INVESTIGATING THE SMART SCIENCE LEARNING EXPERIENCE AMONGST MALAYSIAN STUDENTS

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1999 marks an important milestone when the Malaysian Ministry of Education launched its 3-year pilot Smart Schools Initiative in 87 schools across the country. This study aims to compare the differential perceptions on science learning experience between a group of 383 Form 3 (Year 9 equivalent in the UK) students in two Smart schools and a group of 381 Form 3 students in two Mainstream schools. The perceptions were gauged and compared using the authors-developed Smart Science Learning Experience Inventory or SSLEI (Ong & Ruthven, 2003). SSLEI has two versions: original full-scale SSLEI which measures the overall perceptions of smart science learning experience, and psychometrically revised SSLEI that comprises eight subscales, namely (1) Information and Communication Technology, (2) Supported Learning, (3) Science Process Skills, (4) Constructivist Practice, (5) Self-Determined Learning, (6) Learning Preference, (7) Active Thinking, and (8) Values Inculcation. This article reports the findings of three-way 2 x 2 x 3 (group x gender x class level) multivariate analysis of variance performed on the data from students' self-reports as measured in the revised SSLEI.

BACKGROUND

In early 1996, the Malaysian Ministry of Education held several brainstorming sessions to formalise the smart school conceptual framework and the implications it may have on the country's education system. By year end, Smart Schools Initiative had become one of the seven flagship applications of the Multimedia Super Corridor (MSC) project, promoted by the Multimedia Development Corporation (MDC). One of the reasons for such initiative was to capitalise on the presence of leading-edge technologies and the rapid development of the MSC infrastructure to jump-start deployment of enabling technology to Malaysian schools.

In July 1997, the document entitled "The Malaysian Smart School: A Conceptual Blueprint" (Smart School Project Team, 1997a) was produced. This document asserts that the Malaysian Smart School Concept is derived from best practices from around the world, as well as from the best home-grown practices of teachers and educators in Malaysia. In essence, the Malaysian Smart School 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 (ibid., p.10).*

The Malaysian Government awarded Telekom Smart School Sdn Bhd (TSS) the contract to implement the Smart School Integrated Solution (SSIS) at 90 pilot schools nationwide. The main components of SSIS are:

(1) Teaching-Learning materials in the form of courseware and printed materials for Malay Language, English Language, Science and Mathematics;

(2) The Smart School Management System (SSMS) comprising software for management and administrative functions;

(3) Technology Infrastructure comprising hardware, software, system software, and non-IT equipment; and

(4) System Integration to ensure integration in the following areas:

    (i) among (1), (2), and (3);

    (ii) within the processes in (1);

    (iii) within the processes in (2); and

    (iv) between (1) and (2).

Hence, the formation of a group of 87 pilot Smart Schools (3 new schools failed to be readily built and technologically equipped on time) in 1999 which progressed through completion in December 2002. These pilot schools are expected to serve as the nucleus for the eventual nationwide deployment of SSIS (SSPT, 1997a). By 2010, the term 'Smart' is expected to be redundant when all schools, be they primary or secondary, would have been transformed to that of Smart Schools (SSPT, 1997b).

SCIENCE TEACHING AND LEARNING IN SMART AND MAINSTREAM SCHOOLS

With the introduction of Smart Schools Initiative, Malaysian schools could generally be dichotomised into Smart and Mainstream schools. While the content coverage is the same in both types of schools as students take similar Standardised National Examinations at Forms 3 and 5 in secondary education, what then constitute the "reinvention in terms of teaching and learning" (ibid., p.10)?

It must be stressed that the process of "reinvention" is not synonymous to total revamp in terms of teaching and learning process. Instead, as evident in the policy documents, it reverberates the realignment with the current learning theories and technological advances. Accordingly, such reinvention of teaching and learning process calls for, among others, the capitalisation of technologically-enhanced environment (CDC, 2001a), the explicit inculcation of scientific, thinking and metacognitive skills (CDC, 2002), the employment of student-centred constructivist approach (CDC, 2001b), the promotion of thoughtful practice and informative feedback through mastery learning (CDC, 2001c), the use of pedagogical approaches that match students' learning styles and multiple intelligences, and the inculcation of 16 stipulated noble values (SSPT, 1997a).

It has been persuasively argued that, "The journey of the Smart School project might otherwise be a long and gradual one, but we can now use technology to take us there quickly and efficiently" (SSPT, 1997a, p.37). The corollary that stems from such argument is that science teaching and student learning can be made more efficient and enabling with the use of technology. While acknowledging that technology is not the panacea of education, the argument for the use of technology rests on the notion that it presents many opportunites for an enhanced learning experience. This is because, technology can be used to deliver content, provide support and interaction, and facilitate communication. Accordingly, a technologically-enhanced environment is the main feature that distinguishes a Smart school from a Mainstream school.

This enhancement from the use of technology provides a further conducive environment for self-accessed, self-paced, and self-directed learning. In self-accessed learning, students learn how to access, analyse, process and present information using ICT tools and ICT sources. In self-directed learning, students are given the responsibility for directing, managing and planning their own learning. Self-paced learning — across grades (i.e., vertical integration) and across curriculum (i.e., horizontal integration) — 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 relatively dependent and passive towards a self-accessed, self-paced, and self-directed, the teacher's role undergoes, in tandem, an evolution from 'sage on the stage' to 'guide on the side.'

Additionally, the element of multiple intelligences and learning style is yet another distinguishing feature in the reinvention of teaching and learning process. This element is based on the notion of seven multiple intelligences espoused by Howard Gardner in his ground-breaking book, *Frames of Mind* (Gardner, 1983), which he later added two more additional intelligences as theorised in *Intelligence Reframed: Multiple Intelligences for the 21st Century* (Gardner, 1999). In essence, Gardner (1983, 1999) takes a pluralistic stance and argues that human beings are better described as having a set of relatively autonomous intelligences instead of a single or general intelligence.

However, it is important to stress that in the process of systematic reinvention in terms of teaching-learning practices for Smart schools, some existing elements are retained. In both Smart and Mainstream schools, there is a strong advocacy for the teaching of thinking skills (e.g., critical and creative thinking skills) and thinking strategies (e.g., step-by-step approaches in conceptualising, decision making, problem solving, and reasoning). Equally, it has been advocated that the planning for teaching and learning should take the constructivist elements into consideration, linking students' existing ideas with the new idea so as "to restructure their ideas" (CDC, 1999, p.12).

Science curricula for Smart and Mainstream schools place equal emphasis on the acquisition of science process skills, which should be inculcated, not in isolation and context-free environment, but within a science context in an integrated manner. Similar emphasis is advocated on inculcation of 16 noble values, namely, "compassion, self-reliance, respect, love, freedom, courage, physical and mental cleanliness, co-operation, diligence, moderation, gratitude, rationality, public spiritedness, humility, honesty, and justice" (SSPT, 1997a, p.32).

In essence, 11 science teaching elements could be crystallised from the discussion in the preceding paragraphs. These elements are: the use of ICT, self-directed learning, self-paced learning, self-accessed learning, mastery learning, constructivist practice, multiple intelligences and learning styles, student-centred learning, thinking skills and metacognition, science process skills, and values inculcation. The combination of these elements sets a framework from which students' smart science learning experience could be gauged.

PURPOSE OF THE STUDY

The purpose of this study was to gauge the perceptions of students in Smart and Mainstream schools on their science learning experience in terms of exposure to a range of science teaching approaches as advocated in the policy documents. This is deemed important, as there is a scarcity of research report that shows the extent to which the Smart Schools Initiative has taken root in classroom despite its 3-year rollout. Furthermore, students' perceptions are revealing in that they provide information on subtle but important aspects of classroom life (Fisher, 1994; Fraser, 1994). Additionally, the validity and reliability of students' perceptions on their teachers and learning environment are no longer a bone of contention (Ramsden, 1997). Moreover, judging by previous studies, such usage is widespread among highly respected researchers (Fraser, 1981; Hofstein & Lazarowitz, 1986; Kempa & Orion, 1996).

RESEARCH QUESTIONS

In the light of the foregoing review, this study examined the following research questions:

(1) Is there a difference in perceptions towards the science learning experience as measured by the revised Smart Science Learning Experience Inventory (SSLEI) between students from the Smart and Mainstream schools?

(2) Is there a difference in perceptions towards the smart science learning experience between the male and the female students?

(3) Is there a difference in perceptions towards the smart science learning experience among students at three different class levels (e.g., high, average and low)?

(4) Is there a three-way interaction among group (Smart or Mainstream schools), gender and class level in regard to the perceptions towards the smart science learning experience?

(5) Is there a two-way interaction between group and gender in regard to the perceptions towards the smart science learning experience?

(6) Is there a two-way interaction between group and class level in regard to the perceptions towards the smart science learning experience?

(7) Is there a two-way interaction between gender and class level in regard to the perceptions towards the smart science learning experience?

METHODOLOGY

Research Design

Survey technique by means of a questionnaire was used. From the nature of the study, this approach was chosen as it potentially allowed the views of all of the students to be elicited.

Instrumentation

The 24-item 6-point Likert scale (i.e., 0=Non existence; 1=Very Little; 2=Little; 3=Moderate; 4=Much; and 5=Very Much) revised Smart Science Learning Experience Inventory or SSLEI was used. Its development and validation has been reported in the previous issue of this journal (Ong & Ruthven, 2003). Likert-scaled items were chosen for use since our interest centred on the extent to which participants agreed or disagreed with a number of assertions about the smart science learning experience (Easterby-Smith, Thorpe, & Lowe, 2002).

The revised SSLEI with a Cronbach's alpha measuring at 0.89 comprised eight subscales of smart science learning experience. These subscales, which emerged from the results of a *varimax* rotated factor analysis, comprise some of the earlier 11 predetermined categories and the merger of the others. Cumulatively, these eight subscales accounted for 61.62% of the total variance explained. Table 1 summarises the indicators for the subscales and their alpha reliabilities.

Table 1
Subscale Indicators and Internal Consistency

Subscale	Item*	Indicator	Alpha Reliability
Information and Communication Technology (ICT)	27, 28, 29, 30	Teacher provides/encourages the use of computer hardware and software programmes in teaching and learning.	.81
Supported Learning (SP)	10, 11, 13, 14	Teacher plays an active and supportive role in ensuring progressive understanding of scientific concepts.	.73
Science Process Skills (SPS)	22, 23, 24	Teacher provides the learning tasks that involve hypothesizing, planning and/or carrying out a science investigative or laboratory-based work.	.69
Constructivist Practice (CP)	1, 2, 3	Teacher uncovers students' pre-instructional views, and provides learning activities to test their earlier views so that students construct an understanding of scientific concepts that mirrors the school science view.	.62
Self-Determined Learning (SDL)	7, 8, 9	Teacher allows the learning of topics that a student wants to, interests in, and decides upon within his/her current learning ability.	.64
Learning Preference (LP)	4, 5	Teacher provides appropriate learning experiences that match students' learning styles.	.64
Active Thinking (AT)	17, 18, 19	Teacher encourages students to explain, justify, and discuss using words, graphics and symbols within the context of student-student and student-teacher interactions.	.48
Values Inculcation (VI)	25, 26	Teacher relates current theoretical or practical work to noble values.	.50

* For the complete lists of 30-item SSLEI and 24-item revised SSLEI, see Ong and Ruthven (2003).

Nunnally (1967) recommends the threshold of 0.60 for the alpha reliability coefficient as being acceptable for research purposes. However, the internal consistency of *Active Thinking* and *Values Inculcation* subscales appear to be inadequate, each yielding an alpha of 0.48 and 0.50 respectively. Therefore, results for the subscale of *Active Thinking* in the revised SSLEI need to be interpreted with caution. The alpha coefficient of 0.50 for the *Values Inculcation* subscale, however, is deemed adequate as the subscale consists of only two items.

SUBJECTS AND PROCEDURES

The subjects were 186 male and 197 female students from two Smart schools and 177 male and 204 female students from two Mainstream schools in Malaysia. It was a purposive sampling on the basis of the schools' typicality and the judgement made in the selection process was, in part, informed through a consultation with two officers from the Malaysian Ministry of Education who played a key role in monitoring the Smart schools.

In each school, the administration of the SSLEI was done simultaneously for all the classes under the supervision of teachers in school time. A teacher's guide was prepared for the use of the respective class teachers. In the guide, teachers were asked to inform students that the questionnaire was not meant to be a test and hence, there was no right or wrong answer for each item. Instead, students were encouraged to express their views that best represented their science learning experience.

Data Analysis Procedures

A multivariate analysis of variance (MANOVA) would be performed on the revised SSLEI in order to test whether the centroid (vectors) of means of the combined subscales was the same for each of the three independent variables (i.e., group, gender, and class level).

The class levels were assigned based on the streaming done by the participating schools. The streaming was based on students' previous (i.e., Form 2) end-of-year overall assessment. As such, high-, average-, and low-achieving students generally refer to 'A', 'B & C', and 'D & E' graders respectively. A significant omnibus or overall F-test in MANOVA would be followed by univariate tests for the subscales to test for eventual subscale differences.

RESULTS

The results of the preliminary data analyses for normality and other statistical characteristics for the revised SSLEI and its eight subscales were satisfactory, indicating that the use of parametric methods was appropriate. In this MANOVA, the eight subscales served as the dependent variables while group, gender and class level served as the independent variables. A significant difference in the multivariate analysis for any of the independent variables or the interactions between/among them would be followed by univariate tests for the subscales. The results are reported with respect to each specific research question (RQ).

RQ1: Do students in Smart and Mainstream schools have different perceptions on smart science learning experience?

The results from the MANOVA indicated that there was a significant main effect of group (Smart or Mainstream schools) on the combined dependent variables of smart science learning experience [$F_{(8, 745)} = 20.81$, $p < .001$, Pillai's Trace = 0.18, partial _^{2} = 0.18]. To test for eventual subscale differences involving the groups, univariate ANOVAs were performed on the sum scores of eight subscales using Bonferroni adjusted alpha of 0.006. The descriptive statistics by group, and the results of ANOVAs are given in Table 1. The main effects of group were consistently significant for each of the eight subscales in the revised SSLEI.

Table 1
Means and Standard Deviations for Eight Subscales by Group, and Univariate ANOVA Results

Subscale	Smart Schools		Mainstream Schools		ANOVA		
	M	SD	M	SD	$F_{(1,752)}$	p	partial $\_^2$
ICT	6.74	4.84	3.61	4.54	74.72	.000*	.090
SL	14.66	3.07	12.19	4.02	97.85	.000*	.115
SPS	9.68	3.05	8.08	3.31	46.32	.000*	.058
CP	9.57	2.53	8.54	2.87	26.34	.000*	.034
SDL	8.02	2.93	7.08	3.47	15.97	.000*	.021
LP	6.79	1.91	5.86	2.24	40.56	.000*	.051
AT	8.57	2.70	7.14	3.13	38.44	.000*	.049
VI	5.54	2.69	4.89	2.92	9.07	.003*	.012

* Significant at $p < .006$ (Bonferroni adjusted alpha)

Key:

ICT	=	Information and Communication Technology	SL	=	Supported Learning
SPS	=	Science Process Skills	CP	=	Constructivist Practice
SDL	=	Self-Determined Learning	LP	=	Learning Preference
AT	=	Active Thinking	VI	=	Values Inculcation.

RQ2: Do boys and girls have different perceptions on smart science learning experience?

The results from the MANOVA indicated that there was no significant main effect of gender on the combined dependent variables of smart science learning experience [$F_{(8, 745)} = 1.44$, $p > .05$, Pillai's Trace = 0.02, partial $\_^2 = 0.02$]. Given the non-significant omnibus F-test, this will not be followed up by univariate ANOVAs to test for eventual subscale differences.

RQ3: Do high-, average-, and low-achieving students have different perceptions on smart science learning experience?

The results from the MANOVA indicated that there was a significant main effect of class level on the combined dependent variables of smart science learning experience [$F_{(16, 1492)} = 13.51$, $p < .001$, Pillai's Trace = 13.51, partial $\_^2 = 0.13$]. To test for eventual subscale differences involving the class levels, univariate ANOVAs were performed on the sum scores of eight subscales using Bonferroni adjusted alpha of .006. The between-subjects variable was class level. The descriptive statistics by class level, and the results of ANOVAs, together with Bonferroni Post Hoc tests, are given in Table 2.

The results from ANOVAs indicated that there were significant contributions from the ICT and SL subscales. Class level membership accounted for 18.1% and 1.6% of variance in scores for ICT and SL subscales respectively. For ICT subscale, the post-hoc tests revealed that significant differences were found between high- and average–achieving classes, high- and low-achieving classes, and average- and low-achieving classes. For SL subscale, the post hoc tests revealed that the low achievers rated their experience significantly lower in terms of SL than the average and high achievers. However, there was no significant difference between high- and average-achieving classes.

Table 2
Means and Standard Deviations for Eight Subscales by Class Level, and Univariate ANOVA Results

Sub-scale	Low		Average		High		ANOVA			Post Hoc
	M	SD	M	SD	M	SD	$F_{(2,752)}$	p	Partial _ [2]	test
ICT	8.09	4.68	4.48	4.69	2.96	4.01	83.28	.000*	.181	L>A>H
SL	12.95	4.33	13.54	3.33	13.80	3.68	6.29	.002*	.016	H=A>L
SPS	8.57	3.35	9.03	3.19	8.98	3.34	2.46ns	.007	-	
CP	9.40	2.67	8.73	2.82	9.14	2.68	3.79ns	.010	-	
SDL	8.03	3.09	7.22	3.24	7.50	3.35	3.92ns	.010	-	
LP	6.27	2.29	6.28	2.00	6.44	2.14	0.77ns	.002	-	
AT	8.32	2.87	7.43	2.97	7.95	3.15	5.05ns	.013	-	
VI	5.44	2.91	5.31	2.64	4.81	2.94	2.66ns	.007	-	

* Significant at $p < .006$ (Bonferroni adjusted alpha)
ns = non significant

Key:

ICT = Information and Communication TechnologyLearning
SL = Supported
SPS = Science Process Skills
CP = Constructivist Practice
SDL = Self-Determined Learning
LP = Learning Preference
AT = Active Thinking
VI = Values Inculcation

RQ4: Is there a three-way interaction among group, gender, and class level in regard to the perceptions towards the smart science learning experience?

The results from the MANOVA indicated that there was no significant 3-way school x gender x class level effect on the combined dependent variables of smart science learning experience [$F_{(16, 1492)}$ = 0.88, $p > .05$, Pillai's Trace = 0.02, partial _^{2} = 0.01]. Given the non-significant omnibus F test, this will not be followed up by univariate ANOVAs to test for eventual subscale differences.

RQ5: Is there a two-way interaction between group and gender in regard to the perceptions towards the smart science learning experience?

The results from the MANOVA indicated that there was a significant 2-way group x gender interaction effect on the combined dependent variables of smart science learning experience [$F_{(1, 752)}$ = 15.17, $p < .05$, Pillai's Trace = 0.02, partial _^{2} = 0.02].

The descriptive statistics by group and gender for all the eight subscale are given in Table 3. Analysis of each of the eight subscales, using a Bonferroni adjusted alpha of .006, showed that there was a significant contribution from *Constructivist Practice* (CP) [$F_{(16, 1492)}$ = 0.88, $p < .006$, partial _^{2} = 0.02]. The statistically significant group and gender interaction for CP is shown in Figure 1 in which the profile plots indicate a lack of parallelism. Visual inspection of the profile plots in Figure 1 shows that while the group difference for males is small, there is a substantial group difference for females.

Table 3
Means and Standard Deviations by Group and Gender for Eight Subscales

	Smart Schools (n=383)				Mainstream Schools (n=381)			
	Male (n=186)		Female (n=197)		Male (n=177)		Female (n=204)	
Subscale	M	SD	M	SD	M	SD	M	SD
ICT	6.68	4.80	6.79	4.88	3.72	4.57	3.52	4.53
SL	14.08	3.35	15.21	2.67	12.00	3.75	12.36	4.24
SPS	8.74	3.24	8.99	3.32	9.39	2.98	9.96	3.09
CP	9.18	2.68	9.94	2.33	8.95	2.47	8.18	3.14
SDL	7.95	2.87	8.09	2.99	7.14	3.32	7.03	3.60
LP	6.60	1.95	6.98	1.87	5.83	2.22	5.88	2.26
AT	8.40	2.74	8.72	2.66	7.34	3.00	6.97	3.24
VI	5.39	2.86	5.68	2.51	4.96	2.96	4.83	2.88

Key:

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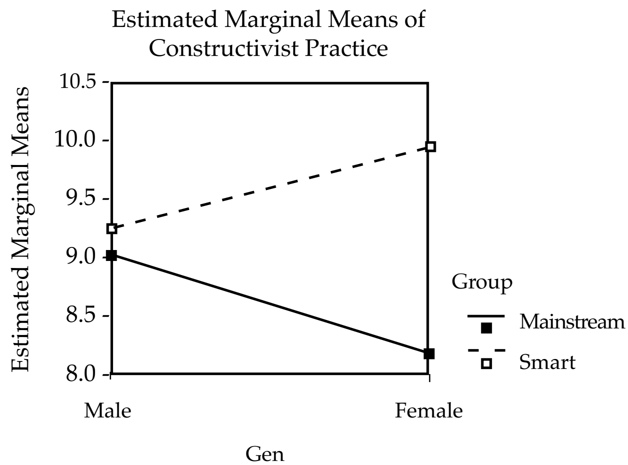

Figure 1: Constructivist Practice Profile Plots for Group and Gender Interaction

To test this statistically, a new independent variable consisting of four new cell codes was computed. This was then followed by a one-way ANOVA and post hoc tests. Using Tamhane Post Hoc Tests, the results indicated that in male ratings, there was no statistical difference between Smart and Mainstream schools (difference = 0.23, p = .953). However, in female ratings, the difference between the two groups (i.e., 1.76) was statistically significant ($p<.001$). This indicates that the main group difference for the CP subscale is attributable to the female ratings.

RQ6: Is there a two-way interaction between group and class level in regard to the perceptions towards the smart science learning experience?

The results from the MANOVA indicated that there was a significant 2-way group x gender interaction effect on the combined dependent variables of smart science learning experience [$F_{(16, 1492)}$ = 2.87, $p < .05$, Pillai's Trace = 0.06, partial _^{2} = 0.03].

The descriptive statistics by group and class level for all the eight subscales are given in Table 4. Analysis of each of the eight subscales, using a Bonferroni adjusted alpha of .006, showed that there was a significant contribution from *Information and Communication Technology* (ICT) [$F_{(2, 752)}$ = 10.32, $p < .006$, partial _^{2} = 0.03]. The statistically significant group and class level interaction for the ICT subscale is shown in the profile plots of Figure 2.

Table 4

Means and Standard Deviations by Group and Class Level for Eight Subscales

	Smart Schools (n=383)						Mainstream Schools (n=381)					
	High (n=100)		Average (n=150)		Low (n=133)		High (n=112)		Average (n=161)		Low (n=108)	
Sub-scale	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
ICT	4.52	4.70	6.70	4.70	8.45	4.43	1.56	2.58	2.40	3.63	7.55	4.95
SL	14.97	2.60	14.71	2.76	14.37	3.66	12.76	4.17	12.45	3.45	11.2	4.48
SPS	9.57	3.17	10.23	2.74	9.16	3.20	8.45	3.41	7.91	3.18	7.84	3.40
CP	9.92	2.39	9.18	2.56	9.74	2.56	8.44	2.75	8.32	3.00	8.97	2.76
SDL	8.30	3.01	7.68	2.92	8.20	2.85	6.79	3.49	6.80	3.47	7.82	3.35
LP	7.08	1.75	6.63	1.90	6.77	2.03	5.87	2.29	5.96	2.05	5.69	2.46
AT	8.57	3.09	8.33	2.51	8.83	2.59	7.40	3.11	6.60	3.13	7.68	3.07
VI	5.20	2.93	5.67	2.48	5.64	2.73	4.46	2.93	4.98	2.75	5.20	3.12

Key:

ICT = Information and Communication Technology
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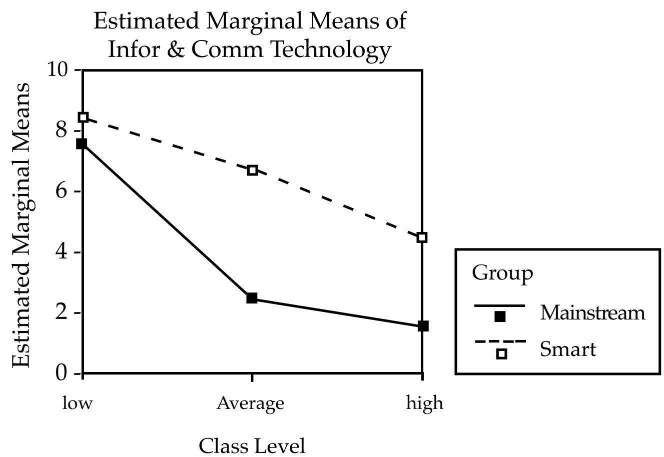

Figure 2: ICT Profile Plots for Group and Class Level Interaction

Visual inspection of the profile plots in Figure 2 shows a similar rating pattern for both Smart and Mainstream schools – the higher the self-report mean scores, the lower the students are in terms of class level. However, the self-report mean score in ICT for each of the class levels in the Smart schools was not uniformly higher than the corresponding class levels in the Mainstream schools.

To test this statistically, a new independent variable consisting six new cell codes was computed. This was then followed by a one-way ANOVA and post hoc tests. Using Tamhane Post Hoc Tests, the results indicated that the difference (i.e., 8.45 – 7.55 = 0.90) in the level of self-reported ICT experience between students from the Smart and Mainstream schools was not significant ($p = .897$) when they were from the low-achieving classes. However, when they were in average-achieving classes, students in the Smart schools reported higher level of ICT experience (i.e., 6.70 – 2.40 = 4.3) than students from the Mainstream schools which was statistically significant ($p<.001$). Equally, the difference (i.e., 4.52 – 1.56 = 2.96) was statistically significant ($p<.001$) when the students were from the high-achieving classes.

RQ7: Is there a two-way interaction between gender and class level in regard to the perceptions towards the smart science learning experience?

The results from the MANOVA indicated that there was a significant 2-way gender x class level interaction effect on the combined dependent variables of smart science learning experience [$F_{(16, 1492)} = 2.87$, $p < .05$, Pillai's Trace = 0.05, partial _^{2} = 0.02].

The descriptive statistics by gender and class level for all the eight subscales are given in Table 5. Analysis of each of the eight subscales, using a Bonferroni adjusted alpha of .006, showed that there were significant contributions from two subscales, namely, *Supported Learning* (SL) [$F_{(2, 752)} = 6.28$, $p < .006$, partial _^{2} = 0.02] and *Self-Determined Learning* (SDL) [$F_{(2, 752)} = 6.57$, $p < .006$, partial _^{2} = 0.02].

Table 5
Means and Standard Deviations by Gender and Class Level for Eight Subscales

	Male (n=363)						Female (n=401)					
	High (n=96)		Average (n=151)		Low (n=116)		High (n=116)		Average (n=160)		Low (n=125)	
Sub-scale	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
ICT	2.53	3.48	4.99	5.01	7.81	4.52	3.31	4.38	3.99	4.33	8.26	4.84
SL	14.15	3.34	13.09	3.21	12.15	4.30	13.52	3.94	13.98	3.39	13.70	4.24
SPS	9.13	3.32	8.81	3.39	8.33	2.97	8.85	3.36	9.23	3.00	8.79	3.67
CP	9.41	2.56	8.68	2.62	9.28	2.71	8.91	2.98	8.78	3.01	9.50	2.64
SDL	8.07	3.16	7.30	3.07	7.46	3.11	7.03	3.45	7.14	3.40	8.56	2.98
LP	6.42	2.16	6.13	1.89	6.19	2.37	6.46	2.13	4.43	2.10	6.38	2.23
AT	8.13	2.88	7.60	2.96	8.05	2.89	7.81	3.36	7.28	2.98	8.56	2.84
VI	4.94	3.15	5.51	2.68	4.85	2.99	4.71	2.77	5.13	2.59	5.90	2.77

Key:
ICT = Information and Communication Technology
SL = Supported Learning
SPS = Science Process Skills
CP = Constructivist Practice
SDL = Self-Determined Learning
LP = Learning Preference
AT = Active Thinking
VI = Values Inculcation

The statistically significant gender and class level interaction for the SL subscale is shown in the profile plots of Figure 3. Visual inspection of the profile plots in Figure 3 shows that, while female ratings are relatively stable across class levels, there is an appreciable trend for male ratings to rise as class level rises.

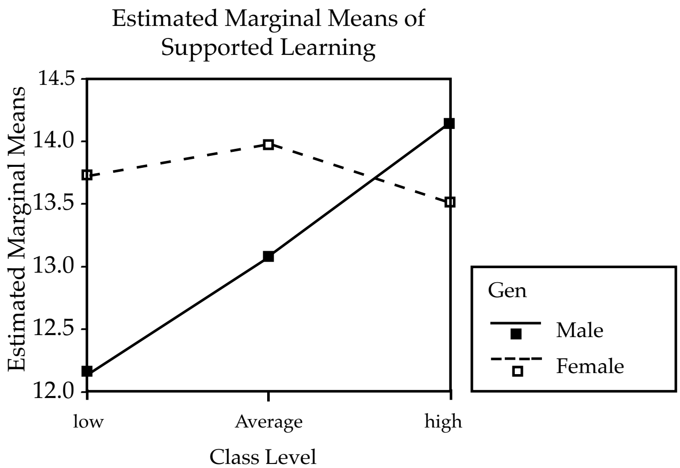

Figure 3: Supported Learning Profile Plots for Gender and Class Level Interactions

To test this statistically, a new independent variable consisting of six new cell codes was computed. This was then followed by a one-way ANOVA and post hoc tests. Using Tamhane Post Hoc Tests, the results indicated that in female ratings, there were no statistically significant differences between low- and average-achieving females (difference = 0.27, p = 1.000), low- and high-achieving females (difference = 0.19, p = 1.000), and average- and high-achieving females (difference = 0.46, p = 0.996). In male ratings, there was a significant difference between low- and high-achieving males (difference = 2.00, p = .003 <.01) although no significant differences were found between low- and average-achieving males (difference = 0.94, p = .540) and between average- and high-achieving males (difference = 2.06, p = .195). This indicates that the main class level effect is related to this trend in male ratings.

The statistically significant gender and class level interaction for the SDL subscale is shown in the profile plots of Figure 4. Visual inspection of the profile plots in Figure 4 shows that while male ratings are relatively stable across class levels, there is an appreciable trend for low-achieving females to rate highly than average- and high-achieving females.

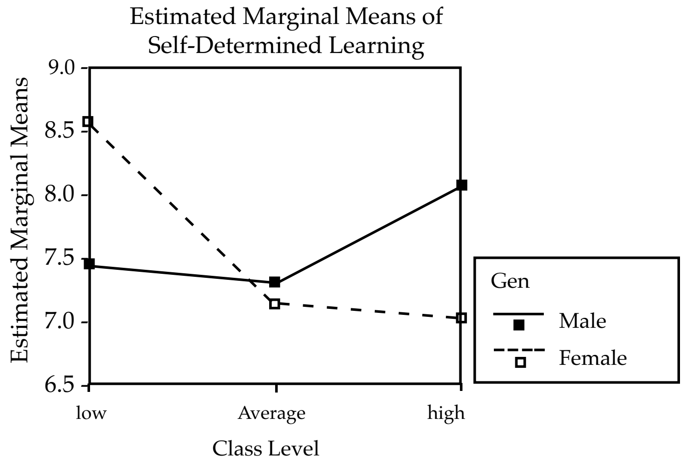

Figure 4: Self-Determined Learning Profile Plots for Gender and Class Level Interaction

To test this statistically, a new independent variable consisting of six new cell codes was computed. This was then followed by one-way ANOVA and post-hoc tests. Bonferroni Post Hoc Tests were used instead of Tamhane given that the Levene's test of homogeneity of variance was not significant ($p > .05$). The results indicated that in male ratings, there were no statistically significant differences between low- and average-achieving males (difference = 0.15, $p = .700$), low- and high-achieving males (difference = 0.62, $p = .164$) and average- and high-achieving males (difference = 0.77, p =. 067). In female ratings, there were significant differences between low- and average-achieving females (difference = 1.42, $p < .001$) and low-and high-achieving females (difference = 1.53, p

<.001) while no significant difference was found between average- and high-achieving females (difference = 0.12, p = .763). This indicates that the only difference in SDL ratings was between girls at different levels, with those at low class level rating SDL higher than those at average and high class levels.

DISCUSSIONS AND CONCLUSIONS

This study is novel and distinctive because the researchers were unaware of any published or unpublished studies that explored students' perceptions on smart science learning experience. Perhaps this could be explained by the infancy stage of the Smart Schools Initiative.

While there were Malaysian studies (i.e., Liau, Mustapha Kassim, & Chan, 2001; Liau & Arellano, 2003) conducted to examine certain psychosocial aspects of the classroom environment by means of the traslated Malay version of *Learning Environment Inventory*, or LEI (Fraser & Fisher, 1983), there was no Malaysian classroom environment study that analyses the data set by employing the 2 x 2 x 3 (group x gender x class level) MANOVA. This explains the reason why the researchers were unable to find any previous studies with which the findings of this study could be directly compared.

Broadly, students in the Smart schools reported a level of science learning experience in terms of ICT, *Supported Learning* (SL), *Science Process Skills* (SPS), *Constructivist Practice* (CP), *Self-Determined Learning* (SDL), *Learning Preference* (LP), *Active Thinking* (AT), and *Values Inculcation* (VI) which was appreciably higher that did students in the Mainstream schools.

While several studies revealed that females generally hold more favourable perceptions on their classroom environments than the perceptions of males in the same classes (i.e., Fisher, Fraser & Rickards, 1997; Fraser, Giddings, & McRobbie, 1995; Henderson, Fisher, & Fraser, 1995), this study indicated that there was no significant difference of perceptions between males and females taken as a whole. However, gender did moderate the main group or class level effect as evident in students' experiences of *Constructivist Practice* (CP), *Supported Learning* (SL), and *Self-Determined Learning* (SDL).

In relation to the CP experience, the main group effect was moderated by gender where girls in Smart schools reported a higher level of CP experience than girls in the Mainstream schools while the male ratings were relatively stable across the groups.

The class level effect on SL indicated that average- and high-achieving students reported significantly higher level of SL experience than low-achieving students. However, this class level effect occurred mainly among male students where male students at low class level tended to rate relatively lower than males at high class level.

In relation to SDL experience, there was neither a straightforward gender nor class level effect. However, there was a significant gender and class level interaction effect. While for the males, there was no significant difference between any of the class levels, for the females, low-achieving girls reported an appreciably higher level of SDL experience than average- and high-achieving girls.

The body of research points to the positive associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Fraser, 1994; Fraser & Fisher 1982; Fraser, Walberg, Welch, & Hattie, 1987; Haertel, Walberg, & Haertel 1981; McRobbie & Fraser 1993). Since the 1990s, girls have consistently outperformed boys in educational achievements as measured by the GCSE examination or other similar standardised examinations (Wong, Lam, & Ho, 2002). Lending further support, Demie (2001) reports that, "Whatever the pupils' ethnic origin, girls tend to perform at higher levels than boys at all key stages" (p.91). Therefore, when girls in

Smart schools reported a higher level of CP experience than girls in the Mainstream schools while the male ratings were relatively stable across the groups, this should be a cause for concern, lest the males be further marginalised and disadvantaged in terms of academic achievement with the advent of Smart Schools Initiative.

Fraser (1981) reports how feedback information based on student perceptions can be employed as a basis for reflection upon, discussion of, and systematic attempts to create better schools and classrooms. On that basis, it is then sensible to suggest that teachers in the Smart schools should strive to improve their pedagogical approaches through the judicious use of inventory such as the revised SSLEI to get feedback based on student perceptions. Equally, teachers in the Mainstream schools could also capitalise on such inventory to guide them when their schools are in the process of transforming into Smart schools.

This study focused on the perceptions of science learning experience amongst students in Smart and Mainstream schools. It would contribute significantly to the research and literature if the future research could aim at uncovering by means of student interviews, the various factors that could have led the males in the Smart schools to rate their science learning experience significantly lower than the girls. On a similar vein, various possible explanations for the phenomenon of low-achieving males to perceive a significantly lower supported learning experience than their female counterparts are worth exploring so that appropriate pedagogical support could then be provided. Equally, classroom observations could also be carried out to assess whether there is congruence between students' perceptions of smart science learning experience and actual classroom practices. These lead to the advocacy for a mixed methodology (i.e., Fraser & Tobin, 1991; Tobin & Fraser, 1998), combining the qualitative and quantitative methods which arguably, adds richness to the whole and enhances the credibility of the results.

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