Japan has become one of the world's leading countries in science and technology and is now competing with other nations of the world for leadership in various fields of information technologies. In addition, the percentage of students who go on to obtain a higher education has increased dramatically. In this mature society, with its advanced levels of science and technology, one large mission of paramount importance is to make true improvements to the country's institutions of higher education. There is an urgent need today to improve qualitatively the way in which scientific research and science education are to be conducted in Japanese universities and research institutes.

In North America, Great Britain and other countries, the fullness of the science education offered at the University and Upper Secondary School levels compensates for weaknesses in the science education provided at the Primary and Middle School levels. In contrast, it would appear to the author that the weaknesses of Japan's institutions of higher education place unreasonable requests and excessive expectations on the science education that is provided at the Primary and Secondary School levels.

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STUDENTS' PERCEPTIONS OF TERTIARY SCIENCE CLASSROOM ENVIRONMENTS

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The classroom environments of science classes in Australian and Canadian tertiary institutions were measured using a modified and personalised form of the College and University Classroom Environment Inventory (CUCEI). Students' and instructors' actual and preferred perceptions of their science classrooms learning environments were measured with the CUCEI. Students' perceptions of their classrooms at the tertiary level indicated a preference for a more favourable learning environment in all areas measured by the seven scales of the CUCEI. Female and male students perceived their classroom environments similarly. Female students however, preferred greater cooperation in their classrooms. All seven scales were significantly related to students' satisfaction. Furthermore, 26% of the variance in students' satisfaction with their course could be attributed to their perceptions of their learning environment. Negative correlations were found between Individualisation, Innovation and Speed and between Individualisation and Difficulty.

INTRODUCTION

Walberg's theory on educational productivity indicates nine factors which contribute to the variance in students' cognitive and affective outcomes. The nine factors being student ability, maturity, motivation, the quality and quantity of instruction, the classroom and home environment, the peer group, and the time involved with the video/television media (Walberg, 1981, 1984). The model was successfully tested as part of a national study showing that student achievement and attitudes were influenced jointly by these factors (Walberg, Fraser, & Welch, 1986). An interesting outcome from these studies was the finding that classroom and school environments were important influences on student outcomes. These findings lend support to Getzels and Thelen's (1960) theoretical model which describes the class as a social system in which group behaviour can be predicated from the personality needs, role expectations, and classroom environment. Research over the last four decades has recognised that students' and teachers' perceptions are important parameters of the social and psychological aspects of the learning environments of school classrooms (Fraser, 1994, 1998). In particular, studies have shown that learning environments are accurate predictors of the quality of learning that students receive (Fraser, 1991; Ramsden, 1991; Templeton & Jensen, 1993).

Classroom studies have also shown that males and female differ in their perceptions of their of classroom environment (e.g., Burkam, Lee, & Smerdon, 1997; Ferguson & Fraser, 1996; Henderson, Fisher, & Fraser, 1998; Rickards, Fisher, & Fraser, 1997; Suarez, Pias, Membiela, & Dupia, 1998). Lim (1995) in his study of secondary school students found that male students perceived their classrooms as allowing greater opportunities for working at their own pace while female students viewed their classrooms as opportunities to participate and have control of their own learning. Parker, Rennie, and Harding (1995) reinforced research done by Johnson and Johnson (1991) showing that learning in science classrooms takes on a competitive nature and boys prefer competitive and individualised learning, whereas, girls prefer learning which involves cooperative models and mutual assistance. Johnson and Johnson (1991), however, showed that as students progressed to higher grades both male and female students seemed to gain more interest in competitive learning.

In recent years, the promotion of positive attitudes towards science is seen as a major aim of science education. Shulman and Tamir (1972) suggested that affective outcomes in education are at least as important as cognitive outcomes and acknowledgement of the importance of affective outcomes is reflected in their increasing emphasis in curricula (Gardner & Gauld, 1990; Hough & Piper, 1982; Mathews, 1974). In a study in middle secondary science classes in Korea, students' attitude scores were higher in classrooms in which students perceived greater leadership, helping/friendly, and understanding behaviours in their teachers (Kim, Fisher, & Fraser, 2000). In a second study in Korea, results indicated that favourable student attitudes could be promoted in classes where students perceived more personal relevance, shared control with their teachers and negotiated their learning (Kim, Fisher, & Fraser, 1999). These results were the same as those of past research of Brekelmans, Wubbels, and Levy (1993) and Fisher, Rickards, Goh, and Wong (1997).

Therefore, in keeping with this previous research and because of the importance of affective outcomes in education, associations between students' perceptions of their learning environments and their attitudes toward their science class were investigated in this study.

TERTIARY CLASSROOM ENVIRONMENTS

Studies with tertiary classroom environments are relatively few in comparison to studies carried out at the primary and secondary levels (Ramsden, 1991; Ramsden & Entwistle, 1981; Ramsden, Martin, & Bowden 1987; Ramsden, Patrick, & Martin, 1988; Richter, 1997). Basically, the students' approaches to learning were functionally related to the environment in which the students found themselves. This includes the classroom environment, the instructor, the institutional environment, and the type of school from which the student came. The three perceptions of good teaching, freedom of learning, and workload were found to be most important in both the final year of secondary school and in tertiary studies. Booth (1997) supported the findings of Ramsden in his research on the experiences and expectations of students in transition to a history degree. He found that apart from good teaching, the students would fare better if there were clear and concise communications, higher student involvement, and university professors who had good inter-personal relationships with their students. Other problems that were reported by Booth (1997) included a lack of general concern for students by the university lecturers and students finding that the tertiary environment was much more task orientated leading to much heavier work loads. Similar findings were also reported by Richter (1997) in a study investigating student transition from secondary to tertiary education in Germany. Again, students perceived the classroom environment less favourably on moving to a higher level of study.

Fraser, Treagust, Williamson, and Tobin, (1987) reported that despite the existence of strong traditional classroom environment research at the primary and secondary level, surprisingly little work had been done at the higher education levels because of the shortage of suitable instruments.

The *College and University Classroom Environment Inventory* (CUCEI) was developed in 1986 to fill this void (Fraser, Treagust, & Dennis, 1986). The CUCEI was specifically designed for small class sizes of about 30 students for upper secondary and tertiary levels utilising either seminar or tutorials as the mode of delivery. The seven-scale, 49 items instrument was designed with both a student and instructor version for the actual and preferred classroom environment. The seven scales in the original CUCEI were Personalisation, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation and Individualism.

The CUCEI is available in actual and preferred versions. The actual version measures the participants' actual perceptions of their classroom learning environment whereas the preferred form measures perceptions of the classroom learning environment preferred by the students. Previous research has indicated differences between students' perceptions of their actual environment and their ideal or preferred environment (e.g., Fraser, 1991; Levy, Creton & Wubbels, 1993; Wong & Fraser, 1995). Therefore, in keeping with this line of research, differences between tertiary students' actual and preferred learning environments were explored in this study. Coll and Fisher (2000) administered both versions of the CUCEI to a second-year chemical technology class in the Chemistry Department of a tertiary institution. Differences between students' perceptions of their actual and preferred environments were observed. Coll and Fisher recommended that tertiary teachers should consider the use of learning environment instruments as an addition to course-evaluation instruments.

Questionnaires like the CUCEI were based on the assumption that a common learning environment was experienced by all students within a classroom. This was challenged in the 1990s when it was suggested that a new form of an instrument should be made available which is better suited than is the conventional class form for assessing differences in perceptions that might be held by different students within the same class (Fraser, Fisher, & McRobbie 1996; Fraser, Giddings, & McRobbie, 1995). These studies and influences led to a different form of learning environment instrument which asks students for their personal perceptions of their role in the environment of the classroom rather than their perceptions of the learning environment in the class as a whole. This form was termed a personal form. Therefore, it was decided to modify the CUCEI into a personal form in keeping with recent research trends.

METHOD

The objectives of this study were to: develop and validate a personal form of the College and University Classroom Environment Inventory (CUCEI); use the modified CUCEI to investigate how students at tertiary level perceive their actual and preferred classroom learning environments; investigate whether perceptions of classroom learning environments vary according to the students' sex; and investigate associations between the nature of the classroom environment and the attitudes of the students towards their science studies at the tertiary level.

Student perceptions of their classroom learning environment were measured using the seven scale, 49-item modified and personalised CUCEI. The CUCEI in this study was modified in three ways. First, the actual and preferred versions of the questionnaire were personalised and secondly, only five of the seven original scales were used and two new scales included; the Cooperation and Equity scales (Fraser, Fisher, & McRobbie, 1996). Finally, the existing four response alternatives were replaced with a five-point Likert Scale. The number of scales was maintained at seven with each scale having seven items. Table 1, shows the seven scales in the final version of the modified CUCEI along with sample items.

Table 1
Descriptive Information for the Modified CUCEI

Scale Name	Description	Sample Items
Personalisation	Extent on opportunities for individual students to interact with the instructor and on concern for students personal welfare.	The instructor goes out of his/her way to help me.
Innovation	Extent to which the instructor plans new, unusual activities, teaching techniques and assignments.	The instructor often thinks of unusual activities.
Student Cohesiveness	Extent to which students know, help and are friendly towards each other.	I make friends easily in this class.
Task Orientation	Extent to which class activities are clear and well organised.	Class assignments are clear and I know what
Individual-isation	Extent to which students are allowed to make decisions and are treated differently according to ability, interests and rate of working.	I am allowed to choose activities and how I will work.
Cooperation	Extent to which students cooperate rather than compete with one another on learning tasks.	I work with other students in this class.
Equity	Extent to which students are treated equally by the teacher.	I am treated the same as other students in this class.

Three attitudinal scales were chosen, namely, Difficulty, Speed and Satisfaction (see Table 2). Studies have shown that in general, satisfaction is perceived to be lower when students moved to a higher level of study (Ferguson & Fraser, 1996; Fraser, Treagust, Williamson, & Tobin, 1987; Midgley, Eccles, & Feldlaufer, 1991). Apart from the researchers' observations and feedback from fellow instructors at the tertiary level, studies have shown that students generally face difficulty when they move to the tertiary level of education (e.g., Booth, 1997; Jarman, 1990;). Speed of courses has often been a complaint of tertiary students. Killen's (1994) work suggests, that the instructors are out of touch with student needs in terms of the heavy workloads, the extensive demands on students' time and the unrealistically high expectations placed on students by their instructors.

Similar findings have also been reported by Vahala and Winston (1994) and Ramsden (1991). Each scale in the attitude measure has seven items and each item has four response alternatives.

Table 2

Descriptive Information of Scales Used to Measure Attitude

Scale Name	**Description**	**Example Items**
Satisfaction	Extent of enjoyment of classes.	I look forward to coming to this class.
Difficulty	Extent to which students find difficulty with the work in the class.	I find the work in this class difficult.
Speed	Extent to which class work is covered quickly.	The pace in this class is rushed.

Data were analysed using the individual and class as the basis to investigate the reliabilities of the seven modified scales. Correlation and regression analyses were performed to investigate associations between learning environment scales and student attitudes.

A total of 504 students participated in the study which covered a variety of science subjects. From Canadian tertiary institutions there were 205 participants and 299 students were from Australian tertiary institutions. Students completed both forms of the CUCEI, the preferred and actual, and the attitude scales.

RELIABILITY AND VALIDITY OF THE CUCEI

Internal Consistency

Table 3 reports two reliability and validity statistics for the two versions of the CUCEI used with the present sample of 504 students. In line with previous research, statistics are reported for two units of analysis, namely, the student's score and the class mean score. The Cronbach alpha reliability coefficients using the individual student as the unit of analysis ranged from 0.73 to 0.93 and 0.76 to 0.94 for the actual and preferred versions, respectively. With class means as the unit of analysis, all alpha reliability values were higher, ranging from 0.84 to 0.97 for the actual version and 0.87 to 0.98 for the preferred. The values presented provide validation data supporting the internal consistency of the CUCEI, for both actual and preferred versions with either the individual student or the class mean as the unit of analysis.

Table 3

Internal Consistency (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with Other Scales), and Ability to Differentiate between Classrooms for the CUCEI

Scale	**Unit of Analysis**	**Alpha Reliability**		**Mean Correlation with Other Scales**		**ANOVA Results (eta^2)**
		Actual	**Preferred**	**Actual**	**Preferred**	**Actual**
Personalisation	Individual	0.87	0.84	0.34	0.45	0.23**
	Class Mean	0.95	0.87	0.30	0.30	
Student Cohesiveness	Individual	0.82	0.83	0.20	0.47	0.28**
	Class Mean	0.96	0.88	0.38	0.43	
Task Orientation	Individual	0.77	0.79	0.27	0.44	0.27**
	Class Mean	0.92	0.92	0.33	0.44	
Cooperation	Individual	0.92	0.93	0.25	0.45	0.11*
	Class Mean	0.96	0.94	0.29	0.38	
Individualisation	Individual	0.82	0.80	0.15	0.25	0.22**
	Class Mean	0.93	0.94	0.34	0.35	
Equity	Individual	0.93	0.94	0.30	0.42	0.09*
	Class Mean	0.97	0.98	0.38	0.45	
Innovation	Individual	0.73	0.76	0.22	0.43	0.13**
	Class Mean	0.84	0.93	0.35	0.39	

**$p < 0.001$ *$p < 0.001$

The sample consisted of 504 tertiary science students in 26 classes

Discriminant Validity

The discriminant validity is described as the extent to which a scale measures an unique dimension not covered by the other scales in the instrument. Table 3 indicates that the mean correlations of the scales in the CUCEI ranged from 0.15 to 0.38 for the actual version and from 0.25 to 0.47 for the preferred form. From these values, the CUCEI appears to measure distinct although somewhat overlapping aspects of classroom environment.

Capability of differentiating between classrooms

Another desirable characteristic of any instrument like the CUCEI is that it is capable of differentiating between the perceptions of students in different classrooms. That is, students within the same class should perceive it relatively similarly while mean within-class perceptions should vary from class to class. This characteristic was investigated for each scale of the CUCEI using a one-way ANOVA, with class membership as the main effect. Table 3 indicates that each CUCEI scale differentiated significantly ($p < 0.01$) between classes and that the eta^2 statistic, representing the proportion of variance explained by class membership, ranged from 0.09 to 0.28 for different scales.

APPLICATIONS WITH THE CUCEI

Students Actual And Preferred Perceptions

Table 4 provides scale means for all seven scales of the CUCEI, and indicates the magnitude of the difference between these means. Students were generally more in agreement about their preferred classroom environment as the standard deviations in the preferred versions were generally lower. Actual preferred differences were explored using a paired *t*-test analysis for each scale of the CUCEI. All seven scales showed statistically significant differences. In each case the students had a preference for more of the learning environment dimension than they actually perceived to be present. For example, they would prefer their classes to be more personalised and task oriented. This is significant because person-environment fit studies (Fraser & Fisher, 1983a, b) have confirmed that students' achievement is greater when they are in their preferred learning environment.

Table 4
Means and Standard Deviations for the Preferred and Actual Forms of the CUCEI for Students

Scales	**Mean**		**Difference**	**Standard Deviation**	
	Actual	**Preferred**	**(P-A)**	**Actual**	**Preferred**
Personalisation	3.56	4.19	0.63**	0.78	0.59
Student Cohesiveness	3.36	3.82	0.46**	0.76	0.79
Task Orientation	3.94	4.28	0.34**	0.52	0.53
Cooperation	3.38	3.93	0.55**	0.95	0.89
Individualisation	2.10	4.23	2.13**	0.71	0.53
Equity	4.42	4.61	0.40**	0.64	0.58
Innovation	3.29	3.48	0.19**	0.69	0.71

** $p < 0.05$

The sample consisted of 504 tertiary science students in 26 classes

Students generally perceived the Individualisation scale as the least favourable. This suggests that students perceive that there is little choice at the tertiary level of studies. This dissatisfaction was expressed in the views of students like the following:

To be frank it is overwhelming (workloads). I was swamped when I first got here. I did not believe how much work they (instructors) expected. In high school they don't have this stuff. I spend 18 hours on a report. It is unreal.

This reasoning seems to be supported by the comments of the Biology and Physics instructors.

We have no control. We have to cover X amount of material before they move on to their second year.

If they work on their own pace they would have nothing done. It is a university lecture and there is a certain amount of material to cover and you cover it.

Differences in Perception based on the Sex of Students

A sub-sample of students in coeducational classes was used to investigate sex differences of students perceptions of their learning environments. There were 99 females and 105 males in this group and t tests for independent samples were used to determine the significance of any differences. As indicated in Table 5, both males and females perceived their learning environments almost identically. This similarity in perceptions replicates findings in other studies, that both male and female students' perceptions moved closer together as they moved into higher level studies (Ferguson & Fraser, 1996; Johnson & Johnson, 1991). However, the findings here also contrast against findings that show that there are statistically significant differences in the perceptions between male and female students (e.g., Burkam, Lee, & Smerdon, 1997; Henderson, Fisher, & Fraser, 1998; Rickards, Fisher, & Fraser, 1997; Ferguson & Fraser, 1996; Suarez, Pias, Membiela, & Dupia, 1998). Though female and male students did not perceive any difference in the level of cooperation in their actual classroom environment, female students indicated that they preferred greater cooperation in their preferred classroom environment. An interesting feature of the results depicted in Table 5 is that both male and female students were in agreement that there was hardly any difference in the way they were treated by the instructors as measured by the Equity scale. This was clearly echoed by three students when they stated without reservations the following:

Our work is pretty much judged equally.
Everyone is very much treated the same.
No, I have not seen any discrepancies in our treatment.

Table 5

Comparison of Means and Differences for the Preferred and Actual Forms of the CUCEI for Male and Female students

Scales	**Actual**		**Difference**	**Preferred**		**Difference**
	Male(M)	**Female(F)**	**(M-F)**	**Male (M)**	**Female (F)**	**(M-F)**
Personalisation	3.43	3.64	-0.21	4.10	4.26	-0.16
Student Cohesiveness	3.33	3.38	-0.05	3.90	3.78	0.12
Task Orientation	3.94	3.93	0.01	4.25	4.34	-0.09
Cooperation	3.37	3.44	-0.07	3.77	4.34	-0.57**
Individualisation	2.14	2.04	0.10	3.10	2.94	0.16
Equity	4.45	4.34	0.11	4.59	4.67	-0.08
Innovation	3.37	3.23	0.14	3.41	3.56	-0.15

**$p < 0.05$ *$p < 0.1$ n = 99 females and 106 males

Associations Between Students' Perceptions of their Learning Environment and Attitudinal Outcomes

The Cronbach alpha measures of internal consistency reliability for the scales of Speed, Difficulty, and Satisfaction were 0.62, 0.77 and 0.76, respectively, using the individual student as the unit of analysis and 0.73, 0.87 and 0.88, respectively, when using the class means. Associations between students' perceptions of the learning environment and students' attitudinal outcomes were analysed using both simple correlation (*r*), which describes the bivariate associations between an attitudinal measure and each CUCEI scale, and the standardised regression weight (ß), which characterises the associations between a measure and a particular environment scale when all other CUCEI scales were controlled. The simple correlations (*r*) reported in Table 6 indicate that all seven scales were significantly positively related to the student Satisfaction outcome ($p < 0.001$), two scales, namely, Individualisation and Innovation were significantly negatively related to the attitudinal measure of Speed and only Individualisation was negatively related with Difficulty. When using the more conservative standardized regression coefficient (ß), which measures the association when the effect of the other scales is held constant, the regression coefficients of the Personalisation, Task Orientation, and Individualisation scales retained their significance with Satisfaction. The results for Speed and Difficulty were the same as for the simple correlations. It is noteworthy that the students' perceptions of their learning environment contributed to 26% of measured variance in students' satisfaction with their science classes.

Table 6
Associations Between CUCEI Actual Scales and the Attitudinal Measures in Terms of Simple Correlation (r) and Standardised Regression Coefficients (ß)

	Speed		Difficulty		Satisfaction	
CUCEI Scales	r	ß	r	ß	r	ß
Personalisation	-0.17**	-0.03	-0.03	0.08	0.41**	0.18**
Student Cohesiveness	-0.22	0.02	-0.03	-0.01	0.18**	0.05
Task Orientation	-0.07	-0.03	-0.00	-0.03	0.36**	0.23**
Cooperation	0.00	-0.10	0.01	0.05	0.21**	0.02
Individualisation	-0.27**	-0.24**	-0.22**	-0.23**	0.21**	0.15**
Equity	-0.66	-0.04	0.03	0.00	0.23**	0.02
Innovation	-0.20**	0.10*	0.08	0.07	-0.25**	0.05
Multiple Correlation R		0.37**		0.24**		0.51**
R^2		0.11		0.06		0.26

*$p < 0.05$ **$p < 0.001$
n=504

CONCLUSIONS

This study confirms the reliability and validity of the modified and personalised form of the CUCEI. Tertiary instructors could find the modified and personalised CUCEI to be a valuable source of information, particularly for comparisons between their students' actual and preferred perceptions. It was clear from the study that students would prefer a more positive learning environment than what they currently perceive to be present. This information can be used to aid teaching and learning in their classrooms as studies have indicated that student perceptions of their own classrooms are reliable indicators that can be utilised for improving teaching and learning (e.g., Fraser, 1991, 1994, 1998; Fraser & Fisher, 1994). Both male and female students perceived their classroom environment similarly at the tertiary level. This is in keeping with findings in other studies, where both male and female students perceptions moved closer together as they moved into higher level studies (Ferguson & Fraser, 1996; Johnson & Johnson, 1991).

Students' perceptions of their learning environment contributed to 26% of measured variance in students' satisfaction with their science classes.

Thus, if tertiary teachers wish to have students more satisfied with and enjoy their science courses more, in particular, they should be task oriented, allow opportunities for individualisation, and interact more with their students.

Finally, there are some desirable ongoing and new directions for classroom environment research at the tertiary level that could prove worthwhile for science educators to pursue. Person-environment fit research could be used to investigate whether students achieve better, cognitively and affectively, when there is a better match between their actual and preferred classroom environment. It would be valuable if the modified instrument was used in various countries to reinforce the validity of the questionnaire. Differences in the perceptions of students and their instructors at the tertiary level could be investigated. Finally, differences in students' perceptions of their classroom and laboratory environments could add to our knowledge on the connection between the laboratory and the classroom at tertiary levels.

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