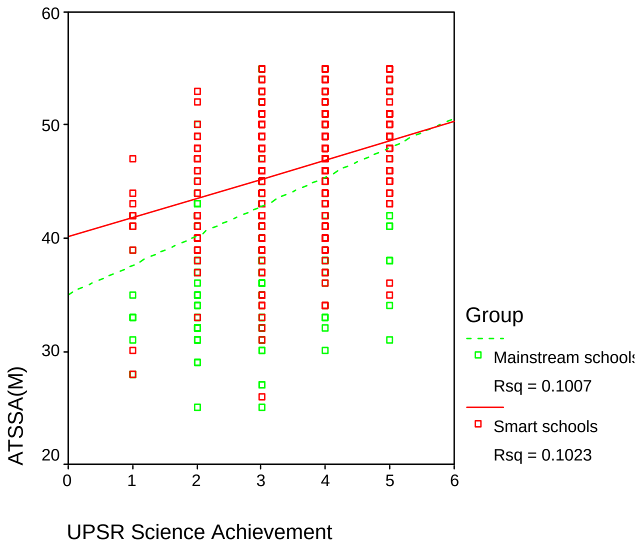

Figure 3. Relationship between the covariate and the dependent variable

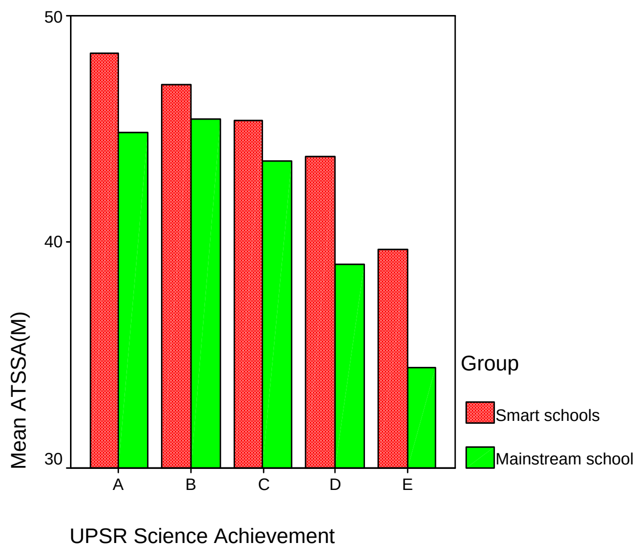

Figure 4. Bar charts for group mean ATSSA(M) score differences by UPSR science achievement

43.24. As such, the results from the ANCOVA, despite the five-case deletion, were considered to be robust.

Next, ANCOVA by school was performed. As shown in Table 5, the adjusted mean attitude scores ranked schools in the order SS1, SS2, MS2, MS1. The analysis of covariance by school yielded an F-ratio of 10.59 that was statistically significant ($p < .001$), suggesting a significant difference in at least one of the pairwise comparisons. The post hoc tests (see Table 5) revealed that within each group, the differences between schools were not significant whereas between groups, all but one of the school differences were significant. This suggests that the significant group differences found earlier were indeed due to group rather than disguised school effects.

Further insight and understanding of the relative effects of Smart and Mainstream science teaching can be gained if a further comparison through an independent t-test is performed to compare the ATSSA(M) scores of students for each of the covariate (entry or UPSR science achievement) grades.

Figure 4 shows the bar chart comparing the mean scores between Smart and Mainstream Schools for students at each grade level of UPSR science achievement. Broadly, it shows that students in the Smart Schools consistently rated their attitudes towards science more favourably than did identical students in the Mainstream Schools across UPSR science achievement grades.

As shown in Table 6, the t-tests were significant at

Table 5. Results obtained from Analysis of Covariance by school for attitudes towards science Analysis of Covariance

Source	Sum of Squares	df	Mean Squares	F	p
School	985.03	3	328.34	10.59	.000
Covariate	2620.94	1	2620.94	84.51	.000
Error	23725.56	765	31.01		

Mean

		Covariate		ATSSA(M)		Adjusted
School	N	Mean	SD	Mean	SD	Mean
SS1	234	3.16	0.98	45.72	5.07	46.09
SS2	152	4.01	0.58	46.61	4.96	45.09
MS1	240	3.24	0.78	43.11	5.80	43.30
MS2	144	3.03	0.83	43.47	7.76	44.14
Total	770	3.33	0.89	44.66	6.03	44.66

Pairwise Comparisons

School (I) – School (J)	Mean Difference (I-J)	p+
SS1 – SS2	1.00	.621
MS1 – MS2	-0.84	.934
SS1 – MS1	2.79	.000**
SS1 – MS2	1.95	.006*
SS2 – MS1	1.78	.020*
SS2 – MS2	0.95	1.00

* Significant at $p < .05$ ** Significant at $p < .001$ + Adjusted for multiple comparisons: Bonferroni

Table 6. Results obtained from unpaired samples t-test for attitudes towards science by UPSR science achievement grade

Science Achievement Grade UPSR	Smart Schools			Mainstream Schools					
	N	Mean	SD	N	Mean	SD	t	p (2-tailed)	Δ+
A	5048.32		4.15	19	44.846.52		2.17	.041*	0.68
B	15346.95		4.54	94	45.416.17		2.09	.038*	0.29
C	13145.40		5.30	210	43.566.30		2.90	.004*	0.31
D	4243.79		4.30	52	38.985.73		4.64	.000**	0.85
E	1039.70		6.04	9	34.445.25		2.01	.060	0.86
Total	38646.07		5.04	384	43.246.59				

* significant at $p < .05$ ** significant at $p < .001$

+ **Δ,** Effect Size = (Smart mean – Mainstream mean) / (pooled SD)

[Note: 5.11, 5.27, 6.00, 5.65, and 6.14 are pooled SDs for A, B, C, D, and E graders respectively]

A, B, C, and D covariate grades. Given the very small sample size, the no significant group difference at E entry grade carries little weight. Therefore, taken together, the results from the independent t-tests support the earlier ANCOVA findings that students in the Smart Schools achieved a higher mean score in attitudes towards science than students in the Mainstream Schools.

CONCLUSION AND DISCUSSION

The ANCOVA results for the ATSSA(M) scores showed that the Form 3 students involved in the 3-year Smart Schools Initiative had a significantly higher adjusted mean score compared to students involved in the Mainstream Programme. The students from Smart Schools achieved a 4.13 point higher adjusted mean score on the ATSSA(M) compared to students in Mainstream Schools [47.72 and 43.59 respectively, $F_{(1, 767)} = 27.13$, $p < .001$]. Such a difference, favouring Form 3 students who participated in the Smart Schools, is also educationally significant given the obtained effect size of +0.68, which is equivalent to approximately two thirds of a standard deviation. This finding was supported by follow-up analyses using ANCOVA by school and independent t-tests by entry (UPSR science achievement) grade. The former confirmed that the significant group difference was indeed contributed by both Smart Schools while the latter, discounting the weight from E entry grade comparison due to low sample size, revealed that group difference in attitudes towards science was significant across all entry grades.

Accordingly, in terms of impact, the results indicated that students in the Smart Schools have significantly more positive attitudes towards science than their counterparts in the Mainstream Schools. However, we are not able to find any previous studies with which these findings could be directly compared. This explains the novelty and distinctiveness of this study, and reflects the infancy of the Smart Schools Initiative. Nevertheless, comparison could still be made based on the logic of parallel impact of other science-based curricular innovations so long as their distinctive features are clearly identified. As such, by parallel impact comparison, the attitudinal outcome in this study is not consistent with research on attitudes towards science and activity-based programmes (i.e., Freedman, 1997; Turpin, 2000; Wideen, 1975). The results from Turpin's (2000) study indicated no significant difference between students involved in the activity-based Integrated Science (IS) programme compared to students involved in the traditional science programme. Equally, Wideen (1975) found no significant difference in attitudes towards science between students in the SAPA (Science – A Process Approach) programme and students in the traditional science programme. When the treatment and control groups covered the same science content with the treatment group additionally participating in one hands-on activity per week, Freedman (1997) found no significant difference in mean attitudes towards science between the two groups.

By virtue of the high level of ICT use in the Smart Schools, then, the attitudinal outcome in this study lends empirical support to optimist-rhetoric, defined as "official claims for the effectiveness of ICT" (Reynolds, Treharne, & Tripp, 2003, p.151) in raising students' motivation and attitudes towards science. Such empirical support is deemed necessary because, as Lewis (2003) observed, "Evidence that the use of ICT has any significant effect on attainment [and attitudes] remains elusive. There is much anecdotal evidence of improved attainment [and attitudes] being linked to effective use of ICT, but little published research" (p.42). Equally, the attitudinal outcome in this study is consistent with the meta-analytic findings of Kulik (2003) where computer-based instruction contributed to a development of favourable attitudes towards school science.

The Smart Schools Initiative promotes the use of ICT alongside other smart teaching elements such as constructivist practice, mastery learning, self-accessed, self-paced and self-directed learning. Additional research is needed to determine which smart teaching elements have greatest effect on students' attitudes towards science. Equally, given that the impact of various possible combinations of these smart teaching elements remains unclear, further study to isolate the relative impact, be it positive or otherwise, of these possible combinations would be illuminating and beneficial. It would also contribute significantly to the research and literature if the future research could determine whether other ICT-based science programmes have a similar impact on attitudes towards science compared to the Smart Schools Initiative

REFERENCES

Bain, A., Houghton, S., Sah, F.B., & Carroll, A. (1992). An evaluation of the application of interactive video for teaching social problem-solving to early adolescents. *Journal of Computer-Based Instruction, 19*(3), 92-99.

Becker, B.J. (1989). Gender and science achievement: A re analysis of studies from two meta-analyses. *Journal of Research in Science Teaching, 26*(2), 141-169.

Cohen, J. (1988). *Statistical power analysis for the behavioural science* (2nd ed.). Hillsdale, NJ: Erlbaum.

Curriculum Development Centre. (1999). *Huraian Sukatan Pelajaran Sains KBSM Tingkatan 3 Edisi Sekolah Bestari* (*Integrated Curriculum for Secondary School: Form 3 Science Syllabus, Smart School Edition*). Kuala Lumpur: Curriculum Development Centre, Ministry of Education.

Curriculum Development Centre (CDC). (2002). *Integrated Curriculum for Secondary Schools: Curriculum Specifications*

Science Form 2. Kuala Lumpur: Curriculum Development Centre, Ministry of Education, Malaysia.

Ferguson, G.A., & Takane, Y. (1989). *Statistical analysis in psychology and education*. NY: McGraw-Hill Publishing Co.

Freedman, M.P. (1997). Relationship among laboratory instruction, attitude toward science and achievement in science knowledge. *Journal of Research in Science Teaching, 34*(4), 343-357.

Gardner, P.L. (1975a) Attitudes to science: A review. *Studies in Science Education, 2*, 1-41.

Germann, P.J. (1988). Development of the attitude toward science in school assessment and its use to investigate the relationship between science achievement and attitude toward science in school. *Journal of Research in Science Teaching, 25*(8), 689-703.

Glass, G.V., & Hopkins, K.D. (1996). *Statistical methods in education and psychology* (3rd ed.). London: Allyn and Bacon.

Gray, J. (1996). The use of assessment to compare institutions. In H. Goldstein & T. Lewis (Eds.), *Assessment: Problems, developments and statistical issues* (pp. 121-133). New York: John Wiley and Sons.

Harvey, T.J., & Edwards, P. (1980). Children's expectations and realisation of science. *British Journal of Educational Psychology, 50*, 74-76.

Hinkle, D.E., Wiersma, W., & Jurs, S.G. (1998). *Applied statistics for the behavioural sciences*. Boston: Houghton Mifflin Co..

Institute of Electrical Engineers. (1994). *Views of science among students, teachers, and parents*. London: Institute of Electrical Engineers.

Jegede, O.J., Okebukola, P.A., & Ajewole, G.A. (1991). Computers and the learning of biological concepts: Attitudes and achievement of Nigerian students. *Science Education 75*(6), 701-706.

Johnson, S. (1987). Gender differences in science: Parallels in interest, experience and performance. *International Journal of Science Education, 9*, 467-481.

Jovanovic, J., & King, S.S. (1998). Boys and girls in the performance-based science classroom: Who's doing the performing? *American Educational Research Journal, 35*(3), 477-496.

Kahle, J.B., & Lakes, M.K. (1983). The myth of equality in science classrooms. *Journal of Research in Science Teaching, 20*(2), 131-140.

Kraemer, H.C., & Thiemann, S. (1987). *How many subjects? Statistical power analysis in research*. Newbury Park, CA: Sage.

Kulik, J.A. (2003). *Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say*. Arlington, Virginia: SRI International.

Kulik, C.C., & Kulik, J.A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behaviour, 7*(1-2), 75-94.

Lewis, S. (2003). Enhancing teaching and learning of science through use of ICT: Methods and materials. *School Science Review, 84* (309), 41-51.

Lowery, L.F. (1967). An experimental investigation into the attitudes of fifth grade students towards science. *School Science and Mathematics, 67*, 569-579.

Martin, M.O., Mullis, I.V.S., Gonzalez, E. J., Gregory, K. D., Smith, T. A., Chrostowski, S.J., Garden, R. A., & O'Connor K. M. (2000). *TIMSS 1999 International Science Report*. Chesnut Hill, MA: International Study Center, Lynch School of Education, Boston College.

Ministry of Education Malaysia. (1997). *Education in Malaysia*. KL: Ministry of Education Malaysia.

Nuttall, D. (1971). *Administrator's manual for Science Attitude Questionnaire*. Slough: NFER.

Oliver, J.S., & Simpson, R.D. (1988). Influences of attitude toward science, achievement, motivation, and science self-concept on achievement in science: A longitudinal study. *Science Education, 72,* 143-155

Ong, E.T. (2004). *The character of 'smart science teaching' in Malaysian schools and its effects on student attitudes, process skills, and achievement*. Unpublished PhD dissertation, University of Cambridge, UK.

Ong, E.T., & Ruthven, K. (2002). Reliability and validity of a Malay version instrument on attitudes towards science. *Journal of Science and Mathematics Education in Southeast Asia, 25*(1), 48-65.

Ormerod, M.B., Rutherford, M., & Wood, C. (1989). Relationships between attitudes to science and television viewing among pupils aged 10 to 13+. *Research in Science and Technological Education, 7*(1), 75- 84.

Osborne, J., Driver, R., & Simon, S. (1998). Attitudes to science: Issues and concerns. *School Science Review, 79*(288), 27-33.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079.

Oskamp, S. (1977). *Attitudes and opinions*. Englewood Cliffs, NJ: Prentice-Hall.

Reynolds, D., Treharne, D., & Tripp, H. (2003). ICT – the hopes and the reality. *British Journal of Educational Technology, 34*(2), 151-167.

Schibeci, R.A. (1984). Attitudes to science: An update. *Studies in Science Education, 11*, 26-59.

School Division. (2002). *Laporan pemantauan kolaboratif pelaksanaan projek rintis sekolah bestari tahun 2001* (*Collaborative Monitoring Report on Smart School Pilot Project Implementation Year 2001*). KL: Ministry of Education, Malaysia.

Smart School Project Team. (1997a). *Smart School Flagship Application: The Malaysian Smart School – A conceptual blueprint*. Kuala Lumpur: Ministry of Education.

Smart School Project Team. (1997b). *The Malaysian Smart School: Implementation Plan*. Kuala Lumpur: Ministry of Education.

Styles, B. (2006). Educational research versus scientific research. *Research Intelligence, 95,* 7-9.

Turpin, T.J. (2000). *A study of the effects of an integrated, activity-based science curriculum on student achievement, science process skills, and science attitudes*. Unpublished EdD dissertation, University of Louisiana at Monroe, USA.

Weinburgh, M.H. (1995). Gender differences in student attitudes toward science: A meta-analysis of the literature from 1970-1991. *Journal of Research in Science Teaching, 32*(4), 387-398.

Wideen, M.F. (1975). Comparison of student outcomes for science – a process approach and traditional science teaching for third, fourth, fifth, and sixth grade classes:

A product evaluation. *Journal of Research in Science Teaching, 12*(1), 31-39.

Yalcinalp, S., Geban, O., & Ozkan, I. (1995). Effectiveness of using computer-assisted supplementary instruction for teaching the mole concept. *Journal of Research in Science Teaching, 32*(10), 1083-1095.

Yager, R.E., & Penick, J.E. (1984). What students say about science teaching and science teachers? *Science Education, 68*(2), 143-152.

Yager, R.E., & Penick, J.E. (1986). Perceptions of four age groups toward science classes, teachers, and the value of science. *Science Education, 70*(4), 355-363

◈◈◈