Pertanika J. Soc. Sci. & Hum. 20 (4): 1117 - 1142 (2012)

PERTANIKA JOURNALS

SOCIAL SCIENCES & HUMANITIES

Journal homepage: http://www.pertanika.upm.edu.my/

Relationships between Actual and Preferred Science Learning Environment at Tertiary Level and Attitudes towards Science among Pre-Service Science Teachers

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ABSTRACT

Over the last four decades, researchers in many countries have shown increasing interest in the conceptualization, assessment, and investigation of students' perceptions of psychosocial dimensions of their classroom environment. Research conducted over the past 40 years has shown the quality of the classroom environment in schools to be a significant determinant of student learning. However, not many studies, especially in the state of Sabah, Malaysia, were conducted to examine the tertiary Science learning environment and its relationship with students' attitudes towards Science. The purpose of this study was to investigate the relationships between the perceptions of actual and preferred Science learning environment at tertiary level and the attitudes towards Science among pre-service science teachers in Sabah, Malaysia. This study was also aimed to ascertain the difference in students' perceptions of Science learning environment and the attitudes towards Science based on gender. This was a non-experimental quantitative research and survey method was used to collect data. Samples were selected by using a cluster random sampling technique. The College and University Classroom Environment Inventory (CUCEI) was adopted to measure pre-service Science teachers' perceptions of Science learning environment. Seven subscales of the CUCEI measured were Personalization, Cooperation, Student Cohesiveness, Equity, Task Orientation, Innovation, and Individualization. Pre-service Science teachers' attitudes towards science were measured using the 'Test of Science-Related Attitudes' (TOSRA). The seven subscales measured in TOSRA were Social Implications of Science, Normality of Scientists, Attitude to Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest

ARTICLE INFO

Article history:
Received: 30 May 2011
Accepted: 9 June 2011

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ISSN: 0128-7702

in Science. Independent samples *t*-test, Pearson product-moment correlation, and multiple linear regression analysis were used to test the stated null hypotheses at a predetermined significance level, alpha = .05. Correlation analysis results showed that there were low to moderate, positive and significant correlations between the actual and preferred Science learning environment and the attitudes towards science. CUCEI subscales can be used to explain appreciable amounts of variance in pre-service Science teachers' attitudes towards science.

Keywords: Science learning environment, attitudes towards science, pre-service science teachers, College and University Classroom Environment Inventroy (CUCEI), Test of Science-Related Attitudes (TOSRA)

BACKGROUND OF THE STUDY

Over the last four decades, researchers in many countries have shown increasing interest in the conceptualization, assessment, and investigation of students' perceptions of psychosocial dimensions of their classroom environment. A considerable amount of work on the assessment and investigation of classroom environment in schools has been conducted. These include studies on the associations between students' perception of interpersonal teacher behaviour and learning outcomes in primary Mathematics classrooms (Goh & Fraser, 1996) and environment-attitude associations in secondary Science classrooms (Wong & Fraser, 1996). In relation to this, the Harvard Project Physics of Walberg (Welch & Walberg, 1972) in the USA and the studies by Fraser (1981, 1986) in Australia are educationally noteworthy. Interest in the study of learning environments becomes more prominent when there is evidence that learning outcomes and students' attitudes towards learning are closely linked to the classroom environment. Studies were conducted to determine the degree of importance of the classroom environment in the teaching and learning processes. The nature of the classroom environment and psycho-social interactions can make a difference in how the students learn and achieve their goals (McRobbie, Roth & Lucas, 1997).

As highlighted by Goodman (1988), student-teachers are guided by past events that create intuitive screens through which new information is filtered and transformed, and that student-teachers' beliefs predict, to a certain extent, their teaching behaviours, and are much more influential than knowledge in determining their future teaching approaches. Today's pre-service Science teachers experienced yesterday's Science learning in the form of text-based, didactic lessons presenting the subject/Science as an inert body of knowledge (Tobin *et al.,* 1990). Pre-service Science teachers usually experience traditional Science learning where teachers are considered as sources of knowledge that should be transmitted to students. The long history of traditional Science learning experiences in primary, secondary, and tertiary levels powerfully impact the way in which pre-service science teachers understand the nature of Science and the

way in which Science should be taught. Consequently, pre-service Science teachers' mental models about Science teaching are usually incompatible with Science teaching as a hands-on and minds-on activity.

PROBLEM STATEMENT

Research conducted over the past 40 years has shown the quality of the classroom environment in schools to be a significant determinant of student learning (Fraser, 1994; 1998). That is, students learn better when they perceive the classroom environment positively. Numerous research studies have shown that students' perception of the classroom environment accounts for appreciable amounts of variance in learning outcomes, often beyond that attributable to background students' characteristics. In the Malaysian context, despite limited efforts in other educational levels, study of learning environment in one crucial dimension of education in Malaysia, teacher education, is not yet explored.

Considerable work (e.g., Ferguson & Fraser, 1996; Rickards *et al.,* 1997; Suarez *et al.,* 1998) carried out with respect to gender and Science education showed that male and female students perceive their learning environment differently. Research on gender differences in classroom environment perceptions has also been conducted in various countries (Fisher *et al.,* 1997; Fisher *et al.,* 1997; Fraser *et al.,* 1995; Henderson *et al.,* 2000; Wong & Fraser, 1997). However, differences in the perceptions of actual and preferred tertiary Science learning environment and the attitudes towards Science based on gender among pre-service science teachers are not yet investigated. Due to the deficient understanding of perceptions of tertiary Science learning environment and its association with attitudes towards Science, this study was aimed to investigate the association betweeen perceptions of tertiary Science learning environment and the attitudes towards Science among primary and secondary school pre-service Science teachers in the state of Sabah, Malaysia.

OBJECTIVES OF THE STUDY

This study attempted to achieve the following objectives:-

i. to ascertain if the 'College and University Classroom Environment Inventory' (actual and preferred version of CUCEI) and the 'Test of Science-Related Attitudes' (TOSRA) are valid and reliable instruments when used in the Sabah context;

ii. to gauge the perceptions of actual and preferred tertiary Science learning environment among primary and secondary school pre-service Science teachers in Sabah;

iii. to gauge the attitudes towards science among primary and secondary school pre-service Science teachers in Sabah;

iv. to determine the difference in the perceptions of actual and preferred tertiary Science learning environment and attitudes towards Science based on gender;

v. to investigate the associations between the perceptions of actual and preferred tertiary Science learning environment and the attitudes towards Science among primary and secondary school pre-service Science teachers in Sabah.

RESEARCH HYPOTHESES

Four null hypotheses formed to be tested in this study are:

i. There is no significant difference in the perception of actual tertiary Science learning environment between male and female pre-service Science teachers in Sabah.

ii. There is no significant difference in the perception of preferred tertiary Science learning environment between male and female pre-service Science teachers in Sabah.

iii. There is no significant difference in the attitudes towards Science between male and female pre-service Science teachers in Sabah.

iv. There is no significant association between the perceptions of actual and preferred tertiary Science learning environment and attitudes towards Science among primary and secondary school pre-service Science teachers in Sabah.

DEFINITION OF TERMS

Some of the terms used in this study are defined as follows:

Learning Environment refers to a space or a place where learners and teachers interact with each other and use a variety of tools and information resources in their pursuit of learning activities (Wilson, 1996). In this study, seven essential aspects of the tertiary Science learning environment investigated are Student Cohesiveness, Individualization, Innovation, Cooperation, Personalization, Equity, and Task Orientation.

Students Cohesiveness refers to the extent to which pre-service Science teachers know, help, and are friendly towards each other.

Individualization refers to the extent to which pre-service Science teachers are allowed to make decisions and treated differently according to ability, interest, and rate of working.

Innovation refers to the extent to which the instructor (lecturer) plans new, unusual class activities, teaching techniques, and assignments.

Cooperation refers to the extent to which pre-service Science teachers cooperate rather than compete with one another on learning tasks.

Personalization refers to the emphasis on opportunities for individual pre-service Science teacher to interact with the instructor and on concern for pre-service Science teachers' personal welfare.

Equity refers to the extent to which pre-service Science teachers are treated equally by the instructor.

Task Orientation refers to the extent to which class activities are clear and well organized.

The Attitudes towards Science

Klopfer (1971) has alleviated the semantic problems associated with the multiple meanings attached to the term 'attitude to science' by providing a comprehensive classification scheme for Science education aims in which six conceptually different categories of attitudinal aims are distinguished. These six categories involve distinctions between the Attitudes to Science and Scientists (H.1), Attitude to Inquiry (H.2), Adoption of Scientific Attitudes like curiosity and open-mindedness (H.3), Enjoyment of Science Learning Experiences (H.4), Interest in Science Learning Experiences (H.5), and Interest in a Career in Science (H.6). In this study, the seven distinct science-related attitudes measured are defined as follows:

Social Implications of Science (S) scale measures one aspect of manifestation of favourable attitudes towards Science which has been afforded importance in the science education literature (Zoller & Watson, 1974; Fraser, 1977a), namely, the attitude towards the social benefits and problems which accompany scientific progress.

Normality of Scientists (N) scale measures one aspect of manitestation of favourable attitudes towards scientists given prominence in Science education, namely, an appreciation that scientists are normal people rather than the eccentrics often depicted in the mass media (Mead & Metraux, 1957; Fraser, 1977b).

*Attitude to Scientific Inquiry (I) sc*ale measures attitude to scientific experimentation and inquiry as ways of obtaining information about the natural world.

Adoption of Scientific Attitudes (A) scale measures specific attitudes (e.g., open-mindedness, willingness to revise opinions, etc) as being of considerable importance in the work as scientists (Cohen, 1971).

Enjoyment of Science Lessons (E) refers to the enjoyment of Science learning experiences (Klopfer, 1971).

Leisure Interest in Science (L) refers to the development of interest in Science and science-related activities (Klopfer, 1971).

Career Interest in Science (C) refers to the development of interest in pursuing a career in Science (Klopfer, 1971).

RESEARCH DESIGN

This was a non-experimental quantitative research. Non-experimental research is a systematic empirical inquiry in which the researcher does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable. Hence, inferences about the relations among variables are made, without direct intervention, from concomitant variation of independent and dependent variables (Johnson & Christensen, 2000). Survey method was used to collect the required data. In this study, the College and University Classroom Environment Inventory (CUCEI), developed by Fraser *et al.* (1987), was used to gauge students' perceptions of tertiary Science learning environment, such as Personalization, Cooperation, Student Cohesiveness, Equity, Task Orientation,

Innovation, and Individualization. On the other hand, students' attitude towards Science was measured using the Test of Science-Related Attitudes (TOSRA). The seven subscales measured were Social Implications of Science, Normality of Scientists, Attitude to Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, and Career Interest in Science.

RESEARCH SAMPLES AND SAMPLING METHOD

A group of primary and secondary school pre-service Science teachers were selected by using cluster random sampling technique from the Teacher Education Institute - Kent Campus and School of Education and Social Development, Universiti Malaysia Sabah, respectively. Universiti Malaysia Sabah is one of the public higher education institutions, which is responsible for the training of pre-service secondary school Science teachers, whereas the Teacher Education Institute – Kent Campus is one of the teachers' education institutions which is responsible for the training of pre-service primary school Science teachers in Malaysia. The samples consisted of 23 males (47%) and 27 female (54%) pre-service Science teachers.

INSTRUMENTATION

The College and University Classroom Environment Inventory (CUCEI) and the Test of Science-Related Attitudes (TOSRA) were used to gauge pre-service Science teachers' perceptions of actual and preferred tertiary science learning environment and attitudes towards science, respectively.

The College and University Classroom Environment Inventory (CUCEI)

In this study, students' perception of tertiary Science learning environment was measured by using the modified and personalized form of the 'College and University Classroom Environment Inventory' (CUCEI) specially developed by Fraser *et al*. (1987). CUCEI was developed to assess the perceptions of the psycho-social environment in university and college classrooms. Originally, CUCEI was developed for use with small groups of about 30 students in seminars and tutorials in higher education classrooms (Fraser & Treagust, 1986; Fraser, Treagust, & Dennis, 1986). The final form of CUCEI contains seven scales: Personalization, Cooperation, Student Cohesiveness, Equity, Task Orientation, Innovation, and Individualization. Each scale comprises seven items, making a total of 49 items in all. There are five responses provided for each item, namely, 'Almost Never', 'Seldom', 'Sometimes', 'Often', and 'Almost Always'. Validation of CUCEI conducted by Fraser and Treagust (1986) yielded scale alpha reliabilities ranging from .70 to .90. Learning environment instruments are typically produced in two forms - actual and preferred. Meanwhile, the actual form asks students to describe their actual classroom learning environment, and in the preferred form, students are asked to describe their preferred or ideal learning environment. The distribution of the CUCEI

items according to its seven subscales is shown in Table 1 below:

The Test of Science-Related Attitudes (TOSRA)

Test of Science-Related Attitudes (TOSRA) was developed by Fraser (1981), and it was designed to measure seven distinct science-related attitudes among secondary school students. These scales are called Social Implication of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Lessure Interest in Science, and Career Interest in Science. The seven scales are suitable for group administration and all can be administered within the duration of a normal class lesson. Furthermore, TOSRA has been carefully developed and extensively field tested and shown to be reliable (alpha = .97). The distribution of TOSRA items according to its seven subscales is shown in Table 2:

TOSRA items involve a response format which requires students to express their degree of agreement with each statement on a five-point Likert scale consisting of the following responses: Strongly Agree (SA), Agree (A), Not Sure (N), Disagree (D), and Strongly Disagree (SD). For positive items, the responses SA, A, N, D, and SD are scored as 5, 4, 3, 2, and 1, respectively. For negative items (denoted by *), the responses SA, A, N, D, and SD are scored 1, 2, 3, 4 and 5, respectively. Omitted or invalid responses are scored 3. The seven separate scale scores are obtained by adding the scores obtained on all items within a given scale. Since each scale contains 10 items, the minimum and maximum scores possible on each scale are 10 and 50, respectively.

DATA COLLECTION

Before administering the CUCEI and TOSRA instrument, formal permission from the related authorities was sought and obtained. The CUCEI and TOSRA were personally-administered by the researchers. Students were gathered in a lecture room at respective institutions and

TABLE 1
Item Distribution of CUCEI according to its Seven Subscales

Subscales	Item No.	No. of Items
Personalization	1, 2, 3, 4, 5, 6, 7*	7
Innovation	8*, 9, 10, 11, 12*, 13, 14*	7
Student Cohesiveness	15*, 16, 17, 18*, 19*, 20, 21*	7
Task Orientation	22, 23, 24*, 25*, 26, 27*, 28	7
Cooperation	29, 30, 31, 32, 33, 34, 35	7
Individualization	36*, 37, 38, 39, 40, 41*, 42*	7
Equity	43, 44, 45, 46, 47, 48, 49	7
	Total	49

* denotes negative item

TABLE 2
Item Distribution of TOSRA according to its Seven Subscales

Subscales	Item No.	No. of Items
Social Implications of Science (S)	1, 8*, 15, 22*, 29, 36*, 43, 50*, 57, 64*	10
Normality of Scientists (N)	2*, 9, 16*, 23, 30*, 37, 44*, 51, 58*, 65	10
Attitude to Scientific Inquiry (I)	3, 10*, 17, 24*, 31, 38*, 45, 52*, 59, 66*	10
Adoption of Scientific Attitudes (A)	4, 11*, 18, 25*, 32, 39*, 46, 53*, 60, 67*	10
Enjoyment of Science Lessons (E)	5, 12*, 19, 26*, 33, 40*, 47, 54*, 61, 68*	10
Leisure Interest in Science (L)	6, 13*, 20, 27*, 34, 41*, 48, 55*, 62, 69*	10
Career Interest in Science (C)	7* 14, 21*, 28, 35*, 42, 49*, 56, 63*, 70	10
	Total	70

* denotes negative item

the the instruments were administered to the students concurrently. The students were informed about the nature of the instruments and how the instruments should be answered. The students were asked to read the statements pertaining to the attitudes towards Science and to indicate their degree of agreement or disagreement with the statement, i.e. 'Strongly Agree', 'Agree', 'Not Sure', 'Disagree' or 'Strongly Disagree'. The students were also asked to read the statements pertaining to the tertiary Science learning environment (actual and preferred) and then indicate their responses ranging from 'Almost Never', 'Seldom', 'Sometimes', 'Often', and 'Almost Always'. The instruments took about half an hour to be completed.

DATA ANALYSIS

Descriptive statistics were used to describe the perceptions of tertiary Science learning environment and the attitudes towards Science among pre-service science teachers in Sabah. Among the descriptive statistics used were mean, standard deviation, and range. On the other hand, as an effort to ensure all the quantitative, data were drawn from a normally distributed population, graphical measures such as histogram, stem-and-leaf plot, normal Q-Q plot, and detrended normal Q-Q plot were plotted for each of the variables studied. Furthermore, numerical measures such as skewness and kurtosis were used to identify any deviations from normal distributions (Hair, Anderson, Tatham, & Black, 1998; Miles & Shevlin, 2001). After the assumptions of using the parametric techniques in analyzing

quantitative data were met, independent sample *t*-test, Pearson product-moment correlation, and multiple linear regression analysis were used to test the stated null hypotheses at a predetermined significance level, alpha = .05.

Independent sample *t*-test was used to determine the difference in the perceptions of tertiary Science learning environment (actual and preferred) and the attitudes towards science between male and female pre-service Science teachers. Meanwhile, Pearson product moment correlation was used to identify possible significant linear relationships among students' perceptions of Science learning environment and their attitudes towards Science. In order to investigate the strength of the associations between students' perceptions of Science learning environment and their attitudes towards Science, simple correlation coefficients were calculated between each scale of the CUCEI and TOSRA instrument.

A stepwise multiple linear regresssion analysis was conducted to test the association of each of the CUCEI scales with each scale of TOSRA when all the other scales were held controlled. Stepwise variables selection method was used in order to get a parsimonious model which could explain most of the variance in students' attitudes towards Science by using the least number of the CUCEI scales. Assumptions (namely, normality, homoscedasticity, linearity, and independence) were also met prior to the multiple linear regression analysis. On the other hand, distance statistics (leverage measure and Cook's distance) and influence statistics (DfBeta and DfFit) were used to identify outliers and influential observations in the data. In order to detect multicollinearity among the independent variables used in this study, correlation matrices, Tolerance (T) and Variance Inflation Factor (VIF) were also used (Hair *et al*., 1998).

RESEARCH FINDINGS AND DISCUSSION

The reliability and validation of the CUCEI and TOSRA instrument are described in detail. This is followed by a description of pre-service science teachers' perceptions of actual and preferred tertiary science learning environment and attitudes towards science and its difference based on gender. The associations between the perceptions of actual and preferred tertiary science learning environment and attitudes towards science are also discussed.

Reliability and Validation of the CUCEI Instrument

The collected data were analyzed to test the internal consistency of the actual and preferred form of the CUCEI scales. For the actual form of CUCEI, it was found that the Cronbach's Alpha reliability ranged from .464 (Innovation) to .917 (Equity), except for Individualization which showed a low reliability of .288. Overall, the Cronbach's Alpha reliability of the actual form of CUCEI was found to be high (.895) (see Table 3). On the other hand, for the preferred form of CUCEI, the Cronbach's Alpha reliability ranged from .562 (Task

Orientation) to .942 (Cooperation), except for Individualization which showed a low reliability of .462. Overall, the Cronbach's Alpha reliability of the preferred form of CUCEI was found to be high, i.e. .904 (Table 3). These figures were comparable to the results reported by Fraser *et al*. (1987). Hence, these findings supported the cross-cultural validity of the classroom environment scales when used for the first time in Sabah context. Each scale in CUCEI was found to display a satisfactory internal consistency reliability.

The discriminant validity is described as the extent to which a scale measures a unique dimension not covered by the other scales in the instrument. Table 4 and Table 5 indicate that the mean correlations of the scales in the actual and preferred forms of CUCEI ranged from .193 to .357 and .322 to .480, respectively. From these figures, CUCEI appears to measure distinct although somewhat overlapping aspects of classroom environment, but maintaining distinctions between each scale in each of the seven dimensions of the instrument.

Reliability and Validation of the TOSRA instrument

On the other hand, the collected data were also analyzed to test the internal consistency of the TOSRA scales. It was found that the Cronbach's Alpha reliability ranged from .620 (Normality of Scientists, N) to .853 (Career Interest in Science, C). Overall, the Cronbach's Alpha reliability of TOSRA was found to be high (.947) (Table 6). Hence, these findings supported the cross-cultural validity of the TOSRA scales when used in the context of Sabah. Each scale in TOSRA was found to display a satisfactory internal consistency reliability.

Table 7 indicates that the mean correlations of the scales in TOSRA ranged from .426 to .714. From these figures, TOSRA appears to measure distinct although somewhat overlapping aspects of attitudes towards Science, but maintaining

TABLE 3
Cronbach's Alpha Reliability of the Actual and Preferred Forms of CUCEI

Subscales	Item No.	Cronbach's Alpha Reliability Coefficients	
		Actual	Preferred
Personalization	1, 2, 3, 4, 5, 6, 7*	.801	.784
Innovation	8*, 9, 10, 11, 12*, 13, 14*	.464	.575
Student Cohesiveness	15*, 16, 17, 18*, 19*, 20, 21*	.806	.674
Task Orientation	22, 23, 24*, 25*, 26, 27*, 28	.511	.562
Cooperation	29, 30, 31, 32, 33, 34, 35	.875	.942
Individualization	36*, 37, 38, 39, 40, 41*, 42*	.288	.462
Equity	43, 44, 45, 46, 47, 48, 49	.917	.904
Overall		.895	.904

* denotes negative item

TABLE 4
Discriminant Validity of the Actual Form of CUCEI

	Personalization	Cooperation	Student Cohesiveness	Equity	Task Orientation	Innovation	Individualization	Mean correlation
Personalization	-	.215	.212	.457**	.375*	.362*	.460**	.347
Cooperation	.215	-	.437**	.555**	.395**	-.015	.275	.315
Student Cohesiveness	.212	.437**	-	.421**	.428**	-.075	.349*	.320
Equity	.457**	.555**	.421**	-	.369*	.208	.127	.356
Task Orientation	.375*	.395**	.428**	.369*	-	.166	.409**	.357
Innovation	.362*	-.015	-.075	.208	.166	-	.329*	.193
Individualization	.460**	.275	.349*	.127	.409**	.329*	-	.325

** Correlation is significant at 0.01 level (2-tailed)
* Correlation is significant at 0.05 level (2-tailed)
Listwise N=46

TABLE 5
Discriminant Validity of the Preferred Form of CUCEI

	Personalization	Cooperation	Student Cohesiveness	Equity	Task Orientation	Innovation	Individualization	Mean correlation
Personalization	-	.646**	.230	.626**	.448**	.574**	.294	.470
Cooperation	.646**	-	.310*	.754**	.372*	.431**	.315*	.471
Student Cohesiveness	.230	.310*	-	.246	.534**	.208	.401**	.322
Equity	.626**	.754**	.246	-	.215	.393**	.240	.412
Task Orientation	.448**	.372*	.534**	.215	-	.576**	.390**	.423
Innovation	.574**	.431**	.208	.393**	.576**	-	.696**	.480
Individualization	.294	.315*	.401**	.240	.390**	.696**	-	.389

** Correlation is significant at 0.01 level (2-tailed)
* Correlation is significant at 0.05 level (2-tailed)
Listwise N=44

TABLE 6
Cronbach's Alpha Reliability of the TOSRA Instrument

Subscales	Item No.	Cronbach's Alpha Reliability Coefficients
Social Implications of Science (S)	1, 8*, 15, 22*, 29, 36*, 43, 50*, 57, 64*	.666
Normality of Scientists (N)	2*, 9, 16*, 23, 30*, 37, 44*, 51, 58*, 65	.620
Attitude to Scientific Inquiry (I)	3, 10*, 17, 24*, 31, 38*, 45, 52*, 59, 66*	.760
Adoption of Scientific Attitudes (A)	4, 11*, 18, 25*, 32, 39*, 46, 53*, 60, 67*	.645
Enjoyment of Science Lessons (E)	5, 12*, 19, 26*, 33, 40*, 47, 54*, 61, 68*	.844
Leisure Interest in Science (L)	6, 13*, 20, 27*, 34, 41*, 48, 55*, 62, 69*	.819
Career Interest in Science (C)	7* 14, 21*, 28, 35*, 42, 49*, 56, 63*, 70	.853
Overall		.947

* denotes negative item

TABLE 7
Discriminant Validity of the TOSRA Instrument

	Social Implications of Science (S)	Normality of Scientists (N)	Attitude to Scientific Inquiry (I)	Adoption of Scientific Attitudes (A)	Enjoyment of Science Lessons (E)	Leisure Interest in Science (L)	Career Interest in Science (C)	Mean correlation
Social Implications of Science (S)	-	.498**	.254	.560**	.648**	.549**	.672**	.530
Normality of Scientists (N)	.498**	-	.280	.529**	.614**	.519**	.644**	.514
Attitude to Scientific Inquiry (I)	.254	.280	-	.499**	.529**	.461**	.530**	.426
Adoption of Scientific Attitudes (A)	.560**	.529**	.499**	-	.697**	.623**	.696**	.601
Enjoyment of Science Lessons (E)	.648**	.614**	.529**	.697**	-	.794**	.890**	.695
Leisure Interest in Science (L)	.549**	.519**	.461**	.623**	.794**	-	.854**	.633
Career Interest in Science (C)	.672**	.644**	.530**	.696**	.890**	.854**	-	.714

** Correlation is significant at 0.01 level (2-tailed).
Listwise N=38

distinctions between each scale in each of the seven dimensions in the instrument.

Pre-Service Science Teachers' Perceptions of Actual and Preferred Tertiary Science Learning Environment

Table 8 shows the mean and standard deviation of pre-service Science teachers' perceptions of the actual and preferred tertiary Science learning environment.

As shown in Table 8, the overall mean value of the students' perceptions of the actual tertiary Science learning environment (M = 3.609, SD = .384) revealed that the students perceived the Science learning environment at tertiary level as positive. This finding implies importantly that these pre-service science teachers, having experienced positive learning environments at the university and teacher education institute, would be more inclined to establish positive learning environments in their classroom to enhance their students' learning. This would definitely reinforce the need to create a positive learning environment as emphasized in the teacher education programmes.

In relation to this, pre-service Science teachers' perceptions of the actual Science learning environment in descending order are Cooperation (M = 4.161, SD = .584), Student Cohesiveness (M = 4.159, SD = .767), Personalization (M = 3.801, SD = .596), Equity (M = 3.791, SD = .814), Task Orientation (M = 3.534, SD = .445), Individualization (M = 3.037, SD = .424), and Innovation (M = 2.780, SD = .544). Pre-service Science teachers perceived that they cooperate rather than compete with one another on Science learning tasks, as well as know, help and are friendly towards each other. They also perceived that the opportunities for individual pre-service teacher to interact with the instructor and concern for their personal welfare were taken care of. However, they perceived that the instructors were not so innovative to plan new, unusual class activities, teaching

TABLE 8
Mean and Standard Deviation of Pre-Service Science Teachers' Perceptions of Actual and Preferred Tertiary Science Learning Environment based on to the CUCEI Subscales

Subscales	No. of Items	*M*		*SD*		Range	
		Actual (n=46)	Preferred (n=44)	Actual (n=46)	Preferred (n=44)	Actual (n=46)	Preferred (n=44)
Personalization	7	3.801	4.354	.596	.513	2.143	2.286
Cooperation	7	4.161	4.671	.584	.507	1.857	2.143
Student Cohesiveness	7	4.159	4.133	.767	.758	3.143	2.857
Equity	7	3.791	4.500	.814	.603	3.571	2.429
Task Orientation	7	3.534	4.069	.445	.583	1.857	1.857
Innovation	7	2.780	3.591	.544	.636	2.286	2.571
Individualization	7	3.037	3.490	.424	.597	1.857	2.286
Overall	49	3.609	4.299	.384	.423	1.673	2.000

techniques and assignments in conducting science-related courses. They also perceived that they were not allowed to make decisions and were not treated differently according to ability, interest, and rate of working.

In constrast, pre-service Science teachers prefer and hope for a better Science learning environment (M = 4.299, SD = .423) in most of the CUCEI subscales, especially Cooperation (M = 4.671, SD = .507) and Equity (M = 4.500, SD = .603). They prefer a Science learning environment, whereby they cooperate rather than compete with one another on science learning tasks. At the same time, they are treated equally by the instructor.

Pre-Service Science Teachers' Attitudes towards Science

Table 9 shows the mean and standard deviation of pre-service Science teachers' attitudes towards Science.

As shown in Table 9, the overall mean value of the students' attitudes towards Science (M = 3.648, SD = .436) showed that they possessed positive attitudes towards the subject. Generally, pre-service Science teachers enjoyed their Science learning experiences. They adopted specific attitudes as being of considerable importance in the work as scientists, and they also showed favourable attitudes towards the social benefits and problems which accompany scientific progress. In relation to this, pre-service Science teachers' attitudes towards Science in descending order are Enjoyment of Science Lessons (M = 3.982, SD = .547), Adoption of Scientific Attitudes (M = 3.784, SD = .456), Social Implications of Science (M = 3.745, SD = .456), Career Interest in Science (M = 3.687, SD = .607), Attitude to Scientific Inquiry (M = 3.597, SD = .574), Leisure Interest in Science (M = 3.555, SD = .645), and Normality of Scientists (M = 3.184, SD = .487).

Mean Difference in the Perceptions of Actual and Preferred Tertiary Science Learning Environment between Male and Female Pre-Service Science Teachers

The first and second null hypothesis was tested by using the Independent sample

TABLE 9
Mean and Standard Deviation of Pre-Service Science Teachers' Attitudes towards Science according to TOSRA Subscales (N = 38)

Subscales	No. of Items	*M*	*SD*	Range
Social Implications of Science (S)	10	3.745	.456	.190
Normality of Scientists (N)	10	3.184	.487	.200
Attitude to Scientific Inquiry (I)	10	3.597	.574	.240
Adoption of Scientific Attitudes (A)	10	3.784	.456	.210
Enjoyment of Science Lessons (E)	10	3.982	.547	.230
Leisure Interest in Science (L)	10	3.555	.645	.280
Career Interest in Science (C)	10	3.687	.607	.260
Overall	70	3.648	.436	1.886

t-test at a specified significance level, alpha = .05. As shown in Table 10, independent sample *t*-test results showed that there is no significant difference in the perception of the actual tertiary Science learning environment between male and female pre-service science teachers (t = -1.795, p = .080). At the same time, no significant difference in the perception of the preferred tertiary science learning environment was found between the male and female pre-service Science teachers (t = -1.753, p = .095) (Table 11). Hence, these findings failed to reject the first and second null hypotheses.

Generally, the female students perceived their tertiary Science learning environment more favourably as compared to their male counterparts. However, the mean differences were not statistically significant except for the subscales of Student Cohesiveness, Cooperation, and Equity. This means the female students perceived that they know, help, and are friendly towards each other, cooperate rather than compete with one another on Science learning tasks, and are treated equally by the instructors.

These findings were supported by previous research findings on gender differences in classroom environment perceptions. For example, in a study by Goh and Fraser (1997), they found that at primary school level, the girls in Singapore generally viewed their classroom environments more favourably than boys.

TABLE 10
Mean Difference in the Perceptions of the Actual Tertiary Science Learning Environment Based on Gender

Subscales	Gender	*n*	*M*	*SD*	Mean Difference	Effect Size	*t*	*df*	*p*
Personalization	Male	21	3.734	.643	.142	.237	-.767	42	.448
	Female	23	3.876	.578					
Cooperation	Male	21	4.047	.588	.152	.259	-.871	42	.389
	Female	23	4.199	.563					
Student Cohesiveness	Male	21	3.769	.826	.741	.965	-3.523	42	.001**
	Female	23	4.510	.553					
Equity	Male	21	3.667	.647	.264	.325	-1.061	42	.295
	Female	23	3.931	.963					
Task Orientation	Male	21	3.463	.531	.114	.258	-.841	42	.405
	Female	23	3.577	.369					
Innovation	Male	21	2.823	.493	.114	.212	.689	42	.495
	Female	23	2.709	.604					
Individualization	Male	21	2.946	.518	.147	.348	-1.129	32.450	.267
	Female	23	3.093	.315					
Overall	Male	21	2.445	.291	.144	.537	-1.795	42	.080
	Female	23	2.589	.242					

** p < .01; The effect size is the mean difference divided by the pooled standard deviation.

TABLE 11
Mean Difference in the Perceptions of the Preferred Tertiary Science Learning Environment Based on Gender

Subscales	Gender	*N*	*M*	*SD*	Mean Difference	Effect Size	*t*	*df*	*p*
Personalization	Male	16	4.197	.592	.210	.409	-1.311	40	.197
	Female	26	4.407	.444					
Cooperation	Male	16	4.321	.573	.542	1.068	-3.416	21.850	.002**
	Female	26	4.863	.346					
Student Cohesiveness	Male	16	3.901	.880	.439	.579	-1.923	40	.062
	Female	26	4.340	.601					
Equity	Male	16	4.126	.745	.571	.950	-2.852	19.988	.010**
	Female	26	4.697	.384					
Task Orientation	Male	16	3.973	.602	.158	.272	-.866	40	.392
	Female	26	4.131	.561					
Innovation	Male	16	3.687	.763	.154	.243	.746	40	.460
	Female	26	3.533	.575					
Individualization	Male	16	3.446	.739	.087	.145	-.442	40	.661
	Female	26	3.533	.528					
Overall	Male	16	2.765	.389	.186	.625	-1.753	20.605	.095
	Female	26	2.951	.212					

** $p < .01$; The effect size is the mean difference divided by the pooled standard deviation.

In Fisher and Rickards' (1998) study, statistically significant gender differences were detected in students' responses to classroom environment scales. They found that the females perceived their teachers in a more positive way compared to the males.

Research on gender differences in classroom environment perceptions has also been conducted in various countries (Fisher *et al.,* 1997; Fisher *et al.,* 1997; Fraser *et al.,* 1995; Henderson *et al.,* 2000; Wong & Fraser, 1997). Overall, these studies have shown that girls generally hold more favourable perceptions of their classroom learning environments than boys in the same classes. These studies serve to inform teachers about the different learning needs of boys and girls. With this knowledge, teachers are likely to be guided in creating a more supportive environment for teaching and learning for both boys and girls.

Considerable work (e.g., Ferguson & Fraser, 1996; Rickards *et al.,* 1997; Suarez *et al.,* 1998) carried out with respect to gender and Science education showed that male and female students perceive their learning environment differently. In general, girls tended to perceive their learning environment just as favourably if not more favourably than boys. This finding further supports the previous related research (see for instance, Fraser *et al.,* 1992; Lawrenz,

1987; Rickards & Fisher, 1997; Wong & Fraser, 1997) in science laboratory learning environments. Females generally have higher expectations of their Science learning environment than their male counterparts. Teachers may like to take note of the perception differences among the sexes so as to maximize learning of each individual in class. In relation to this, Myint and Goh (2001), in a study investigating gender differences in graduate teacher trainees' perceptions of their learning environments, found that out of seven scales, only Student Cohesiveness was significantly different. Female graduate teacher trainees perceived that within their classroom environment, they knew each other well and maintained good friendships among themselves. This also appeared to corroborate with similar findings on gender differences in the classrooms.

Mean Difference in the Attitudes towards Science between Male and Female Pre-Service Science Teachers

The third null hypothesis was tested by using the Independent sample *t*-test at a specified significance level, alpha = .05. As shown in Table 12, the independent sample *t*-test results showed that there is no significant difference in the attitudes towards Science between male and female pre-service Science teachers (t = -1.188, p = .243). Hence, this finding failed to

TABLE 12
Mean Difference in Attitudes towards Science between the Male and Female Pre-Service Science Teachers

Subscales	Gender	*n*	*M*	*SD*	Mean Difference	Effect Size	*t*	Df	*p*
Social Implications of Science (S)	Male	18	3.611	.530	.226	.495	-1.559	35	.128
	Female	19	3.837	.334					
Normality of Scientists (N)	Male	18	3.111	.608	.136	.280	-.835	35	.409
	Female	19	3.247	.360					
Attitude to Scientific Inquiry (I)	Male	18	3.533	.472	.093	.162	-.488	35	.629
	Female	19	3.626	.666					
Adoption of Scientific Attitudes (A)	Male	18	3.667	.516	.223	.489	-1.492	35	.145
	Female	19	3.889	.387					
Enjoyment of Science Lessons (E)	Male	18	3.917	.653	.120	.220	-.654	35	.517
	Female	19	4.037	.452					
Leisure Interest in Science (L)	Male	18	3.406	.735	.279	.432	-1.311	35	.198
	Female	19	3.684	.549					
Career Interest in Science (C)	Male	18	3.611	.701	.115	.190	-.572	35	.571
	Female	19	3.726	.514					
Overall	Male	18	3.551	.513	.170	.390	-1.188	35	.243
	Female	19	3.721	.347					

The effect size is the mean difference divided by the pooled standard deviation.

reject the third null hypothesis. Generally, female students possessed more favourable attitudes towards Science as compared to their male student counterpart. However, the mean differences were not statistically significant.

In a study to describe classroom environment and teacher interpersonal behaviour in secondary Science classes in Korea *et al.* (2000) found that relative to girls, boys perceived their learning environments and their teachers' interpersonal behaviour to be more favourably and reported more favourable attitudes towards their Science classes.

Associations between Perceptions of the Actual and Preferred Science Learning Environment, and Attitudes towards Science

The fourth null hypothesis was tested by using the Pearson's product-moment correlation and multiple linear regression analysis at a specified significance level, alpha = .05. Correlation analysis results showed that there were low to moderate, positive, and significant correlations between the subscales of the actual science learning environment and the subscales of attitudes towards Science. Pearson's product-moment correlation coefficients were found in the range of .330 to .642 (Table 13). On the other hand, there were also low to moderate, positive, and significant correlations between the subscales of the preferred science learning environment and the subscales of attitudes towards Science. Pearson's product-moment correlation coefficients were found in the range of .339 to .577 (Table 13). The results shown in Table 16 also revealed that the CUCEI subscales can be used to explain appreciable amounts of variance in the pre-service Science teachers' attitudes towards Science. Thus, these findings had rejected the fourth null hypothesis successfully.

The findings of this study are consistent with the previous research done in this field of study. For example, in his theory on educational productivity, Walberg (1981; 1984) includes classroom environment as one of the nine factors that contributes to the variance in students' cognitive and affective outcomes. The other eight factors are ability, maturity, motivation, the quality of instruction, the quantity of instruction, the psychological environment at home, the peer group outside the classroom, and the time involved with video/television media. The model was successfully tested as a part of a national study showing that student achievement and attitudes were influenced jointly by these factors (Walberg, Fraser, & Welch, 1986). A relevant outcome was the finding that classroom and school environments were important influences on student outcomes.

In a study to investigate learning environments and student attitudes to Science at the senior secondary and tertiary levels, Nair and Fisher (2001) found that Personalization, Individualization and Innovation were significantly related to the attitudinal measure of Speed; only the Individualization scale with Difficulty and all the seven scales were significantly related to the student satisfaction outcome

TABLE 13
Simple Correlation and Multiple Regression Analyses for the Association between the Perceptions of Actual and Preferred Science Learning Environment and the Attitudes towards Science

		Attitudes towards Science													
		S		N		I		A		E		L		C	
CUCEI scales		r	β	r	β	r	β	r	β	r	β	r	β	r	β
Personalization	A	.344*	.099	.331*	.240	.396*	.303*	.452**	.333*	.453**	.283*	.571**	.571**	.453**	.386**
	P	.420*	-.023	.208	.022	.339*	.662**	.577**	.555**	.425*	.486**	.471**	.479**	.533**	.579**
Cooperation	A	.442**	.339*	.382*	.235	.128	-.234	.377*	.127	.375*	.108	.288	.014	.465**	.320*
	P	.360*	-.165	.366*	.162	.159	-.062	.537**	.315	.422*	.280	.425*	.199	.418*	.158
Student	A	.281	.134	.145	.086	.398*	.313*	.477**	.412**	.349*	.243	.273	.150	.290	.176
Cohesiveness	P	.217	-.017	.112	-.026	.395*	.145	.407*	.253	.332	.215	.247	.070	.331	.162
Equity	A	.329	.061	.286	.181	.183	-.178	.371*	.027	.243	-.059	.277	-.018	.253	-.229
	P	.526**	.453**	.449**	.462**	.075	-.116	.506**	.224	.327	.170	.381*	.096	.395*	.167
Task Orientation	A	.415*	.296*	.400*	.358*	.403*	.081	.330*	.008	.642**	.434**	.536**	.177	.501**	.235
	P	.455**	.350**	.262	.090	.170	.231	.378*	.070	.386*	.074	.348*	.019	.458**	.108
Innovation	A	.110	.034	.163	.118	.090	.010	.148	.058	.206	.035	.305	.076	.193	.078
	P	.389*	-.117	.293	.068	-.059	-.844**	.376*	-.016	.242	-.160	.291	-.060	.332	-.080
Individualization	A	.153	-.077	.023	-.064	.337*	.053	.322	.019	.287	.023	.444**	.177	.290	.101
	P	.155	-.166	.118	.048	.229	.587**	.372*	.167	.135	-.038	.095	-.044	.110	-.052
Total Model Fit:															
F-value	A	7.859		6.015		6.278		11.039		11.920		19.845		9.109	
	P	13.291		10.830		8.123		17.827		12.670		12.180		20.692	
Significance	A	.001		.019		.004		.000		.000		.000		.001	
	P	.000		.002		.000		.000		.001		.001		.000	
Multiple	A	.531		.358		.480		.582		.602		.571		.555	
Correlation, R	P	.642		.462		.620		.555		.486		.479		.579	
% Explained	A	28.2		12.8		23.0		33.9		36.2		32.6		30.8	
	P	41.2		21.3		38.5		30.8		23.6		22.9		33.5	

** Correlation is significant at 0.01 level (2-tailed)
* Correlation is significant at 0.05 level (2-tailed)
A= Actual; P = Preferred; S = Social Implications of Science; N = Normality of Scientists; I = Attitude to Scientific Inquiry; A = Adoption of Scientific Attitudes; E = Enjoyment of Science Lessons; L = Leisure Interest in Science; C = Career Interest in Science.

($p< .001$). The beta weights showed that all the three attitude scales retained their significance with the Individualization scale in a more conservative multivariate test. The multiple regression correlation indicates a significant association between the classroom environments, as measured by all the CUCEI scales and the three attitudinal outcomes; the speed at which the courses are taught, the degree of difficulty of the courses taken and, students' satisfaction with the course they are taking (Nair & Fisher, 2001).

More generally, this study also replicated the finding that there is a strong link between student outcomes and their perceptions of the learning environment (Fraser & Fisher, 1982; den Brok *et al.,* 2004; Wubbels & Brekelmans, 1998). In more specific, the findings are similar to those of other studies using the WIHIC and TOSRA (e.g., Adolphe *et al.,* 2003; Allen, 2003; Hunus & Fraser, 1997; Wahyudi, 2004; Kim *et al.,* 2000).

For instance, Wong and Fraser (1996) investigated Singaporean secondary Chemistry students' and teachers' perceptions of their laboratory lessons. They investigated differences in the perceptions of actual and preferred chemistry laboratory environments between teachers and students, students of different streams, as well as male and female students. They also examined the associations between classroom environment and students' attitudes towards Chemistry. They reported that (1) the perceptions of students and teachers differed, (2) students wanted to experience more positive laboratory lessons than those presently provided, (3) students from different streams differed only in their preferred perceptions, (4) females held more favourable perceptions than males, and (5) positive assocations existed between the nature of the Chemistry laboratory environment and students' attitudinal outcomes.

Hunus and Fraser (1997) used a modified version of the WIHIC in Brunei, and reported on the associations between the perceptions of learning environment and attitudinal outcomes. Simple and multiple correlations showed that there was a significant relationship between the set of environment scales and students' attitudes towards Chemistry theory classes. The Student Cohesiveness, Teacher Support, Involvement, and Task Orientation scales were positively associated with the students' attitudes.

Allen (2003) reported the results of a simple correlation analysis between the scales of the WIHIC and TOSRA. In his study, Investigation was significantly correlated with Inquiry. Additionally, Involvement, Task Orientation and Investigation were significantly correlated with Enjoyment. All correlations found were positive.

A study by Wahyudi (2004) found association between students' outcomes and the status of classroom learning environments. Both simple analysis and multiple regression analysis procedures showed that all the scales of Indonesian WIHIC were statistically, significantly, and positively associated with the two

scales of the Indonesian adapted TOSRA and students' cognitive scores. Overall, these findings show that many or all of the WIHIC scales are positively related to student attitudes. High associations have particularly been found for the scales Teacher Support, Equity and Investigation.

What is Happening in this Class (WIHIC) questionnaire and Questionnaire on Teacher Interaction (QTI) were used to describe classroom learning environment and the teachers' behaviour in Korea (Kim, Fisher, & Fraser, 2000). They found that there were positive relationships between classroom environment and interpersonal teachers' behaviour with students' attitudinal outcome.

Using SLEI, associations with students' cognitive and affective outcomes were found for a sample of 489 senior high school Biology students in Australia (Fisher *et al.,* 1997). Fisher *et al.* (1997) extended research regarding associations between students' outcomes and their perceptions of their laboratory lessons by including practical performance and cognitive achievement as student outcomes in Biology classes. They reported that each outcome was associated with environmental perceptions. In relation to this, Fraser *et al.* (1995) also found that associations existed between classroom environment perceptions of students and their attitudes towards Science laboratories.

Wolf and Fraser (2008) conducted a study to compare inquiry and non-inquiry laboratory teaching in terms of students' perceptions of the classroom learning environment, attitudes towards Science, and achievement among middle-school physical science students. Learning environment and attitude scales were found to be valid and related to each other for a sample of 1434 students in 71 classes.

Hence, findings of previous research have further supported the existence of associations between the perceptions of actual and preferred tertiary Science learning environment and the attitudes towards Science among primary and secondary school pre-service Science teachers, as evident in this study.

CONCLUSION

The results of this study have indicated that CUCEI and TOSRA are valid and reliable instruments to gain a better picture of the Science learning environment at tertiary level, the perceived learning needs, and pre-service Science teachers' attitudes towards Science. Data analyses in the present and past studies have revealed relationships between the Science classroom learning environment and the attitudinal and achievement outcomes of students. However, it cannot be concluded in absolute terms that the nature of the environment has caused the observed student attitudinal or student achievement outcomes. In order for such a conclusion to be reached, classroom intervention studies would have to be conducted. Such studies will add meaning to the currently reported association.

IMPLICATIONS OF THE STUDY

Measuring learning environment with an appropriate tool will help lecturers

to examine their Science classes and continuously improve to a productive Science learning environment. It will be an advantage for lecturers to use this instrument in finding out the nature of their Science classrooms. Such information can then be used with other source of data to be aware of the changing needs of the Science classroom environment. It also provided support to the fact that lecturers need to take gender differences into consideration when planning and designing the Science curriculum for pre-service Science teachers at tertiary level.

Recent research on classroom environment has also indicated positive associations between the nature of the class environment and students' attitudinal and achievement outcomes (Fraser & O'Brien, 1985; McRobbie & Fraser, 1993; Goh *et al.,* 1995; Wong & Fraser, 1997). Hence, lecturers should not neglect pre-service Science teachers' attitude while pursuing academic excellence. They should make conscious efforts in planning and improving Science lessons in order to improve pre-service Science teachers' attitude to Science. The differences between the actual and preferred perceptions of pre-service Science teachers signal a need to look into the possible areas where tertiary Science learning environment can be improved.

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