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Technology in the Classroom

Readings for Research Stream

Assessing and Changing IT Learning Environments

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Hand Scoring Procedures

Appendix A illustrates typical hand scoring procedures for the CLES. Items are arranged in blocks so that all items from the same scale are found together. All items in Appendix A except Item 6 are scored by allocating the circled number (i.e., 1 for Almost Never, 2 for Seldom, etc.). Item 6 is scored in the reverse manner. Omitted or invalidly answered items are scored 3. To obtain scale totals, the six item scores for each scale are added. For example, the total score for the first scale (Personal Relevance) is obtained by adding scores for items 1 to 6.

Personal Forms of Scales

Fraser and Tobin (1991) point out that there is potentially a major problem with nearly all existing classroom environment instruments when they are used to identify differences between subgroups within a classroom (e.g., males and females) or in the construction of case studies of individual students. The problem is that items are worded in such a way that they elicit an individual student's perceptions of the class as a whole, as distinct from a student's perceptions of his/her own role within the classroom. For example, items in the traditional class form might seek students' opinions about whether '*the work of the class is difficult*' or whether '*the teacher is friendly towards the class*'. In contrast, a personal form of the same items would seek opinions about whether '*I find the work of the class difficult*' or whether '*the teacher is friendly towards me*'. Confounding could have arisen in past studies which employed the class form because, for example, males could find a class less difficult than females, yet males and females still could agree when asked for their opinions about the class as a whole. The distinction between personal and class forms is consistent with Stern, Stein and Bloom's (1956) terms of 'private' beta press, the idiosyncratic view that each person has of the environment, and 'consensual' beta press, the shared view that members of a group hold of the environment.

When Fraser, Giddings and McRobbie (1995) developed and validated parallel class and personal forms of both an actual and preferred version of the SLEI, item and factor analyses confirmed that the personal form had a similar factor structure and comparable statistical characteristics (e.g., internal consistency, discriminant validity) to the class form when either the individual student or the class mean was used as the unit of analysis. Also students' scores on the class form were found to be systematically more favourable than their scores on the personal form, perhaps suggesting that students have a more detached view of the environment as it applies to the class as a whole. As hypothesised, gender differences in perceptions were somewhat larger on the personal form than on the class form. Although a study of associations between student outcomes and their perceptions of the science laboratory environment revealed that the magnitudes of associations were comparable for class and personal forms of the SLEI, communality analyses showed that each form accounted for appreciable amounts of

outcome variance which was independent of that explained by the other form (Fraser & McRobbie 1995). This finding justifies the decision to evolve separate class and personal forms because they appear to measure different, albeit overlapping, aspects of the science laboratory classroom environment.

Administration of the WIHIC questionnaire followed by interviews with 45 students showed that many students have perceptions from the perspective of the class as a whole that differ from their perceptions of their personal role within the classroom (Fraser, Fisher & McRobbie 1996). Underlying many of the responses was the idea that, because the individual student is only part of the class, interactions with an individual student (Personal form) are less frequent than the interactions with the class as a whole (Class form). Further discussion of the distinction between Personal and Class forms can be found in McRobbie, Fisher and Wong's chapter in this *Handbook*.

VALIDATION OF SCALES

This section reports typical validation data for selected classroom environment scales. Table 2 provides a summary of a limited amount of statistical information for the nine instruments (LEI, CES, ICEQ, MCI, CUCEI, QTI, SLEI, CLES and WIHIC) considered previously. Attention is restricted to the student actual form and to the use of the individual student as the unit of analysis. Table 2 provides information about each scale's internal consistency reliability (alpha coefficient) and discriminant validity (using the mean correlation of a scale with the other scales in the same instrument as a convenient index), and the ability of a scale to differentiate between the perceptions of students in different classrooms (significance level and η^2 statistic from ANOVAs). Statistics are based on 1,048 students for the LEI, except for discriminant validity data which are based on 149 class means (Fraser, Anderson & Walberg 1982), 1,083 students for the CES (Fisher & Fraser 1983c), 1,849 students for the ICEQ (Fraser 1990), 2,305 students for the MCI (Fisher & Fraser 1981), 372 students for the CUCEI (Fraser & Treagust 1986), 3,994 high school science and mathematics students for the QTI (Fisher, Fraser & Rickards 1997), 3,727 senior high school students for the SLEI (Fraser, Giddings & McRobbie 1995) and 1,081 high school science students for both the CLES and WIHIC (previously unpublished results).

INSTRUMENTS FOR ASSESSING SCHOOL ENVIRONMENT

In contrast to work on classroom-level environment, relatively little research has been directed towards helping teachers assess and improve the environments of their own schools. Earlier instruments include Stern's (1970) College Characteristics Index (CCI) and Halpin and Croft's (1963) Organizational Climate Description Questionnaire (OCDQ). The *Work Environment Scale* (WES; Moos 1981) was designed for use in any work milieu rather than for use specifically in schools. To

Table 1 Factor Loadings, Internal Consistency Reliability (Cronbach Alpha Coefficient), and Ability to Differentiate Between Classrooms (ANOVA Results) for the *What Is Happening In This Class?* (WIHIC) Questionnaire

Item No	Factor Loading													
	Student Cohesiveness		Teacher Support		Involvement		Investigation		Task Orientation		Cooperation		Equity	
	Aust	Taiw	Aust	Taiw	Aust	Taiw	Aust	Taiw	Aust	Taiw	Aust	Taiw	Aust	Taiw
1	.62	.59												
2	.47	.56												
3	.53	.68												
4	.68	.60												
5	.60	.71												
6	—	—												
7	.64	.63												
8	—	.59												
9			.64	.67										
10			.68	.65										
11			.65	.75										
12			.56	.55										
13			.63	.62										
14			.68	.70										
15			.62	.59										
16			.43	—										
17					.65	.53								
18					.77	.65								
19					.46	—								
20					.58	.50								
21					.47	.41								
22					.49	.45								
23					—	—								
24					—	—								
25							.65	.61						
26							.58	.64						
27							.71	.70						
28							.63	.61						
29							.64	.68						
30							.63	.66						
31							.66	.66						
32							.61	.64						
33									.65	.49				
34									.58	.49				
35									.55	.59				
36									.62	.51				
37									.71	.54				
38									.65	.58				
39									.67	.62				
40									.63	.58				
41											.55	.44		
42											.59	.40		
43											.58	.53		
44											.63	.47		
45											.65	.47		
46											.67	.54		
47											.62	.58		
48											.52	.56		
49													.68	.56
50													.70	.65
51													.69	.67
52													.71	.66
53													.72	.71
54													.74	.58
55													.63	.60
56													.68	.64
Alpha Reliability														
Individual	0.81	0.86	0.88	0.87	0.84	0.85	0.88	0.90	0.88	0.86	0.89	0.87	0.93	0.90
Class Mean	0.87	0.91	0.95	0.95	0.88	0.90	0.95	0.96	0.96	0.94	0.93	0.92	0.97	0.95
Eta ²	0.11**	0.07**	0.14**	0.34**	0.09*	0.11**	0.15**	0.22**	0.14**	0.36**	0.15**	0.28**	0.15**	0.24**

Loadings smaller than .4 omitted

The sample consisted of 1081 students in 50 classes in Australia and 1879 students in 50 classes in Taiwan.

* $p < 0.05$ ** $p < 0.01$

An analysis of variance (ANOVA) was used to determine the ability of each WIHIC scale to differentiate between the perceptions of students in different classes. The η^2 statistic was calculated to provide an estimate of the strength of association between class membership and the dependent variable (WIHIC scale). The bottom of Table 1 presents the ANOVA results for Taiwan and Australia. Each scale differentiated significantly between classes ($p < 0.01$) in both Taiwan and Australia. The amount of variance in scores accounted for by class membership (i.e. η^2) ranged from 0.07 to 0.15 in Australia and from 0.07 to 0.36 in Taiwan.

The reliability of the Student Attitude scale was determined using the Cronbach alpha coefficient for the Australian and Taiwanese data for two units of analysis (the individual and the class mean). The reliability of the English version of the Student Attitude scale with the Australian sample was 0.74 using the individual as the unit of analysis and 0.81 for the class mean as the unit of analysis. For the Mandarin version of the Student Attitude scale, the alpha reliability with the Taiwanese sample was 0.92 for the individual as the unit of analysis and 0.98 for the class mean as the unit of analysis.

5.2 Differences between Australia and Taiwan in Environment and Attitude

Table 2 shows the differences in mean environment and attitude scores for Taiwan and Australia. Australian students consistently perceived their learning environments more favorably than did Taiwanese students. Effect sizes and t tests were calculated to investigate the differences between students' perceptions in Australia and Taiwan (Table 2). In order to estimate the magnitudes of the differences (in addition to their statistical significance), effect sizes were calculated as recommended by Thompson (1998a, 1998b). The effect size for five of the seven scales of the WIHIC questionnaire ranged between approximately a quarter of a standard deviation (0.27) and over three quarters of a standard deviation (0.86) for class means. These effect sizes suggest a substantial difference between countries on the learning environment scales with the exception of Student Cohesiveness and Teacher Support. T tests for paired samples, using the class as the unit of analysis, were used to investigate whether differences in scale scores between Australia and Taiwan were statistically significant. Students in Australia consistently viewed their classroom environment (in terms of WIHIC scales) more favorably than did students in Taiwan. There was a statistically significant difference ($p < 0.05$) for the scales of Involvement, Investigation, Task Orientation, Cooperation and Equity (see Table 2).

Table 2: Mean, Standard Deviation, Effect Size and t Test for Paired Samples for Differences Between Australia and Taiwan in Perceptions of Classroom Environment and Attitude for the Class Mean as the Unit of Analysis

WIHIC Scale	Mean		Standard Deviation		Difference between Countries	
	Aust	Taiw	Aust	Taiw	Effect Size	t
Student Cohesiveness	3.16	3.16	0.13	1.54	0.00	0.06
Teacher Support	2.47	2.42	0.29	0.28	0.17	0.74
Involvement	2.48	2.30	0.21	0.19	0.86	4.60*
Investigation	2.36	2.29	0.24	0.25	0.27	1.43
Task Orientation	3.18	3.10	0.18	0.22	0.38	2.10*
Cooperation	3.04	2.96	0.18	0.22	0.43	2.44*
Equity	3.17	3.00	0.22	0.28	0.65	3.40*
Attitude	2.35	2.64	0.44	0.37	0.72	-3.55*

* $p < .05$

An interesting anomaly arose in that students in Taiwan expressed a significantly more positive attitude towards science than did students in Australia ($p < 0.01$). The effect size for student attitudes was over two thirds of a standard deviation (0.72) for class means, also suggesting a large difference between countries. Despite students in Australia holding more favorable perceptions of the learning environment, it appears that students in Taiwan had more positive attitudes towards their science class. These findings prompted the researchers to examine the perceptions of the students in each country more closely during the qualitative data collection which is discussed further in the following sections.

5.3 Using Qualitative Methods to Check the Cross-cultural Viability of the WIHIC

Whilst the statistical analyses described above established the cross-cultural validity of the WIHIC questionnaire, the researchers were keen to draw on qualitative information to explore further the viability of the questionnaire for use in Australia and Taiwan. Using information collected through interviews with students in Taiwan and Australia, the researchers were better able to determine not only whether students across cultures had interpreted the items of the questionnaire consistently, but also the reasons for their responses to questionnaire items. In doing so, the researchers not only were in a better position to interpret the quantitative data more accurately, but also to understand better the students' perceptions and feelings about particular aspects of their classroom environment. It was during this process that the researchers were able to identify the strong points and pitfalls associated with using a questionnaire framed in a Western context in a different culture.

A notable point was that the students' anecdotes were generally consistent with their perceptions as described by the WIHIC questionnaire. Therefore, the questionnaire data appear to provide a basis for measuring students' perceptions of the learning environment in both countries. Overall, the interviews suggested that students interpreted items in ways that were reasonably consistent with meaning intended by questionnaire developer.

The questionnaire data provided a basis on which researchers could examine the similarities and differences between learning environments in Australia and Taiwan from the students' perspective. The researchers found that, where statistically significant differences in questionnaire scale means were found, student interviews usually provided a plausible explanation, suggesting further support for the viability of the questionnaire. The inclusion of interview data was vital for making sense of the questionnaire results in both countries.

One pitfall which was highlighted through students' interviews was that, despite the accuracy of the back translations, the Chinese version of the questionnaire did not always capture the full or literal meaning of the original questionnaire. In some cases, the questionnaire items were outside of the realm of students' experience, as with the item 'I discuss ideas in class', because some Taiwanese students had not been involved in 'discussions' in class in the Western sense, and therefore interpreted 'discussion' as 'questioning'.

After gathering the qualitative data, three important points emerged for the researchers of both countries. Firstly, whilst the classroom environments are different in the two countries, the questionnaire scores do not necessarily reflect fully the overall quality of education. Secondly, when interpreting the data in terms of scales of the WIHIC questionnaire, consideration needs to be given to whether the scales reflect what is considered to be educationally important in the countries and cultures from which the data were collected. Finally, comparisons of quantitative data from different countries should be made with caution because we found that there were some items for which students in one country consistently interpreted items slightly differently from students in another country (as with the Student Cohesiveness scale).

6.0 Information Gathered Using Observations and Interviews

The results of the large-scale quantitative probe, in addition to the interviews based on items of the WIHIC questionnaire, posed anomalies and dialectic tensions about which the researchers were keen to find out more. As a result of critical reflexivity and dialectic tensions, there evolved

research methods that were more culturally sensitive and that the researchers felt would help them to understand social and cultural factors that influence the learning environment. These included observations and interviews with the participants and narrative stories. The following section outlines the differences between the cultures and education systems of the two countries and how they might impinge on the learning environment that is created.

This section explores factors that influence the learning environment in Australia and Taiwan. Data were gathered using classroom observations and participant interviews. The observation data are presented in the form of stories (Carter, 1993; Casey, 1995; Clandinin & Connelly, 1994), written to portray cultural archetypes of science classrooms in each country. The themes presented in the two stories (one from Taiwan and the other from Australia) take into consideration observations and interviews made over a number of occasions, in the respective countries, and they aim to provide an authentic paragon with which the reader can identify (Adler & Adler, 1994). Although all aspects of the stories might not be present in any one classroom, none are uncommon in the science classrooms that were observed. The two stories, *A Science Classroom in Taiwan* (Figure 1) and *A Science Classroom in Australia* (Figure 2), are followed by our interpretive commentary (based on interviews with selected students and their teachers from the classrooms observed), as suggested by Geelan, (1997). The stories and their subsequent commentaries aim to provide a culturally-sensitive basis upon which the researcher was able to explain differences and similarities between the learning environments in each country.

The first story (Figure 1) attempts to represent Australian science classrooms by extracting themes that were familiar over a number of observations. This is followed by interpretive commentary to help place the story in context with individual science classrooms observed in Australia.

Figure 1. A Science Class In Australia

A bite in the faint breeze hints of the winter to come but is contradicted by a wide expanse of cloudless blue sky. The sand dunes that I remember have given way to terra-cotta tiled rooves and dual carriage ways. The school, at ten years old, is relatively new and the neoteric design and facilities reflect this. Rusty brown stains on the walls, caused by minerals in the bore water used to irrigate the lawns and gardens throughout the hot dry summer, look strangely out of place on this modern building.

The science teacher, whose class I am here to observe, escorts me through the maze of single-storey buildings. A cacophony of sounds assail us as we walk: students preparing for the next lesson; magpies squabbling over scraps of food; doors banging shut on metal lockers; and the talking, laughing and screeching of students on their break. Above the din, a student's voice is raised as he shouts to 'dob in' a fellow student for taking his ruler. The shout is ignored by the teacher as the ruler is thrust back into the student's hand. Another student falls into step with us and banters light-heartedly with the teacher before moving off to rejoin his mates.

The teacher guides me through a door with a conspicuous 'Staff Only' sign which leads to the science department. I am led through to the teachers' work area, a hive of activity with a desk for each teacher piled with papers and books. Materials, resources books and files related to teaching science at each age level are visible on bookshelves and in messy piles. A photocopier is placed in a prominent position, not far from a sink on which coffee cups, ingrained with tannin and caffeine, are turned upside down to drain.

After a brief introduction to members of the staff, we move through to one of six science laboratories where this teacher's next lesson will be held. The spacious bright room, with large windows along one wall, looks out over neatly manicured grass and pathways that surround the school. There are four rows, each with two long gray benches, with tall stools neatly tucked under them. A bench, meant for student laboratory work, stretches along three walls of the laboratory, and is fitted with sinks and gas connections. Suspended on the wall above the bench are shelves filled with test-tubes, pipettes and beakers. At the front of the class is a bench which has been raised slightly higher than the others. Fitted with a perspex shield, sink and fittings for a Bunsen burner, it is clearly meant for demonstrations. Today, however, it is strewn with teacher's notes, books and an overhead projector.

In the few minutes before the lesson starts, the teacher explains that the school has a separate class for high-ability students and that the grade 10 class which I am to observe is randomly selected from the remaining students. The teacher goes on to explain that one science lesson a week has been devoted to a library session, during which small groups of students have the opportunity to research a topic of their choice and prepare a presentation. Rather than devote several lessons to listening to the presentations, the teacher has chosen to start each lesson with one presentation based on this research.

The siren wails, reminding me of an air raid warning, and the teacher excuses himself. He steps onto the verandah and waits for the students to settle down before allowing them to pour into the laboratory. Twenty-five students rush to grab stools and move them next to friends. The boys look scruffy and disheveled, dressed in sloppy joes, jeans and sneakers and sporting a range of hair cuts from long unbrushed mops to short, army-style, crew cuts. In contrast, the girls look neat, are fashionably dressed in a variety of designer label sweat shirts, and have freshly brushed hair.

After much scraping of chairs on the hard floor and chatter among the students, the teacher draws their attention to the front of the class. Three girls, all of whom appear to be nervous, walk to the front and read their presentations from sheets that act as cue cards. A boy from the audience points out a mistake made by one of the girls during the presentation. The girl looks uncomfortable and turns to the teacher who excuses the error as 'mis-read information'. The teacher proceeds to turn the boy's point into a problem-solving exercise, taking the heat off the girl and giving other students in the class the opportunity to discuss and resolve the problem amongst themselves.

Once resolved, the teacher asks the students to evaluate the group's presentation. The students have a sheet on which they rate each presentation according to objectives that they have pre-determined, such as interest or content. The teacher provides a short reminder about how to complete the sheet before a student near the back calls out to let the teacher know that he doesn't have one. It appears that several students, for a variety of reasons, have not brought their sheets to class. Prepared for just such an event, the teacher lightly chastizes them and hands out duplicates. The students proceed to evaluate the presentation, whilst the girls work as a group and do a self evaluation that will be included in their portfolio.

The evaluation is followed by a short, sharp question-and-answer session that is geared towards revising the last lesson. Not all students are on task (with a group of students at the back talking amongst themselves), but the majority are. The subject for this lesson is radio-isotopes, a difficult one for students at this level, but part of the curriculum. The teacher selects students with their hands up to answer the questions, making a point of praising those who answer correctly and encouraging those who don't with "good try" or "close but not quite".

The group at the back continues to chatter and is ignored by the teacher until the volume starts to escalate. The teacher stops what he is saying and asks them to keep the noise down just as one member of the group retorts: "He's borrowing paper." The manner of his response borders on rude, but the teacher lets it go without comment. Rather, he turns to write notes on the board for the students to copy. After a bustle of activity and clicking of files, the class is almost silent for the first time as students take down the notes.

As the first of the students finish, the teacher explains the activity which is to follow. Students are to become radioactive particles—they must toss a die and, if it is a 6, the particle (student) decays. The reaction includes outward groans and none of the students seem overly enthusiastic. As the teacher distributes the dice amongst the students, they start chatting amongst themselves, clicking and tapping the dice, steadily increasing the noise level. Two girls are brushing their hair near the front, putting it back into pony tails. A late arrival walks in and is given a die before sitting down. Ignoring the fact that the other students are not paying attention, the teacher instructs them to toss their dice.

I am amazed that anything could be heard over the noise, but 25 dice were promptly tossed. Two students shoot their dice across the floor, claiming it to be an accident when the teacher looks at them. When asked by the teacher to raise their hands if they threw a six, an inordinate number of students respond. Like me, the teacher must wonder about this because he goes on to explain the need for honesty if the activity is to work.

The teacher does not record the first throw and instructs students to throw again. This time, two students throw a six, which the teacher records on a table that he has drawn on the board. During

subsequent throws, I notice that a boy at the back of the class raises his hand twice. When the teacher realizes that there is a discrepancy in numbers, the boy brazenly yells out: "You counted me twice." The teacher looks annoyed but does not make an issue of it. To make the numbers in his table correct, the teacher asks one of the remaining students to stand out.

At the end of the activity, the teacher moves amongst the students, collecting the dice. When he returns to the front of the class, he explains how to convert the table which they have made into a graph. As he makes up the graph, a student draws his attention to an error that he has made with the scale. Affably, the teacher thanks the student for pointing out his mistake, congratulates him on his powers of observation and adds: "It shows what an incompetent mathematician I am." The mistake is rectified and the graph completed before the teacher goes on to demonstrate how to work out the half-life of an isotope. Whilst most of the students appear to be listening and others are taking notes, I notice that the group of students at the back of the class are passing notes to each other. The teacher starts to talk about the half-life of isotopes and radioactivity and to relate them to the effects of nuclear weapons and its use in the treatment of cancer. As the teacher describes his personal experience with cancer and the effects of Hiroshima, it becomes clear that these real-life examples, and the element of gore in his descriptions, have captured the students' attention. They are not only paying attention but also asking questions and contributing to the discussion, including students in the group at the back of the class.

The teacher glances at the clock on the wall and I can almost feel his reluctance to draw the discussion to a close as he asks the students to copy the table and graph into their files. As they do so, he wheels out a video player and turns on a short movie about isotopes. It is complex in nature and appears to be above the level of the students, yet they sit quietly, half watching as they finish their graphs and pack away their books for the next lesson.

Illustrated in the story in Figure 1 are aspects of Australian science classes that can be considered fairly typical. It describes a lesson in which the teacher uses a variety of teaching methods and moves between whole-class and small-group activities. Whilst some of the classes that were observed were more teacher-centered, the majority of teachers purposefully moved away from such approaches. Of these teachers, many said that they felt it important to provide opportunities for students to be involved in discussions, group activities and cooperative work.

The use of an activity to help to explain the half-life of an isotope to students is described in this story. Whilst interviews revealed a range of factors that prevented teachers from moving away from teacher-centered methods as often as they would like, it was generally agreed that doing so was beneficial to the students. According to interviews with teachers in Australia, they have considerable freedom to decide how they deliver the content of the curriculum. Interviews indicated that the methods by which the content of the curriculum is delivered is left largely to the discretion of the school and, in some cases, individual teachers.

The science teachers' work area is described as being filled with books, resources and a photocopier. According to the teachers whom were interviewed, these resources are essential for their teaching to assist them to design programs and decide how they can best tailor the curriculum to suit the needs of their students. Many teachers design and photocopy worksheets and information sheets and, in one school, the science teachers had cooperatively designed and printed a series of science topic books relevant to the students from their school.

Relayed in the story is the use of self- and peer-assessment in the classroom. Many science classes observed in Western Australia made use of student portfolios to build a profile of students' achievement based on a variety of sources. The design of these portfolios and the way in which they were used varied between schools as they were generally designed collaboratively by teachers in the science department.

A question-and-answer session, in which the teacher revises a previous lesson, becomes the focus of part of the story. The Australian teachers whom were observed generally asked questions to the whole class and selected only those students who raised their hands, with the only exception being when the teacher used questioning as a means of classroom control (e.g. when a student was

talking at an inappropriate time). Once the students responded to the question, the teacher often thanked them for their answers or any comments which they made and, if the answer was wrong, the teacher made remarks such as "good try" or "almost". Teacher interviews revealed that this group of Australian teachers was sensitive to students' difficulties in answering questions in a whole-class situation and tried not to put the students' self-esteem at risk.

Finally, the story captures a variety of disruptions to the lesson, ranging from discussions between students to talking back to the teacher. With the exception of the higher-ability classes, this behavior was not uncommon in the science classrooms observed.

The next story develops a cultural archetype based on observations of science classrooms in Taiwan (Figure 2). This story, like the Australian story, develops themes that were common over a number of observations.

Figure 2. A Science Class in Taiwan

The drive to the school was an experience in itself. Never had I known such traffic. Rivers of motor scooters weaved in, out and around our car as we sped along roads choked with traffic. We are greeted by a huge archway, enscribed with the name of the school, as we enter the school grounds. Iris, my colleague and friend, has come to act as an interpreter, and she clears our entrance to the school with the security guard at the gate. The humidity hits us as we step out of the airconditioned car and make our way toward the building. The path passes through a lawn, dotted with garden beds and bordered with miniature hedges. These beds house small bushes, trimmed and clipped over years, to form exotic shapes.

I have been informed that protocol dictates that we meet with the principal before observing the classrooms, and so we make our way to her office on the third floor. As we climb the wide staircase we are greeted by students in neatly pressed uniforms, armed with brooms and dustpans, cleaning their allotted areas.

At the office, we are greeted by the principal and seated in large comfortable chairs. Over a cup of tea, we discuss the research project and the our reasons for observing the science teacher. I am shown the rather impressive school trophy collection, kept in large glass cabinets behind her desk, before a student is asked to take us to the classroom where I am to observe a lesson.

We climb to the fourth floor and enter the classroom through a door at the back of the room. The teacher hasn't arrived yet and the general chatter and noise of students is deafening. My blonde hair attracts the attention of some of the students, drawing furtive glances and giggles. "Hello lady" shouts a class clown. I reply, sending the class into whoops of laughter. As a Westerner, I am something of a novelty.

A synthesized recording of the chimes of Big Ben is blasted through speakers, heralding the start of the next lesson. The teacher's arrival sends students scurrying to sit behind small wooden desks. Each desk has a single shelf underneath on which books and pens have been placed. Bags, satchel like, are draped on the backs of chairs. Emptied of the necessary equipment, the bags still looking ominously full.

Prompted by a class leader, seven straight rows of students, with six in each, stand, bow their traditional salute and greet the teacher, out of sync and in boisterous voices. There is confusion—I am sitting in somebody's seat. After a brief disruption, the students are all facing the teacher, with their books open and eyes forward, ready for the lesson. Iris and I are both perched at the back of the class, with our knees between two students and our chairs touching the wall behind us. It's a tight fit.

The teacher smiles a welcome over the heads of the students. Above her hangs the Taiwan flag, below which is a poster depicting the country's founder, Sun Yat Sen, looking benignly at students. Bold characters, peeling slightly through age, placed on either side of the poster, demand that students respect their teacher and treasure wisdom. There are two blackboards in the class, one at the front of the class (that was wiped clean by a student as we waited) and one at the back that is covered in Chinese characters.

From behind the podium at the front of the class, the teacher begins the lesson. Her voice, amplified through a microphone worn around her neck, sings out above the noises outside: a jackhammer thumping

Table 2: Internal consistency (alpha reliability), discriminant validity (mean correlation of a scale with other scales), and ANOVA results for class membership differences (eta² statistic and significance level) for student actual form of nine instruments using individual as unit of analysis

Scale	Alpha rel.	Mean correl. with other scales	ANOVA results eta ²	Scale	Alpha rel.	Mean correl. with other scales	ANOVA results eta ²
Learning Environment Inventory (LEI) (N=1,048 students)							
Cohesiveness	0.69	0.14	—	College and University Classroom Environment Inventory (CUCEI) (N=372 students)			
Diversity	0.54	0.16	—	Personalisation	0.75	0.46	0.35*
Formality	0.76	0.18	—	Involvement	0.70	0.47	0.40*
Speed	0.70	0.17	—	Student Cohesiveness	0.90	0.45	0.47*
Material Environment	0.56	0.24	—	Satisfaction	0.88	0.45	0.32*
Friction	0.72	0.36	—	Task Orientation	0.75	0.38	0.43*
Goal Direction	0.85	0.37	—	Innovation	0.81	0.46	0.41*
Favouritism	0.78	0.32	—	Individualisation	0.78	0.34	0.46*
Difficulty	0.64	0.16	—	Questionnaire on Teacher Interaction (QTI) (N=3,994 students)			
Apathy	0.82	0.39	—	Leadership	0.82	— ^b	0.33*
Democracy	0.67	0.34	—	Helping/Friendly	0.88	—	0.35*
Clowniness	0.65	0.33	—	Understanding	0.85	—	0.32*
Satisfaction	0.79	0.39	—	Student	0.66	—	0.26*
Disorganisation	0.82	0.40	—	Responsibility/Freedom	—	—	—
Competitiveness	0.78	0.08	—	Uncertainty	0.72	—	0.22*
Classroom Environment Scale (CES) (N=1,083 students)							
Involvement	0.70	0.40	0.29*	Dissatisfied	0.80	—	0.23*
Affiliation	0.60	0.24	0.21*	Admiring	0.76	—	0.31*
Teacher Support	0.72	0.29	0.34*	Strict	0.63	—	0.23*
Task Orientation	0.58	0.23	0.25*	Science Laboratory Environment Inventory (SLEI) (N=3,727 students)			
Competition	0.51	0.09	0.18*	Student Cohesiveness	0.77	0.34	0.21*
Order and Organisation	0.75	0.29	0.43*	Open-Endedness	0.70	0.07	0.19*
Rule Clarity	0.63	0.29	0.21*	Integration	0.83	0.37	0.23*
Teacher Control	0.60	0.16	0.27*	Rule Clarity	0.75	0.33	0.21*
Innovation	0.52	0.19	0.26*	Material Environment	0.75	0.37	0.21*
Individualised Classroom Environment Questionnaire (ICEQ) (N=1,849 students)							
Personalisation	0.79	0.28	0.31*	Constructivist Learning Environment Survey (CLES) (N=1,081 students)			
Participation	0.70	0.27	0.21*	Personal Relevance	0.88	0.43	0.16*
Independence	0.68	0.07	0.30*	Uncertainty	0.76	0.44	0.10*
Investigation	0.71	0.21	0.20*	Critical View	0.85	0.31	0.14*
Differentiation	0.76	0.10	0.43*	Shared Control	0.91	0.41	0.17*
My Class Inventory (MCI) (N=2,305 students)							
Cohesiveness	0.67	0.20	0.21*	What Is Happening In This Classroom (WHITC) (N=1,081 students)			
Friction	0.67	0.26	0.31*	Student Cohesiveness	0.81	0.37	0.09*
Difficulty	0.62	0.14	0.18*	Teacher Support	0.88	0.43	0.15*
Satisfaction	0.78	0.23	0.30*	Involvement	0.84	0.45	0.10*
Competitiveness	0.71	0.10	0.19*	Investigation	0.88	0.41	0.15*
				Task Orientation	0.88	0.42	0.15*
				Cooperation	0.89	0.45	0.12*
				Equity	0.93	0.46	0.13*

^a This statistic is not available for the LEI.

^b This statistic is not relevant for the QTI.

improve the WES's face validity for use in schools, the word 'people' was changed to 'teachers', 'supervisor' was changed to 'senior staff', and 'employee' was changed to 'teacher' (Fisher & Fraser 1983b; Fraser, Docker & Fisher 1988). Of the WES's 10 scales, three measure Relationship Dimensions (Involvement, Peer Cohesion, Staff Support), two measure Personal Development Dimensions (Autonomy, Task Orientation) and five measure System Maintenance and System Change Dimensions (Work Pressure, Clarity, Control, Innovation, Physical Comfort). The WES consists of 90 items of True/False response format, with an equal number of items in each scale. Validation data for the WES were generated in a study of 34 primary and secondary schools in Tasmania (Docker, Fraser & Fisher 1989).

The *School-Level Environment Questionnaire* (SLEQ) was designed especially to assess school teachers' perceptions of psychosocial dimensions of the environment of the school. A review of potential strengths and problems associated with existing school environment instruments suggested that the SLEQ should contain eight scales (Fisher & Fraser 1991; Rentoul & Fraser 1983). Two scales measure Relationship Dimensions (Student Support, Affiliation), one measures the Personal Development Dimension (Professional Interest) and five measure System Maintenance and System Change Dimensions (Staff Freedom, Participatory Decision Making, Innovation, Resource Adequacy and Work Pressure). The SLEQ consists of 56 items, with each of the eight scales being assessed by seven items. Each item is scored on a five-point scale with the responses of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree. In addition to an actual form which assesses perceptions of what a school's work environment is actually like, the SLEQ also has a preferred form. In a study of the school-level environment of Catholic schools, Dorman, Fraser and McRobbie (1997) developed a 57-item school environment instrument which includes modified versions of five SLEQ scales (Student Support, Affiliation, Professional Interest, Resource Adequacy and Work Pressure), but which adds the two new scales of Empowerment (the extent to which teachers are empowered and encouraged to be involved in decision-making processes) and Mission Consensus (the extent to which consensus exists within the staff with regard to the overarching goals of the school). This instrument was used in studies of differences in the school environment of Catholic and government schools (Dorman & Fraser 1996) and of associations between school environment and classroom environment (Dorman, Fraser & McRobbie 1997).

RESEARCH INVOLVING EDUCATIONAL ENVIRONMENT INSTRUMENTS

Three types of past research considered in this section involve (1) associations between student outcomes and environment, (2) use of environmental dimensions as criterion variables (including the evaluation of educational innovations and investigations of differences between students' and teachers' perceptions of the same classrooms) and (3) investigations of whether students achieve better when

nearby, a plane passing overhead, the distant hum of traffic, a car horn. She asks a question to the whole class which is followed by an answer, chorused from the class in unison— boys' voices drowning out those of the girls. There are more questions and more answers as the previous lesson is revised thoroughly.

Today's lesson will be about ferns and it is clear from the posters and specimens that the teacher has brought in that she is well prepared. Students turn to the correct page in their textbook and I notice that the teacher is referring to her own copy before starting. The teacher begins her lesson in a lively, animated style, her eyes seeming to include each student as she speaks. I am surprised that I am able to follow the lesson with some accuracy, despite not understanding the language. The teacher makes frequent use of the blackboard to illustrate the various parts of the fern and describe their propagation. I notice that most of the students are listening and watching her, although one girl is resting her head on her desk and a boy is staring absently out of the window.

A burst of laughter from the students draws my attention to the latest illustration on the board, a rather sketchy drawing that vaguely resembles a fern. The teacher takes it good naturedly and continues to draw a second diagram showing the spores of the fern. At this point, the teacher produces the specimens which she has brought into the class. She explains, drawing examples on the board, and illustrating important facts before giving each one to a student. Each specimen is described at length and the relevant points are outlined in the text. Students turn the pages of the text in unison and some make notes.

A student near the front is whispering to her neighbor, who answers with a nod of her head. The teacher looks in their direction briefly but ignores the pair. One of the students is handed a specimen which is examined and touched, providing a moment's distraction. At regular intervals, the teacher asks the students whether they have a question, and waits for a few moments. Invariably there were none, except on this occasion. A student wanted to know whether a fern that he had seen in Singapore had medicinal value. The teacher, deciding that the question was not directly related to the lesson, defers it until the end.

The day is hot, sultry, oppressive. Six fans, hanging from a ceiling spotted with mildew and flaking paint, whirl ineffectually overhead, barely stirring the sticky air. Students begin to fidget and move around in their seats. I find myself shifting positions to get more comfortable on the wooden slats of the chair and to encourage circulation. Those students who were taking notes at the beginning of the lesson have stopped. To the left of me, there is small group of boys fiddling with their pens— practicing the art of flicking them expertly from one finger to another, twirling them as they do.

At this point, the teacher produces a poster that has been drawn and colored by hand. The illustration of the canopy is well done and draws oohs and aahs from the students. From her position at the front of the class, the teacher attracts students' attention, this time with a brief story of an experience that she had had climbing the mountains outside Kaohsiung. I notice that the pen flicking stops and the boy, who was looking out of the window, is paying attention to the teacher. The story is brought to an abrupt close when she examines her watch (something I have noticed her do throughout the lesson). The students are instructed to put their books away and given a reminder of tomorrow's test. Several students turn around automatically, to look to the blackboard behind me that lists the tests to be taken over the next week.

I had assumed that the lesson had finished but, once the textbooks were out of sight, the teacher called out a number from her book. Random selection of a students by their identity numbers was common practice in the classrooms, and I even remember one teacher using the second timer on his digital watch to ensure that the selection was fair. There is a burst of laughter from the other students as the boy who was selected stands up next to his chair. The teacher asks him a question and he responds in a quiet voice. Whilst the teacher gives no outward indication that he is correct, he must have been because he sits down. Looking at her book, she selects another student. There is another burst of laughter as another number is selected and a boy pulls himself to his feet.

The boy listens to the question, looking at his feet and rubbing his hands together. I find myself feeling nervous for him, willing him to get the answer right. I needn't have been concerned because his answer, whilst wrong, was merely corrected before he sat down. I continued to watch him after he had sat, but there was no ridicule from his peers and no side-long glances or shrugs borne out of embarrassment that I would have expected in an Australian class. The process was repeated until the lesson had been covered. Students laughed and cheered when their peers were called, as if part of a game. The students

answered the questions in quiet voices (in contrast to the boisterous ones that had greeted me when I had arrived) and sat down once they had been corrected.

When the last of the questions had been answered, the teacher outlined the important points and showed the students on what pages of the textbook they can be found. Raising her voice, to be heard over the din made by the chimes of Big Ben played through the speakers, she winds up the lesson. Once the chimes stop playing, there is relative quiet and the students stand to bow their salute to the teacher, marking the end of the lesson.

The class described in this story is fairly typical of junior high school science classes in Taiwan, and reveals distinct differences between classrooms in the two countries. Besides the physical differences between science classes in Australia and Taiwan such as the weather, school structure and classroom layout, other more subtle differences discussed below could only be explained after interviews with the participants: the nature of the curriculum (section 6.1); pressures experienced by teachers (section 6.2); respect for the teacher (section 6.3); questioning techniques (section 6.3); and educational aims (section 6.4).

6.1 The Nature of the Curriculum

Interviews with teachers and students in both countries indicated that the nature of the curriculum could be a major influence on the learning environment created by teachers in each country. The story of a Taiwanese classroom describes a teacher-centered lesson in which students appear to play a fairly passive role. Without exception, the classes observed by the researcher in Taiwan were teacher-centered and, whilst the roles of the students varied between teachers, there were generally few opportunities for discussions or questions. Interviews with teachers revealed that the teacher-centered approaches were largely a result of the examination-driven nature of the curriculum:

The way we teach is constrained. Students have to do the entrance exam to senior high school and they like to be crammed ... The exams, the [content of the] textbook and the amount of homework restrict how much work we can do outside of the textbook. Every aspect of science education is constrained. (Taiwanese Teacher, Interview 3, p. 3)

The story describes the teacher's battle to fit the required content into each lesson and the desire of the teacher to avoid giving the students additional work. The science curriculum (for both biology and physics) is presented to students in the form of textbooks, and examinations are based on the content of these. As a result, it is important for teachers to cover all areas. Teachers whom were interviewed explained that teacher-centered methods were the most practical way to cover the content in the given time frame and diversions (described in the story as student questions referring to real-life situations) are often not possible given the time constraints:

The textbook is very big and the teacher has to go through each stage. There is too much to teach ... and there isn't enough time to cover the content of the book. Ideally I would like to give students the chance to learn what is not in the textbook ... (but I) don't do that ... because of the shortage of time. (Taiwanese Teacher, Interview 3, pp. 2-3).

It would appear that the competitive nature of the curriculum encourages teachers to concentrate on developing academic ability as efficiently as possible. Diversions from these teacher-centered methods are also viewed negatively by many parents, teachers and students as being off-task:

Under the education system that we have in Taiwan, the lecture kind of teaching is the most efficient way to teach students and get a good score. ... The students' time is already very tight and they work too hard already, so [by teaching in this way] I can do something for them. For example, I don't ask the students to go to the library for information for their study, because it would be another burden on the students. (Taiwanese Teacher, Interview 1, p. 6)

Rote learning, described in the story as a question-and-answer session that makes use of chorused answers to revise a previous lesson, is frequently used in Taiwan. Many of the lessons observed

involved rote learning at some stage, and it was felt by teachers and students that such learning would better prepare students for the examinations. One teacher, referring to a comment made about moving away from teacher-centered methods, stated that: "The students know how the class should be taught ... and that there will be a problem if the teacher changes this" (Taiwanese Teacher, Interview 3, p. 3). Good examination results are of paramount importance to students in Taiwan because good results increase the likelihood of being allocated a position in a 'star' school (i.e. a school with outstanding results measured by the number of students who enter university).

In contrast, the Australian teachers whom were interviewed generally expressed a desire to use methods that were not teacher-centered in their science classes. Their reasons were varied, but generally it was felt that, by using a variety of approaches, students would be better able to develop a range of abilities in their students. In many cases, these teachers claimed that they were encouraged, through professional development days and by other staff, to use a variety of methods in their teaching.

Rote learning was frowned upon by many of the teachers interviewed in Australia and one commented that "developing the students' ability as learners is more important than the acquisition of content knowledge" (Interview, Teacher 1, p. 2). In general, these teachers were of the opinion that, by incorporating a range of teaching styles, they were more likely to cater for the range of learning styles that could be present in their class. In addition, they felt that their students were more likely to understand concepts if they were actively involved in their learning.

Interviews indicated that the nature of the curriculum was largely responsible for the type of teaching approaches used in each country. Teachers whom were interviewed in Australia indicated that, like Taiwan, the science curriculum in Western Australia is defined by set content that needs to be covered. However, unlike Taiwan, where the curriculum is examination-driven and presented in the form of a textbook (whose depth and scope leave little time for any method of teaching other than teacher-centered), the methods by which the Western Australian curriculum was delivered was left largely to the teacher. Consequently, the nature of the curriculum led to quite different learning environments in each country.

6.2 Pressures Experienced by Teachers

Interviews with teachers in both countries revealed that pressures, each from different sources, could influence the learning environment created in each country. In Taiwan, interviews revealed that teachers experienced pressures from their principal, parents and other teachers when the test scores of their science classes were displayed for comparisons with other teachers. The principal, keen for schools to maintain or improve their position (according to the number of students who gain access into star schools), pressures teachers to push students toward improving their test results. The home-room teacher also pressures teachers to ensure that the grades of students in his/her class don't slip and that they improve their performance if the results are lower than those of other teachers:

The class scores are [posted] in one of the offices and the teachers go there to check their class. ... They want to see whether they have a good score compared to the other teachers. ... The score of the class puts the teacher under a lot of pressure [from the home-room teacher] and ..., if your class score is the lowest, your attitude towards that class can change. (Taiwanese Teacher, Interview 1, p. 6)

Parents, keen that their students attend a star school to improve their chances of attending university, also pressure teachers. In Taiwan, social mobility is available to students of any status through education. Because the expectation of many parents is that their child will attend university, they exert pressure on students to perform well in examinations. In addition, parents have high expectations of teachers and their ability to obtain high performance from the students:

[T]he parents' attitudes can act as a constraint [to our teaching] because sometimes, if the teacher is not on task in the classroom, the students will tell their parents and they will go to the school to tell the teacher to teach more content. (Taiwanese Teacher, Interview 1, p. 5)

Teachers in Australia, however, are under pressures of a different kind. Many of the Australian teachers whom were interviewed felt that pressures which they experienced were more likely to come from the expectations of the school science department, school and State Department of Education than the parents or principal. These teachers generally felt that they were expected to perform tasks over and above classroom teaching, routine lesson planning, assessment and programming tasks, such as tailoring the curriculum to the students' needs or designing and implementing student self-assessment projects.

Observations of science classrooms in Australia did not appear to reflect these pressures. The teaching methods and approaches varied widely between teachers, with some being highly innovative and creative in their lessons and others (the majority of teachers observed) using more whole-class activities and teaching (as described in the first story in Figure 1). Interviews with teachers, however, indicated the tasks that they needed to perform outside of teaching can affect the lessons that they teach because less time is available to plan lessons.

It would appear that the pressures of an examination-driven curriculum experienced by teachers in Taiwan are more likely to create a consistently teacher-centered learning environment. In contrast, the pressures related to those factors experienced by teachers in Australia have a more indirect influence on the learning environment, dictated through time available for planning rather than dictating a particular teaching method or range of methods.

6.3 Respect for the Teacher

Classroom observations and interviews suggest that there could be differences in the ways in which students regard their teachers, with students in Taiwan having more respect for teachers than students in Australia. The traditional bow of students at the beginning and end of lessons, described in the story, is considered to be a mark of respect. Interviews with teachers and students in Taiwan indicated that teachers have a high status within the community and that they are highly respected by their students. According to Huang (1997), teachers in Taiwan hold a professional status within the community and are respected as experts in their field. Reinforcing their status and professional standing, one of the teachers whom was interviewed in Taiwan made a point of intentionally distancing himself from his students:

If I'm too close or friendly, students feel that I am more of a friend than a teacher. So, if I'm too close, they won't feel pressured to study... [By distancing myself], they [the students] won't forget what position they hold or lose respect. (Taiwanese Teacher, Interview 1, p. 1)

Whilst the teachers in both countries complained about discipline problems with students, we noted that there was more evidence of disruptive behavior in science classes in Australia (described in the first story in Figure 1 as answering back and chatting between friends) than in Taiwan. It was noted that, unlike teachers in Taiwan who distance themselves from students, teachers in Australia tended to treat students more as equals. In some cases, it appear that this meant that students were more likely to act in a manner that could be considered disrespectful to the teacher.

In Taiwan, the teacher's knowledge was not questioned by any of the students interviewed. They rarely questioned the teaching methods or the lesson content: "I like what the teacher is teaching me. She teaches very well and it is always interesting. So I don't need to question the way she teaches" (Item 63, Taiwanese Student F). On the other hand, students whom we interviewed in Australia were more likely to complain about their teacher and the teaching methods.

Some Australian students complained that they found science lessons boring and said that they would choose to have science taught differently. There were cases (especially for students in lower-ability classes) of students viewing science and their science teachers as something to be endured because the subject was compulsory: "I find science confusing and sometimes I don't understand Mr C. Science just isn't interesting" (Item 45, Australian Student 4.3). "Sometimes we get to do investigations ... Sometimes they're not interesting. I'm not interested in science" (Item 39, Australian Student 4.2). It was interesting to note, however, that students in both countries claimed that they would prefer science classes to include more experiments and laboratory work.

For the classroom in Taiwan, described in the second story (Figure 2), there was only one incident during the lesson of students talking. During classroom observations, the researcher noted that student disruptions were minimal, with brief, whispered discussions with a neighbor being the only signs of disturbance. Students whom were interviewed indicated that these discussions were generally related to points that were unclear from the lecture. Whilst teachers in Taiwan discussed 'discipline problems' with the researcher, it appears that these problems are associated more with inattentiveness than disruptions to the lesson.

In the classroom in Australia described in the first story (figure 1), there were several incidences of students talking between themselves, calling out or answering back to the teacher. The teachers whom were interviewed expressed the opinion that a lack of discipline was one of the biggest constraints to their teaching. These teachers complained that disruptive students often prevented them from being able to teach in ways in which they would ideally like. In some cases, teachers felt that they often found themselves in the role of counselor and spent teaching time sorting out students' problems. One teacher expressed concern at the lack of avenues to which a teacher could turn for assistance with disruptive behavior.

The students whom we observed in Australia were more likely to interrupt or be disrespectful towards the teacher. In Taiwan, there appears to be a larger gap between the status of teachers and students than in Australia, where students and teachers interact more as equals. This point is highlighted in the first story which describes an Australian teacher performing tasks, such as giving out papers, that normally would be undertaken by students in Taiwan. Teachers whom were observed in Australia appeared more likely to treat students as equals and, in some cases, this meant that students were more likely to act in a manner that could be considered disrespectful to the teacher.

6.4 Questioning Techniques

Both stories describe the use of questioning in the classrooms, but it appears that the techniques used were different for the two countries. The question-and-answer session described in Australia depicts a teacher posing questions to the whole class and selecting only from students with their hands raised. Interviews with teachers indicated that they were careful not to damage the self-esteem of students and to ensure that the student's pride amongst his/her peers was protected. According to student interviews, many students were reluctant to raise their hands unless they were reasonably sure of the answer, while others made a point of never answering questions in class. Students explained that ridicule from peers was possibly the main reason for their reluctance to answer questions: "I usually don't like putting my hand up. ... If I get the answer wrong, then I get embarrassed [because] other kids in the class could laugh at me" (Australian Student A).

In contrast, teachers whom were observed in Taiwan (described in the story in Figure 2) randomly select students using the students' identity numbers (stitched above the pocket on their school shirts) rather than their names. The selected student stood up to answer the question and, if the answer was wrong, the teacher bluntly told him or her so. The student then either tried again or sat down and listened to the answer of another student. Interviews with students revealed that they were not uncomfortable with this method of questioning and that questions were used as a means of gauging what students need to know or what they do not understand to enable them to improve and learn. As one student put it, "When he [the teacher] teaches important content, he checks that we understand. So he asks us questions" (Taiwanese Student, Interview 2, Item 23).

6.5 Educational Aims

A final factor that was considered important to the teacher's creation of the learning environment was the educational aims considered important in each country. In Taiwan, the teachers whom were interviewed indicated that education was focused predominantly on the development of the academic ability of students. Social and emotional aspects of a student's development were generally considered to be more the responsibility of the family and wider community than of the school (Stevenson & Stigler, 1992). In contrast, teachers in Australia whom were interviewed

considered academic development to be one of a number of aspects to be developed in students, with social, emotional, and physical development holding equal value. It was interesting to note that the educational aims held by these Australian teachers were more academically oriented for students at the senior high school level, where the curriculum is more examination driven.

The science classrooms described in the stories presented in this section have quite different learning environments. If these stories are to be considered archetypes for the science classrooms in their respective countries, then they can be used to help explain the differences and similarities. It would appear that teachers in both countries create learning environments to suit a variety of social and cultural factors within their respective countries. There are different opinions in Australia and Taiwan of what is considered to be the ideal learning environment.

Interviews with students and teachers indicated that, whilst the classroom environments are different in the two countries (as indicated by the mean scale scores of the WIHIC questionnaire), this does not necessarily reflect the overall quality of education. Students in Taiwan perceived that the classroom practices assessed by each scale of the WIHIC occurred to a lesser extent than did their Australian counterparts. In a Western sense, this could be considered a 'less favorable' perception of the learning environment, but this has to be considered in terms of the questionnaire and whether the scales reflect what is considered to be educationally, socially and culturally important in the countries where the data were collected.

The observations and interviews provided valuable insights into the learning environment in each country. They provided insights into cultural and social factors that would not have been possible with questionnaire responses alone. The use of stories to describe observations of the learning environment in each country (Figures 1 and 2) raised interesting questions related to the researchers' voice and forced the researchers to recognize that they had approached the study with a set of assumptions that would have undoubtedly influenced their interpretations of their observations. It was necessary to acknowledge that the researchers also had possible biases with which they approached the study. These factors led the researchers to make a retrospective analysis of the stories written during observations to describe one of the researcher's journey during the study during which she 'crossed cultural borders'.

7.0 Findings Related to Recognizing and Minimizing Cultural Bias

This section explores two factors associated with the bias and assumptions that researchers bring to a cross-cultural study. In the first place, stories and dialectical tensions are explored to identify differences in the lenses that researchers of different cultures brought to the present study and how these affected what they observed and how they interpreted their observations. Secondly, a retrospective analysis of the stories written during the course of study, is used to explore the notion of *border crossing* and the journey that one of the researcher's took over the course of the present cross-cultural study.

7.1 Identifying the Different Lenses that Researchers Bring to a Study

Critical reflexivity was considered an important factor during the present study. Stories were written by one researcher from Taiwan and one from Australia at the end of observations made in each country. Four stories are based on observations in Taiwan (one example of which is in Figure 3) and two on observations in Australia (one example of which is in Figure 4), all of which provided commentaries that helped to highlight the different lenses through which researchers from different cultures perceived classrooms.

Figure 3. Jill's Story About a Taiwanese Classroom

There is much fidgeting and fiddling with pens. Someone, a boy, at the back is squirming in his chair. The plant specimens, examples of different ferns, are making their way around the class for students to inspect. One student slaps his neighbour with a long fern frond, unnoticed by the teacher.

The teacher talks continuously, pausing only to write on the board, or draw a diagram, or wait for a question that is never asked. He looks at his watch, continues to talk about what is written on the board, and consults the exercise book, as he has done all through the class.

He examines his watch once more and decrees that everyone should pack up. There is a general chorus of approval and one boy is so excited that he claps. Shortly after the textbooks are out of sight, there is a hum of agreement and a burst of laughter from one of the children. At first, I think that this signals the end of a very tedious session in which students have sat and listened to endless talks by the teacher. But I was wrong. A boy, looking nervous, is standing next to his chair. At first, I assume that he has a question to ask, but I find that the teacher is going to ask him a question to which he must respond. The teacher gives no indication that he is correct but he must have been for he sits down. The teacher is looking at the book which he is holding and from it he calls on another student.

Is he selecting them by name? I am surprised when he obviously doesn't know where the child is sitting. Another burst of laughter and hum of agreement which I felt must be relief from students whom hadn't been selected. An overweight and exceedingly nervous young lad stands up. At this stage, students don't listen to the question, much less the answer— obviously it is the problem of the unfortunate one. I find myself feeling nervous for him even though I cannot know what the teacher will ask. I find that I'm willing him to get it right, to be able to sit down again. I realised then that the teacher was only half listening whilst selecting a third victim— for they seemed to me to be unwilling prey. The number (as I learnt later) of the student is called out at random. I'm not sure if the teacher even knows the names of his students. The third student stands and I can't recall whether it was a girl or a boy, only that nobody was interested in the question or the answer which appeared (by the teacher's reaction) to be wrong. After responding to the student's answer, possibly a correction, the teacher continues to talk. In much the same manner as the rest of the class, he commands attention from different positions in the room but invites no input from the students.

Pouring his knowledge into very bored, very tired-looking students, he drones on, drowned out by the sound of the chimes piped through the speakers. The most involvement that he has included in the lesson has taken place in the final five minutes. Now, as is tradition, students stand, bow in unison and chorus a farewell to the teacher.

Thunderously loud, all students talk at once, a little louder than their neighbours, to be heard. The noise and excitement mark the end of a very long school day.

Figure 4. Iris' Story About the Same Taiwanese Classroom

It's 5.10 p.m. and a student near the front has already put her head on the table. There has been seven hours of learning already today and this is the eighth hour.

The teacher has spoken a lot— on topics from non-vascular plants to vascular plants, from moss to ferns and seed plants. The teacher has lectured for 40 minutes and the students feel that they can't put more learning into their minds. The teacher thinks that maybe he has talked too much already and decides to stimulate the students by giving them a chance to practise. There's insufficient time for a test and, if they do one, it would need to be scored— too much work to do. Why not just ask the students? So the teacher asked, "Do you have any questions?"

The students do not respond and the teacher can't check whether they understand or not. So the teacher said, "I had planned to give you a small test, but there is not enough time. I want to check whether you understand or not, so I will ask you questions."

The students seem unwilling and yell out "Ya-aa". The teacher goes on. "When I call a number, please stand up and answer the question. If you answer incorrectly, it's okay, but you must answer so that I will know whether you have understood or not." The teacher called out, "35".

The other students yelled out, feeling happy that they were not called. The teacher asked, "Why is moss so short?" Some students said that the question was too simple. Student 35 thinks that he can't answer it, so the

teacher reminded her that "it relates to no root, no stem, no leaf". The student remembers and answers that "there is no vascular system" and then sits down, happy that it is all over.

The other students are nervous again as they listen for which number will be called. "21", the teacher said. "Aah", again, a happy yell.

"What is the name of the large fern tree that appeared three million years ago?"

The student can't answer so the teacher waited for a while and said, "that's a tree fern". Then the teacher called, "14". More yells.

The teacher asked, "Ferns are reproduced by spores— where are they located?"

Students at the back are playing together and the last students in the fifth line takes a piece of paper with "superstar of the school" written on it and holds it in front of the camera.

"42", the teacher called. Students have lost their excitement and there's no yelling out. "Why isn't moss very tall?"

At the back of the fourth and fifth lines, two students are playing together. At last, the bell rings. But the teacher still reminds students about non-vascular and vascular plants, from moss to seed plants. "You must read about them at home. Then, when I talk tomorrow, you will understand it."

But the students are busy packing their bags for home. At last, they stand up and salute to thank their teacher in the traditional way and leave today's class.

The stories helped to identify differences in researchers' perceptions of aspects of the study. One such difference was the researchers' views of what constituted a good teacher. The researcher from Taiwan considered that the most important element of being a good teacher was good content knowledge. For the Australian researcher, the most important feature was concerned with the interpersonal relationships developed between the teacher and the students. This difference in perceptions was to create a different lens through which each researcher viewed their observations. It was found that the researcher from Taiwan was more likely to pay attention to the content of the lesson and the depth of knowledge that the teacher relayed to the students. In contrast, the Australian teacher was more likely to focus on the teacher's interpersonal skills and the way in which the teacher related to the students at different levels.

The lense through which the researchers observed each lesson was also colored by the view that each held of what constituted 'active participation'. Prior to observations, we had discussed the importance of 'active participation' during a science lesson and, in many cases, we discussed the degree to which 'active participation' had taken place during these lessons. It was not until after we had read a number of stories about our observations that we realized that we each held different views. The Australian researcher had used this term to describe lessons or activities that encouraged a 'hands-on' approach (i.e., more student-centered and involving physically maneuvering, touching and investigating a variety of materials). The Taiwanese researcher, however, perceived the term 'active participation' as a 'minds-on' phenomenon in which students not only pay attention to what is taught, but assimilate the new information with different or similar information that has been learned. This requires the teacher to keep the students interested and attentive to what is being taught. Once again, these differences colored what each of the researchers considered important during the observations, and the stories often reflected these.

7.2 The Notion of Border Crossing in a Cross-Cultural Study

Finally, the researchers' stories were used to illustrate one of the Western researcher's shift from a largely Eurocentric perception of the education system in Taiwan to a critical awareness of the Australian education system. The stories and their subsequent commentaries, in combination with student and teacher interviews, were the catalyst for the Western researcher's 'border crossing', as

in their preferred environments. A separate section later focuses on teachers' practical attempts to improve their classroom and school climates.

Associations Between Student Outcomes and Environment

The strongest tradition in past classroom environment research has involved investigation of associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Fraser & Fisher 1982; Haertel, Walberg & Haertel 1981; McRobbie & Fraser 1993). Numerous research programs have shown that student perceptions account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics. For example, Fraser's (1994) tabulation of 40 past studies in science education shows that associations between outcome measures and classroom environment perceptions have been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments and a variety of samples (ranging across numerous countries and grade levels).

Using the SLEI, associations with students' cognitive and affective outcomes have been established for a sample of approximately 80 senior high school chemistry classes in Australia (Fraser & McRobbie 1995; McRobbie & Fraser 1993), 489 senior high school biology students in Australia (Fisher, Henderson & Fraser 1997) and 1,592 grade 10 chemistry students in Singapore (Wong & Fraser 1996). Using an instrument suited for computer-assisted instruction classrooms, Teh and Fraser (1995a) established associations between classroom environment, achievement and attitudes among a sample of 671 high school geography students in 24 classes in Singapore. Using the QTI, associations between student outcomes and perceived patterns of teacher-student interaction were reported for samples of 489 senior high school biology students in Australia (Fisher, Henderson & Fraser 1995), 3,994 high school science and mathematics students in Australia (Fisher, Fraser & Rickards 1997) and 1,512 primary school mathematics student in Singapore (Goh, Young & Fraser 1995).

Multilevel Analysis

While many past learning environment studies have employed techniques such as multiple regression analysis, few have used the multilevel analysis (Bock 1989; Bryk & Raudenbush 1992; Goldstein 1987), which takes cognisance of the hierarchical nature of classroom settings. Because classroom environment data typically are derived from students in intact classes, they are inherently hierarchical. Ignoring this nested structure can give rise to problems of aggregation bias (within-group homogeneity) and imprecision.

Two studies of outcome-environment associations compared the results obtained from multiple regression analysis with those obtained from an analysis involving

the hierarchical linear model. The multiple regression analyses were performed separately at the individual student level and the class mean level. In the ILM analyses, the environment variables were investigated at the individual level, and were aggregated at the class level. In Wong, Young and Fraser's (1997) study involving 1,592 grade 10 students in 56 chemistry classes in Singapore, associations were investigated between three student attitude measures and a modified version of the SLEI. In Goh, Young and Fraser's (1995) study with 1,512 grade 5 mathematics students in 39 classes in Singapore, scores on a modified version of the MCI were related to student achievement and attitude. Most of the significant results from the multiple regression analyses were replicated in the ILM analyses, as well as being consistent in direction.

Meta-Analysis of Studies

The findings from prior research are highlighted in the results of a meta-analysis involving 734 correlations from 12 studies involving 823 classes, eight subject areas, 17,805 students and four nations (Haertel, Walberg & Haertel 1981). Learning posttest scores and regression-adjusted gains were found to be consistently and strongly associated with cognitive and affective learning outcomes, although correlations were generally higher in samples of older students and in studies employing collectivities such as classes and schools (in contrast to individual students) as the units of statistical analysis. In particular, better achievement on a variety of outcome measures was found consistently in classes perceived as having greater Cohesiveness, Satisfaction and Goal Direction and less Disorganisation and Friction. Other meta-analyses synthesised by Fraser, Walberg, Welch and Hattie (1987) provide further evidence supporting the link between educational environments and student outcomes.

Cooperative Learning

Among the various lines of programmatic research on classroom environment, the work on the relative effectiveness of cooperative, competitive and individualistic goal structures stands out because of the volume of studies completed (Johnson & Johnson 1991). Although many past studies of student achievement have found that cooperative learning is more successful than either competitive or individualistic learning, the evidence is not always consistent. The generally positive effect of cooperative learning approaches on student achievement is illustrated by the findings of a comprehensive meta-analysis involving 122 studies (Johnson, Maruyama, Johnson, Nelson & Skon 1981), but this synthesis is not totally conclusive and generalisable. For instance, a large proportion of these studies involved group outcomes (e.g., the group's ability to solve problems) rather than the conventional student individual outcome which is so important in primary and secondary schooling.

they helped to redefine self-conscious boundaries that were originally established through cultural-centrism.

In the past, studies involving the notion of *border crossing* (Giroux, 1992) have explored the idea of moving from different cultures and micro-cultures encountered in everyday life, in several different contexts, including minority groups crossing into the world of white Anglo-Saxons (Lugones, 1987) and students' journeys from their everyday lives into the subculture of school science (Aikenhead, 1996; Cobern & Aikenhead, 1998). The present study went beyond past research in non-Western countries that merely involved translating a questionnaire into another language and using it to replicate previous research in Western countries. Through using a range of intensive qualitative methodologies during numerous visits to Taiwanese schools, the Western researcher in the present study 'crossed the cultural border' not only to gain a deeper understanding of classroom environments in Taiwan, but also to reexamine her ideas about education in her own country.

The Australian researcher commenced this study with a more Orientalist mind bent, described by Said (1995, p. 45) as the "sense of Western power over the Orient". Initially, the Australian researcher tended to use her own culture as a benchmark to determine whether science classes in Taiwan were effective or appropriate, and explained differences between the science classes of each country using her own experiences and cultural understandings. The initial reactions which she had towards science classrooms in Taiwan and her comparisons of the learning environments led her to view education in Australia as more conducive to effective learning. The ensuing discourse assumed the role of Orientalism in which she "expressed the strength of the West and the Orient's weakness" (Said, 1995, p. 45), as seen by herself, a Westerner.

The concept of border crossing (Giroux, 1992) was used to make sense of the researcher's shift from Orientalism towards rethinking and reinvestigation of assumptions about what she knew to be true of schools and the culture in Taiwan. Her initial reaction to science teaching in Taiwan was one of 'symbolic violence' (Bourdieu, 1992), in which she felt that science in Taiwan went against much that she had learned to represent good teaching. However, after subsequent discussions with colleagues and interviews with teachers, she was able to make sense of particular actions and to recognize difficulties and pressures under which teachers in Taiwan work. She began to empathize with these teachers and understand the problems which they faced. This, coupled with the Taiwanese researcher's conflicting view of what constituted an effective teacher, forced her to reexamine her own views.

Whilst the examination-driven curriculum in Taiwan appears to have forged teaching styles different from in Australia, interviews with students revealed that they were not as unhappy with classes in Taiwan as the researcher had imagined. In fact, students whom we interviewed in Taiwan had more positive attitudes towards science classes than those in Australia. This disclosure forced the researcher to take a more objective look at teaching in her own country and, as a result, she began to find that perhaps it was not as superior as she had first imagined. She no longer considered Australian education to be relatively free of faults and, in contrast, commenced a more critical discourse about Australian education than was possibly necessary.

As a border crosser, she began to recognize that neither system was superior, neither had all the answers and, in retrospect, both had a lot to offer the other. The researcher's awareness of Orientalism, and the difficulties that this mind bent could pose, made her more critical of her own reactions towards education in Taiwan. This awareness would not have been possible if she had not felt at ease with her fellow researchers and able to question and probe aspects of their culture.

8.0 Discussion

The research described in this paper is different from the large majority of studies in science education in that it extended beyond the confines of a single country to involve researchers from two different countries in working collaboratively in pursuing the same research questions both in their own country and in the other country. This study is also distinctive in that it went beyond past

cross-national research which was restricted to translating a questionnaire developed in the West into another language, and then using it on another country to replicate previous research in Western countries. This study used a multimethod approach in which the use of qualitative research methods (observations, interviews and narrative stories) augmented questionnaire data to provide richer interpretations and insights. Overall, the study highlighted the importance of cross-national studies to help our understanding not only of classroom environments in other countries, but also of classroom environments in our own country, it supported the value of using multiple research methods, and it enabled the researchers to 'cross the border' into the world of science education in another country.

The quantitative data, collected using the What is Happening in This Class? (WIHIC) questionnaire and an attitude scale in the first phase of this study, supported the reliability and validity of both the English and Mandarin versions of all scales. The final 56-item version of the classroom environment questionnaire had 8 items in each of the 7 scales. The *a priori* factor structure was replicated with nearly all of the items loading on its own factor and no other factor. Internal consistency (alpha reliability) for two units of analysis and ability to differentiate between classrooms were found to be satisfactory. Overall, the study provides very strong support for the reliability and validity of a widely-applicable learning environment questionnaire for use in two countries and in two languages.

A comparison of scale means between the two countries revealed interesting anomalies that, in the spirit of the interpretive approach, prompted the researchers to seek why differences might occur. The initial data indicated that Australian students consistently perceived their classroom environments more favorably than did students in Taiwan on all scales but, in contrast, Taiwanese students had a more positive attitude towards their science classes. To explore these findings in more depth, the researchers took the roles of 'bricoleur' as described by Denzin and Lincoln (1994), in that they pieced together the data collected using different methodology to gain deeper insights into the learning environments.

Whilst the quantitative data made an important contribution to the bricolage of information built up during the study, it was limited when used for comparative purposes. We found that students from Australia and Taiwan responded to questionnaire items in ways that were meaningful to their own situations and were often influenced by social and cultural factors. Consequently, the interpretation of the data became more meaningful when combined with data gathered using other research methods. This provided a precautionary note regarding 'imposed etic' (Berry, 1969), experienced when researchers use a questionnaire framed in one cultural context and impose those categories, variables, concepts and constructs on a different culture.

The generation and analysis of data collected using classroom observations, interviews with participants and narrative stories allowed the researcher to explore the students' perceptions of the learning environment; identify factors which influence the learning environments in Taiwan and Australia; and make meaningful interpretations which took into account the background, culture and situation of individuals. Through adopting an interpretive approach that enabled the researchers to weave together the data collected from multiple paradigms and methodologies, it was possible to examine components which could be influenced by culture such as "situational and contextual factors, ... [including] social expectations, norms, task definitions and social cues" (Maehr & Nicholls, 1980, p. 8) that otherwise might be overlooked.

The learning environments created in each country were found to be influenced by the nature of the curriculum, with the more examination-driven curriculum in Taiwan leading to more teacher-centered approaches in the classroom. Consequently, emphases considered important to science education in Western Australia, such as involvement, are not always as important or possible in Taiwan. The pressures experienced by teachers in each country appear to influence the learning environment and in some respects appear to be on opposing ends of a pendulum swing. Whilst there are pressures related to an examination-driven curriculum, there also are pressures related to implementing innovative ideas and tailoring a less prescriptive curriculum to students' needs.

The degree of respect that students held for their teacher appeared to influence the classroom environment. The decidedly rowdier environment in Australia, where students appeared to be more disruptive in class, was held in contrast to the classes in Taiwan that were comparatively quiet and free of students' disruptions. There were points, good and bad, to be said for both learning environments, with students in Taiwan being less inclined to ask the teacher questions than their Australian counterparts, but with the Australian students being more likely to encounter occasions when learning was interrupted by the disruptive behavior of others.

It was felt that each country has much to learn from the other with regard to the development of a learning environment which fosters positive attitudes and a love of learning. The comparative nature of the present study of learning environments in Taiwan and Australia made possible the examination of similarities and differences between the learning environment and students' perceptions in each country. By comparing the learning environments in two such different cultures, the researchers were able to identify the qualities inherent in each. As such, cross-cultural comparisons of this type have the potential to provide understanding of concepts as seen by the people within the culture under study, generating new insights (Brislin, 1983; Fraser, 1999; Stigler & Hiebert, 1997) and making possible the inclusion of the social context in which behaviors occur (Bilmes & Boggs, 1979; Tseng & Hsu, 1980). Comparative studies of this nature enable researchers, teachers and teacher educators to gain better understandings about their own beliefs and the social and cultural restraints to their teaching.

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Items in the What is Happening in this Class? Questionnaire

Student Cohesiveness

1. I make friendships among students in this class.
2. I know other students in this class.
3. I am friendly to members of this class.
4. Members of the class are my friends.
5. I work well with other class members.
6. I help other class members who are having trouble with their work.
7. Students in this class like me.
8. In this class, I get help from other students.

Teacher Support

9. The teacher takes a personal interest in me.
10. The teacher goes out of his/her way to help me.
11. The teacher considers my feelings.
12. The teacher helps me when I have trouble with the work.
13. The teacher talks with me.
14. The teacher is interested in my problems.
15. The teacher moves about the class to talk with me.
16. The teacher's questions help me to understand.

Involvement

17. I discuss ideas in class.
18. I give my opinions during class discussions.
19. The teacher asks me questions.
20. My ideas and suggestions are used during classroom discussions.
21. I ask the teacher questions.
22. I explain my ideas to other students.
23. Students discuss with me how to go about solving problems.
24. I am asked to explain how I solve problems.

Investigation

25. I carry out investigations to test my ideas.
26. I am asked to think about the evidence for statements.
27. I carry out investigations to answer questions coming from discussions.
28. I explain the meaning of statements, diagrams and graphs.
29. I carry out investigations to answer questions which puzzle me.
30. I carry out investigations to answer the teacher's questions.
31. I find out answers to questions by doing investigations.

32. I solve problems by using information obtained from my own investigations.

Task Orientation

33. Getting a certain amount of work done is important to me.
34. I do as much as I set out to do.
35. I know the goals for this class.
36. I am ready to start this class on time.
37. I know what I am trying to accomplish in this class.
38. I pay attention during this class.
39. I try to understand the work in this class.
40. I know how much work I have to do.

Cooperation

41. I cooperate with other students when doing assignment work.
42. I share my books and resources with other students when doing assignments.
43. When I work in groups in this class, there is teamwork.
44. I work with other students on projects in this class.
45. I learn from other students in this class.
46. I work with other students in this class.
47. I cooperate with other students on class activities.
48. Students work with me to achieve class goals.

Equity

49. The teacher gives as much attention to my questions as to other students' questions.
50. I get the same amount of help from the teacher as do other students.
51. I have the same amount of say in this class as other students.
52. I am treated the same as other students in this class.
53. I receive the same encouragement from the teacher as other students do.
54. I get the same opportunity to contribute to class discussions as other students.
55. My work receives as much praise as other students' work.
56. I get the same opportunity to answer questions as other students.

Items are scored 1, 2, 3, 4 and 5, respectively, for the responses Almost Never, Seldom, Sometimes, Often and Almost Always.

Educational Productivity Research

Psychosocial learning environment has been incorporated as one factor in a multifactor psychological model of educational productivity (Walberg 1981). This theory, which is based on an economic model of agricultural, industrial and national productivity, holds that learning is a multiplicative, diminishing-returns function of student age, ability and motivation; of quality and quantity of instruction; and of the psychosocial environments of the home, the classroom, the peer group and the mass media. Because the function is multiplicative, it can be argued in principle that any factor at a zero-point will result in zero learning; thus either zero motivation or zero time for instruction will result in zero learning. Moreover, it will do less good to raise a factor that already is high than to improve a factor that currently is the main constraint to learning. Empirical probes of the educational productivity model were made by carrying out extensive research syntheses involving the correlations of learning with the factors in the model (Fraser, Walberg, Welch & Hattie 1987; Walberg 1986) and secondary analyses of large data bases collected as part of the National Assessment of Educational Achievement (Walberg 1986) and National Assessment of Educational Progress (Fraser, Welch & Walberg 1986; Walberg, Fraser & Welch 1986). Classroom and school environment was found to be a strong predictor of both achievement and attitudes even when a comprehensive set of other factors was held constant.

Use of Environment Perceptions as Criterion Variables

Evaluation of Educational Innovations

Classroom environment instruments can be used as a source of process criteria in the evaluation of educational innovations (Fraser, Williamson & Tobin 1987). An evaluation of the Australian Science Education Project (ASEP) revealed that, in comparison with a control group, ASEP students perceived their classrooms as being more satisfying and individualised and having a better material environment (Fraser 1979). The significance of this evaluation is that classroom environment variables differentiated revealingly between curricula, even when various outcome measures showed negligible differences. Recently, the incorporation of a classroom environment instrument within an evaluation of the use of a computerised database revealed that students perceived that their classes became more inquiry oriented during the use of the innovation (Maor & Fraser 1996). Similarly, in two studies in Singapore, classroom environment measures were used as dependent variables in evaluations of computer-assisted learning (Teh & Fraser 1994) and computer-application courses for adults (Khoo & Fraser 1997). In an evaluation of an urban systemic reform initiative in the USA, use of the CLES painted a disappointing picture in terms of a lack of success in achieving constructivist-oriented reform of science education (Dryden & Fraser 1996).

Differences Between Student and Teacher Perceptions of Actual and Preferred Environment

An investigation of differences between students and teachers in their perceptions of the same actual classroom environment and of differences between the actual environment and that preferred by students or teachers was reported by Fisher and Fraser (1983a) using the ICEQ with a sample of 116 classes for the comparisons of student actual with student preferred scores and a subsample of 56 of the teachers of these classes for contrasting teachers' and students' scores. Students preferred a more positive classroom environment than was actually present for all five ICEQ dimensions. Also, teachers perceived a more positive classroom environment than did their students in the same classrooms on four of the ICEQ's dimensions. These results replicate patterns emerging in other studies in school classrooms in the USA (Moos 1979), Israel (Hofstein & Lazarowitz 1986), The Netherlands (Wubbels, Brekelmans & Hooymaners 1991) and Australia (Fraser 1982b; Fraser & McRobbie 1995), and in other settings such as hospital wards and work milieus (e.g., Moos 1974).

Studies Involving Other Independent Variables

Classroom environment dimensions have been used as criterion variables in research aimed at identifying how the classroom environment varies with such factors as teacher personality, class size, grade level, subject matter, the nature of the school-level environment and the type of school (Fraser 1994). For example, larger class sizes were found to be associated with greater classroom Formality and less Cohesiveness (Anderson & Walberg 1972). Kent and Fisher (1997) established associations between teacher personality and classroom environment (e.g., extravert teachers' classes having high levels of Student Cohesiveness). Knight (1992) reported differences in the classroom environment perceptions of African American and Hispanic students, and Levy, Wubbels, Brekelmans and Morganfield (1994) reported cultural differences (based on place of birth and primary language spoken at home) in student perceptions of teacher-student interaction.

Several studies have attempted to bring the fields of classroom environment and school environment together by investigating links between classroom and school environment (Fisher, Fraser & Wubbels 1993; Fisher, Grady & Fraser 1995; Fraser & Rentoul 1982). When Dorman, Fraser and McRobbie (1997) administered a classroom environment instrument to 2,211 students in 104 classes and a school environment instrument to 208 teachers of these classes, only weak associations between classroom environment and school environment were found. Although school rhetoric often would suggest that the school ethos would be transmitted to the classroom level, it appears that classrooms are somewhat insulated from the school as a whole.

In a study of students' preferences for different types of classroom environments, girls were found to prefer cooperation more than boys, but boys preferred

both competition and individualisation more than girls (Owens & Straton 1980). Similarly, Byrne, Hattie and Fraser (1986) found that boys preferred friction, competitiveness and differentiation more than girls, whereas girls preferred teacher structure, personalisation and participation more than boys. Several studies have revealed that females generally hold perceptions of their classroom environments that are somewhat more favourable than the perceptions of males in the same classes (Fisher, Fraser & Rickards 1997; Fraser, Giddings & McRobbie 1995; Henderson, Fisher & Fraser 1995).

Person-Environment Fit Studies of Whether Students Achieve Better in Their Preferred Environment

Using both actual and preferred forms of educational environment instruments permits exploration of whether students achieve better when there is a higher similarity between the actual classroom environment and that preferred by students. By using a person-environment interaction framework, it is possible to investigate whether student outcomes depend, not only on the nature of the actual classroom environment, but also on the match between students' preferences and the actual environment (Fraser & Fisher 1983b, 1983c; Wong & Watkins 1996). Using the ICEQ with a sample of 116 class means, Fraser and Fisher's study involved the prediction of posttest achievement from pretest performance, general ability, the five actual individualisation variables and five variables indicating actual-preferred interaction. Overall, the findings suggested that actual-preferred congruence (or person-environment fit) could be as important as individualisation *per se* in predicting student achievement of important affective and cognitive aims. The practical implication of these findings is that class achievement of certain outcomes might be enhanced by attempting to change the actual classroom environment in ways which make it more congruent with that preferred by the class.

TEACHERS' ATTEMPTS TO IMPROVE CLASSROOM AND SCHOOL ENVIRONMENTS

Although much research has been conducted on educational environments, less has been done to help teachers to improve the environments of their own classrooms or schools. This section reports how feedback information based on student or teacher perceptions can be employed as a basis for reflection upon, discussion of, and systematic attempts to improve classroom and school environments (Fraser 1981). The proposed methods have been applied successfully in studies at the early childhood (Fisher, Fraser & Bassett 1995), primary (Fraser & Deere 1983; Fraser, Docker & Fisher 1988), secondary (Fraser, Seddon & Eagleson 1982; Thorp, Burden & Fraser 1994; Woods & Fraser 1996) and higher education levels (Fisher & Parkinson in press; Yarrow & Millwater 1995; Yarrow, Millwater & Fraser 1997).

The attempt at improving classroom environments described below (Fraser & Fisher 1986) made use of the short 24-item version of the CES discussed previously. The class involved in the study consisted of 22 grade 9 boys and girls of mixed ability studying science at a government school in Tasmania. The procedure followed by the teacher of this class incorporated the following five steps:

- (1) *Assessment.* All students in the class responded to the preferred form of the CES first, while the actual form was administered in the same time slot one week later.
- (2) *Feedback.* The teacher was provided with feedback information derived from student responses in the form of the profiles shown in Figure 1 representing the class means of students' actual and preferred environment scores. These profiles permitted ready identification of the changes in classroom environment needed to reduce major differences between the nature of the actual environment and the preferred environment as currently perceived by students. Figure 1 shows that the interpretation of the larger differences was that students would prefer less Friction, less Competitiveness and more Cohesiveness.
- (3) *Reflection and discussion.* The teacher engaged in private reflection and informal discussion about the profiles in order to provide a basis for a decision about whether an attempt would be made to change the environment in terms of some of the dimensions. The main criteria used for selection of dimensions for change were, first, that there should exist a sizeable actual-preferred difference on that variable and, second, that the teacher should feel concerned about this difference and want to make an effort to reduce it. These considerations led the teacher to decide to introduce an intervention aimed at increasing the levels of Teacher Support and Order and Organisation in the class.
- (4) *Intervention.* The teacher introduced an intervention of approximately two months' duration in an attempt to change the classroom environment. This intervention consisted of a variety of strategies, some of which originated during discussions between teachers, and others of which were suggested by examining ideas contained in individual CES items. For example, strategies used to enhance Teacher Support involved the teacher moving around the class more to mix with students, providing assistance to students and talking with them more than previously. Strategies used to increase Order and Organisation involved taking considerable care with distribution and collection of materials during activities and ensuring that students worked more quietly.
- (5) *Reassessment.* The student actual form of the scales was re-administered at the end of the intervention to see whether students were perceiving their classroom environments differently from before.

The results summarised graphically in Figure 1 show that some change in actual environment occurred during the time of the intervention. When tests of statistical significance were performed, it was found that pretest-posttest differences were

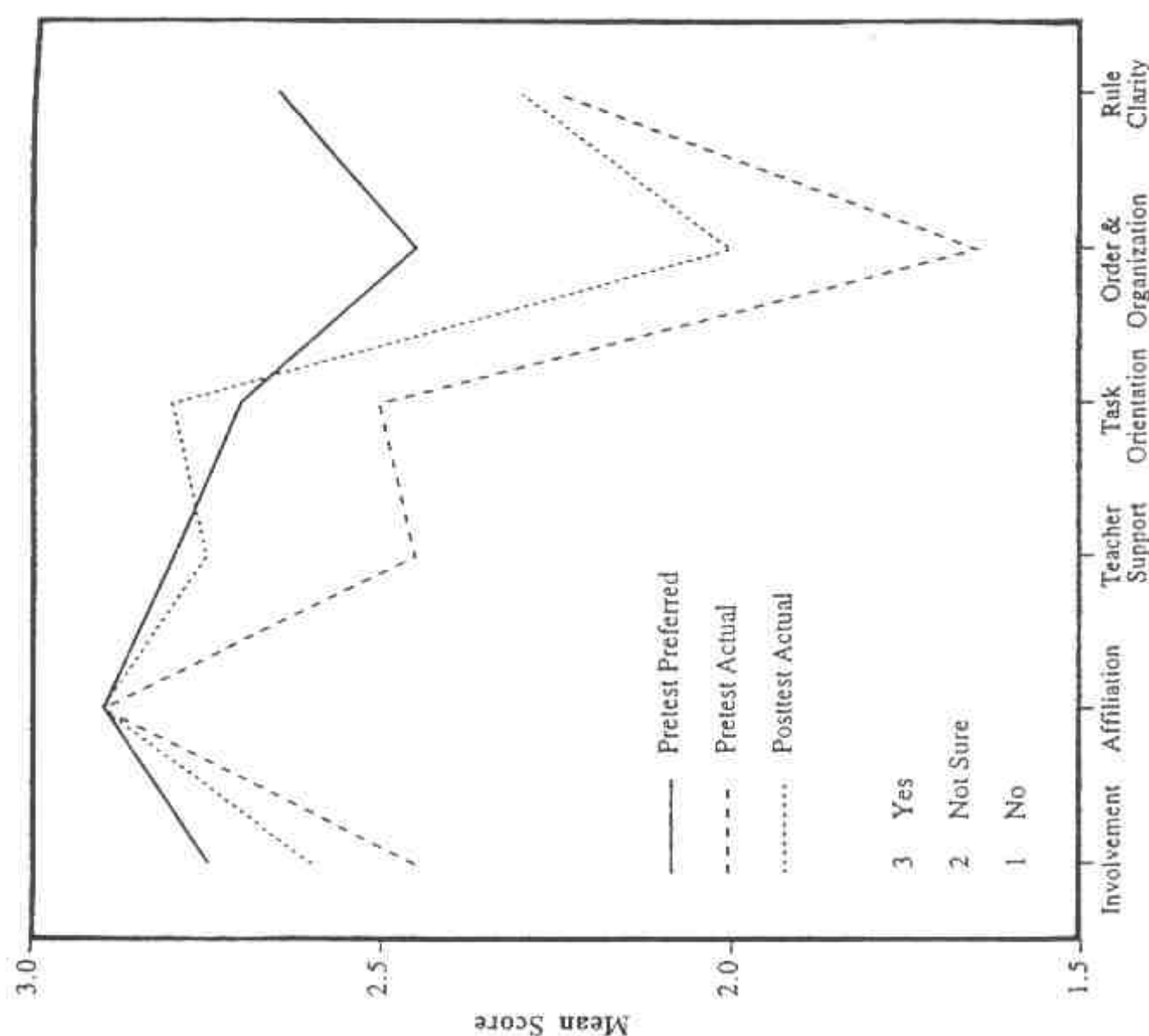


Figure 1: Pretest actual, pretest preferred and posttest actual means.

significant ($p < 0.05$) only for Teacher Support, Task Orientation and Order and Organisation. These findings are noteworthy because two of the dimensions on which appreciable changes were recorded were those on which the teacher had attempted to promote change. (Note also that there appears to be a side effect in that the intervention could have resulted in the classroom becoming more task oriented than the students would have preferred.) Although the second administration of the environment scales marked the end of this teacher's attempt at changing a classroom, it might have been thought of as simply the beginning of another cycle.

Woods and Fraser (1995) used this basic approach to improving classroom environments with 16 teachers who used the actual and preferred forms of the Classroom Interaction Patterns Questionnaire to assess student perceptions of six dimensions of teacher behaviour (Praise and Encouragement, Open Questioning, Lecture and Direction, Individual Work, Discipline and Management, and Group Work). Whereas half of the teachers received feedback and attempted changes in their classrooms, the other half only administered the questionnaires. The study showed that the teachers who received feedback, compared with the teachers who didn't receive feedback, were able to achieve more reductions in actual-preferred discrepancies on most classroom environment dimensions.

Yarrow, Millwater and Fraser (1997) reported a study in which 117 preservice education teachers were introduced to the field of learning environment through being involved in action research aimed at improving their university teacher education classes and their 117 primary school classes during teaching practice. The CUCIEI was used at the university level and the MCI was used at the primary level. Improvements in classroom environment were observed, and the preservice teachers generally valued both the inclusion of the topic of learning environment in their preservice programs and the opportunity to be involved in action research aimed at improving classroom environments.

The methods described previously for improving classroom environments have been adapted for use by teachers wishing to improve their school-level environments. Fraser, Docker and Fisher (1988) used the WES as part of teacher development activities and reported a case study of a successful school change attempt in a primary school with a staff of 24 teachers. The SLEQ (Fisher & Fraser 1991) was used in similar school improvement studies using the same basic strategy in a primary school of 15 teachers. After an intervention had been implemented for approximately 10 weeks, it was found that sizeable changes had occurred in two of the targeted areas (of about two-thirds of a standard deviation and about half a standard deviation, respectively).

RECENT TRENDS AND DESIRABLE FUTURE DIRECTIONS

Combining Quantitative and Qualitative Methods

Educational researchers claim that there are merits in moving beyond choosing between quantitative or qualitative methods, to combining quantitative and qualitative methods. In recent years, significant progress has been made towards the desirable goal of combining quantitative and qualitative methods within the same study in research on classroom learning environments (see Fraser & Tobin 1991 and Tobin & Fraser's chapter in this *Handbook*).

For example, a team of 13 researchers was involved in over 500 hours of intensive classroom observation of 22 exemplary teachers and a comparison group of non-exemplary teachers (Fraser & Tobin 1989). The main data collection methods were based on interpretive research methods and involved classroom observation,

interviewing of students and teachers, and the construction of case studies. But, a distinctive feature was that the qualitative information was complemented by quantitative information obtained from questionnaires assessing student perceptions of classroom psychosocial environment. These instruments furnished a picture of life in exemplary teachers' classrooms as seen through the students' eyes. The study suggested that, first, exemplary and non-exemplary teachers could be differentiated in terms of the psychosocial environments of their classrooms as seen through their students' eyes and, second, that exemplary teachers typically create and maintain environments that are markedly more favourable than those of non-exemplary teachers (Fraser & Tobin 1989).

In a study which focused on the elusive goal of higher-level cognitive learning, a team of six researchers intensively studied the grade 10 science classes of two teachers (Peter and Sandra) over a ten-week period (Tobin, Kahle & Fraser 1990). Each class was observed by several researchers, interviewing of students and teachers took place on a daily basis, and students' written work was examined. The study also involved quantitative information from questionnaires assessing student perceptions of classroom psychosocial environment. Students' perceptions of the learning environment within each class were consistent with the observers' field records of the patterns of learning activities and engagement in each classroom. For example, the high level of Personalisation perceived in Sandra's classroom matched the large proportion of time that she spent in small-group activities during which she constantly moved about the classroom interacting with students. The lower level of Personalisation perceived in Peter's class was associated partly with the larger amount of time spent in the whole-class mode and the generally public nature of his interactions with students.

Fraser's (1996) multilevel study of the learning environment of a science class in Australia incorporated a teacher-researcher perspective as well as the perspective of six university-based researchers. The research commenced with an interpretive study of a grade 10 science teacher's classroom learning environment at one school, which provided a challenging learning environment in that many students were from working class backgrounds, some were experiencing problems at home, and others had English as a second language. Qualitative methods involved several of the researchers visiting this class each time it met over five weeks, using student diaries, and interviewing the teacher-researcher, students, school administrators and parents. A video camera recorded activities during each lesson for later analysis. Field notes were written during and soon after each observation, and team meetings took place three times per week. The qualitative component of the study was complemented by a quantitative component involving the use of a questionnaire which linked three levels: the class in which the interpretive study was undertaken; selected classes from within the school; and classes distributed throughout the same State. This enabled a judgement to be made about whether this teacher was typical of other teachers at her school, and whether the school was typical of other schools within the State. Some of the features identified as salient in this teacher's classroom environment were

peer pressure and an emphasis on laboratory activities. (For another example of a multilevel classroom environment study which combined quantitative and qualitative methods, see Waxman, Huang & Wang 1996.)

School-Level Environments

Although science education researchers have paid more attention to classroom environment research than to school environment research, desirable future directions include a greater emphasis on the school-level environment and the integration of classroom and school climate variables within the same study. Docker, Fraser and Fisher (1989) reported the use of the WES with a sample of 599 teachers in investigating differences between the environment of various school types. Reasonable similarity was found for preferred environment scales, but teachers' perceptions of their actual school environments varied markedly in that the climate in primary schools was more favourable than the environment of high schools on most scales. For example, primary schools were viewed as having greater Involvement, Staff Support, Autonomy, Task Orientation, Clarity, Innovation and Physical Comfort and less Work Pressure. Similarly, when the SLEQ was used in a study of differences between the climates of primary and high schools for a sample of 109 teachers in 10 schools (Fisher & Fraser 1991), the most striking finding was that the climate in primary schools emerged as more favourable than the environment of high schools on most SLEQ scales. Dorman and Fraser (1996) used a school environment questionnaire based on the SLEQ in a comparison of Catholic and government schools. Data from 208 science and religion teachers from 32 schools showed significant differences of approximately one standard deviation between the two school types on teacher-perceived Mission Consensus and Empowerment. Catholic school teachers saw their schools as more empowering and higher on Mission Consensus than government school teachers.

School Psychology

Given the school psychologist's changing role, the field of psychosocial learning environment provides a good example of an area which furnishes a number of ideas, techniques and research findings which could be valuable in school psychology (Fraser 1987; Hertz-Lazarowitz & Od-Cohen 1992). Traditionally, school psychologists have tended to concentrate heavily and sometimes exclusively on their roles in assessing and enhancing academic achievement and other valued learning outcomes. The field of classroom environment provides an opportunity for school psychologists and teachers to become sensitised to subtle but important aspects of classroom life, and to use discrepancies between students' perceptions of actual and preferred environment as a basis to guide improvements in classrooms (Burden

& Fraser 1993). Similarly, expertise in assessing and improving school environment can be considered important in the work of educational psychologists (Burden & Fraser 1994).

Links Between Educational Environments

Although most individual studies of educational environments in the past have tended to focus on a single environment, there is potential in simultaneously considering the links between and joint influence of two or more environments. For example, Marjoribanks (1991) shows how the environments of the home and school interact and codetermine school achievement, and Moos (1991) illustrates the links between school, home and parents' work environments. Several studies have established associations between school-level and classroom-level environment (Dorman, Fraser & McRobbie 1997; Fraser & Rentoul 1982). In order to investigate whether the socio-cultural environment influences Nigerian students' learning of science, Jegede, Fraser and Okebukola (1994) developed and validated the *Socio-Cultural Environment Scale* to assess students' perceptions of Authoritarianism, Goal Structure, African World-View, Societal Expectations and Sacredness of Science with 600 senior secondary students. Apparently, students' socio-cultural environment in non-Western societies can create a wedge between what is taught and what is learned.

Cross-National Studies

Science education research which crosses national boundaries offers much promise for generating new insights for at least two reasons (Fraser 1997). First, there usually is greater variation in variables of interest (e.g., teaching methods, student attitudes) in a sample drawn from multiple countries than from a one-country sample. Second, the taken-for-granted familiar educational practices, beliefs and attitudes in one country can be exposed, made 'strange' and questioned when research involves two countries.

Huang and Fraser (1997) reported one of the few cross-national studies undertaken in science education. It involved six Australian and seven Taiwanese science education researchers in working together on a cross-national study of learning environments. The WIHIC was administered to 50 junior high school science classes in each of Taiwan (1,879 students) and Australia (1,081 students). An English version of the questionnaire was translated into Chinese, followed by an independent back translation of the Chinese version into English again by team members who were not involved in the original translation. Qualitative data, involving interviews with teachers and students and classroom observations, were collected to complement the quantitative information and to clarify reasons for patterns and differences in the means in each country.

The scales of Involvement and Equity had the largest differences in means

between the two countries, with Australian students perceiving each scale more positively than students from Taiwan. Data from the questionnaires were used to guide the collection of qualitative data. Student responses to individual items were used to form an interview schedule which was used to clarify whether items had been interpreted consistently by students and to help to explain differences in questionnaire scale means between countries. Classrooms were selected for observations on the basis of the questionnaire data, and specific scales formed the focus for observations in these classrooms. The qualitative data provided valuable insights into the perceptions of students in each of the countries, helped to explain some of the differences in the means between countries, and highlighted the need for caution when interpreting differences between the questionnaire results from two countries with cultural differences.

Transition from Primary to High School

There is considerable interest in the effects on early adolescents of the transition from primary school to the larger, less personal environment of the junior high school at this time of life. Midgley, Eccles and Feldlaufer (1991) reported a deterioration in the classroom environment when students moved from generally smaller primary schools to larger, departmentally-organised lower secondary schools, perhaps because of less positive student relations with teachers and reduced student opportunities for decision making in the classroom. Ferguson and Fraser's (1996) study of 1,040 students from 47 feeder primary schools and 16 linked high schools in Australia also indicated that students perceived their high school classroom environments less favourably than their primary school classroom environments, but the transition experience was different for boys and girls and for different school size 'pathways'.

Teacher Education

Although the field of psychosocial learning environment provides a number of potentially valuable ideas and techniques for inclusion in teacher education programs, little progress has been made in incorporating these ideas into teacher education. Fraser (1993) reported some case studies of how classroom and school environment work has been used within preservice and inservice teacher education to (1) sensitise teachers to subtle but important aspects of classroom life, (2) illustrate the usefulness of including classroom and school environment assessments as part of a teacher's overall evaluation/monitoring activities, (3) show how assessment of classroom and school environment can be used to facilitate practical improvements in classrooms and schools and (4) provide a valuable source of feedback about teaching performance for the formative and summative evaluation of student teaching. It appears that information on student perceptions of the classroom learning environment during preservice teachers' field experience

adds usefully to the information obtained from university supervisors, school-based cooperating teachers and student teacher self-evaluation (Duschl & Waxman 1991). Créton, Hermans and Wubbels (1990) have used a systems communication perspective to provide guidance on how teacher education programs can be changed to improve interpersonal teacher behaviour in the classroom (e.g., changing escalating spirals of breakdown in communication).

Teacher Assessment

An innovative teacher assessment system called the Louisiana STAR (System for Teaching and Learning Assessment and Review) specifically includes learning environment dimensions among a set of four performance dimensions (Ellett, Loup & Chauvin 1989). The other three performance dimensions are Preparation, Planning and Evaluation (e.g., teaching methods, homework, assessment), Classroom and Behaviour Management (e.g., student engagement, monitoring student behaviour) and Enhancement of Learning (e.g., content accuracy, thinking skills, pace, feedback). With the STAR, multiple observers complete an assessment in 45 minutes by focusing on preparation and planning in addition to in-class performance, on student learning as well as teaching behaviour, on higher-level as well as lower-level student learning, and on differential provision for different children. Teachers who were effective in terms of the psychosocial learning environment dimension were found to encourage positive interpersonal relationships within a classroom environment in which students felt comfortable and accepted. The teacher, through verbal and non-verbal behaviours, modelled enthusiasm and interest in learning, included all students in learning activities and encouraged active involvement.

DISCUSSION AND CONCLUSION

The major purpose of this chapter devoted to perceptions of psychosocial characteristics of classroom and school environments has been to make this exciting research tradition in science education more accessible to wider audiences. In its attempt to portray prior work, attention has been given to instruments for assessing classroom and school environments (including some interesting new instruments and the distinction between Personal and Class forms), several lines of previous research (e.g., associations between outcomes and environment, use of environment dimensions as dependent variables, person-environment fit studies of whether students achieve better in their preferred environment), and teachers' use of learning environment perceptions in guiding practical attempts to improve their own classrooms and schools. Also new lines of research which suggest desirable future directions for the field were discussed, including the desirability of combining quantitative and qualitative methods, school-level environment, links between different educational environments, cross-national studies, changes in

environment during the transition from primary to high school, and incorporating educational environment ideas into school psychology, teacher education and teacher assessment.

This section of the *Handbook* devoted to learning environments has five other chapters which are summarised below. In 'The Teacher Factor in the Social Climate of the Classroom', Theo Wubbels and Mieke Brekelmans review research on teachers' contributions to a positive social climate in science classes, particularly through their interaction or communication with students. The way in which a teacher interacts with students is important because it is a predictor of student learning and discipline problems and of teacher job satisfaction and burnout. The chapter considers data-gathering methods (such as observation and questionnaires, including the Questionnaire on Teacher Interaction, associations between student outcomes and teacher-student interactions, and correlates of teacher-student interactions (e.g., teacher age, experience and cognition, student gender and setting).

McRobbie, Fisher and Wong's chapter on 'Personal and Class Forms of Classroom Environment Instruments' differentiates between a learning environment questionnaire which assesses the whole-class environment (Class form) and one which assesses a student's perception of his or her role within a classroom (Personal form). Personal forms are better suited for investigating within-class subgroups and for case studies of individual students. Differences were found in the means obtained on Personal and Class forms, and these were illuminated through student interviews. The Personal form and the Class form each accounted for unique variance in student outcomes that could not be explained by the other form.

Hanna Arzi's chapter entitled 'Enhancing Science Education Through Laboratory Environments: More than Walls, Benches and Widgets' assumes that laboratory work is both a means and an end in science education and that some of school science teaching should be carried out in a flexibly-designed laboratory. The chapter considers the goal of laboratory work, the structure and function of laboratories, and the physical design of laboratories. A case study of designing science environments is reported.

In 'Reading the Furniture: The Semiotic Interpretation of Science Learning Environments', Bonnie Shapiro broadens the term 'learning environment' to include signs, symbols and rule sets as powerful features that influence learning and teaching. The chapter considers the historical development of semiotics as a research approach, and provides five case studies of the use of a semiotic interpretive perspective. Finally, implications of the semiotic perspective for teaching, learning and curriculum organisation are explored, and the value of a semiotic awareness of school learning environments is discussed.

Kenneth Tobin and Barry Fraser, in 'Qualitative and Quantitative Landscapes of Classroom Learning Environments', consider multiple theoretical perspectives for framing learning environment research and its methods, and they advocate combining qualitative and quantitative methods to maximise the potential of research. A major contribution of the chapter is a case study involving an analysis

of a learning environment at multiple levels or 'grain sizes'. The credibility of assertions from this study was enhanced by the use of qualitative and quantitative information from multiple data sources and grain sizes.

Based on research on learning environments, several practical implications for policy-makers and practitioners can be drawn (see, Fraser & Wubbels 1995). First, learning environment assessments should be used in addition to student learning outcome measures to provide information about subtle but important aspects of classroom life. Second, because teachers and students have systematically different perceptions of the same classrooms, student feedback about classrooms should be collected. Third, teachers should strive to create 'productive' classroom learning environments as identified by research (e.g., classroom environments with greater organisation, cohesiveness and goal direction and less friction). Fourth, in order to improve student outcomes, classroom environments should be changed to make them more similar to those preferred by the students. Fifth, the evaluation of innovations, new curricula and reform efforts should include classroom environment assessments to provide process measures of effectiveness. Sixth, teachers should use assessments of actual and the preferred learning environments to monitor and guide attempts to improve classrooms and schools. Seventh, learning environment assessments should be used by school psychologists in helping teachers change their styles of interacting with students and improve their classroom and school environments.

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4. Wubbels, T. Teacher-student relationships in science and mathematics classes
- ✓ 5. Maor, D.M., & Fraser, B.J. Use of classroom environment perceptions in evaluating inquiry-based computer-assisted learning
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APPENDIX A

Constructivist Learning Environment Survey

Actual Form

Directions for Students

These questionnaires contain statements about practices which could take place in this class. You will be asked how often each practice takes place.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted. Think about how well each statement describes what this class is like for you.

Draw a circle around

- | | | |
|---|-----------------------------|---------------|
| 1 | if the practice takes place | Almost Never |
| 2 | if the practice takes place | Seldom |
| 3 | if the practice takes place | Sometimes |
| 4 | if the practice takes place | Often |
| 5 | if the practice takes place | Almost Always |

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Practice Example

Suppose you were given the statement 'I choose my partners for group discussion'. You would need to decide whether you choose your partners 'Almost always', 'Often', 'Sometimes', 'Seldom' or 'Almost never'. If you selected 'Often', then you would circle the number 2 on your questionnaire.

Learning about the world		Almost Never	Seldom	Sometimes	Often	Almost Always
In this class . . .						
1.	I learn about the world outside of school.	1	2	3	4	5
2.	My new learning starts with problems about the world outside of school.	1	2	3	4	5
3.	I learn how science can be part of my out-of-school life.	1	2	3	4	5
In this class . . .						
4.	I get a better understanding of the world outside of school.	1	2	3	4	5
5.	I learn interesting things about the world outside of school.	1	2	3	4	5
6.	What I learn has nothing to do with my out-of-school life.	1	2	3	4	5
Learning about science		Almost Never	Seldom	Sometimes	Often	Almost Always
In this class . . .						
7.	I learn that science cannot provide perfect answers to problems.	1	2	3	4	5
8.	I learn that science has changed over time.	1	2	3	4	5
9.	I learn that science is influenced by people's values and opinions.	1	2	3	4	5
In this class . . .						
10.	I learn about the different sciences used by people in other cultures.	1	2	3	4	5
11.	I learn that modern science is different from the science of long ago.	1	2	3	4	5
12.	I learn that science is about creating theories.	1	2	3	4	5
Learning to speak out		Almost Never	Seldom	Sometimes	Often	Almost Always
In this class . . .						
13.	It's OK for me to ask the teacher 'Why do I have to learn this?'	1	2	3	4	5
14.	It's OK for me to question the way I'm being taught.	1	2	3	4	5
15.	It's OK for me to complain about teaching activities that are confusing.	1	2	3	4	5
In this class . . .						
16.	It's OK for me to complain about anything that prevents me from learning.	1	2	3	4	5
17.	It's OK for me to express my opinion.	1	2	3	4	5
18.	It's OK for me to speak up for my rights.	1	2	3	4	5

Learning to learn		Almost Never	Seldom	Sometimes	Often	Almost Always
In this class . . .						
19.	I help the teacher to plan what I'm going to learn.	1	2	3	4	5
20.	I help the teacher to decide how well I am learning.	1	2	3	4	5
21.	I help the teacher to decide which activities are best for me.	1	2	3	4	5
In this class . . .						
22.	I help the teacher to decide how much time I spend on learning activities.	1	2	3	4	5
23.	I help the teacher to decide which activities I do.	1	2	3	4	5
24.	I help the teacher to assess my learning.	1	2	3	4	5
Learning to communicate		Almost Never	Seldom	Sometimes	Often	Almost Always
In this class . . .						
25.	I get the chance to talk to other students.	1	2	3	4	5
26.	I talk with other students about how to solve problems.	1	2	3	4	5
27.	I explain my understandings to other students.	1	2	3	4	5
In this class . . .						
28.	I ask other students to explain their thoughts.	1	2	3	4	5
29.	Other students ask me to explain my ideas.	1	2	3	4	5
30.	Other students explain their ideas to me.	1	2	3	4	5

Fraser, B.J.:

Assessing and improving classroom environment

Fraser, B.J. (1989). Assessing and improving classroom environment. *What research says No. 2*. Perth: Curtin University of Technology

ASSESSING AND IMPROVING CLASSROOM ENVIRONMENT

Barry J. Fraser

STUDENTS SPEND a vast amount of time, in the order of 15,000 hours, in school classrooms during primary and secondary schooling. Consequently, the quality of life in these classrooms is of great importance and students' reactions to and perceptions of their school experiences are significant.

Teachers often speak of a classroom's climate, environment, atmosphere, tone, ethos or ambience and consider it to be both important in its own right and influential in terms of student learning. It would be rare, however, for science and mathematics teachers to include classroom environment measures among their evaluation procedures. Typically, teachers concentrate almost exclusively on the assessment of academic achievement, and devote little attention to factors which might be related to their students' performance.

Although classroom environment is a somewhat subtle concept, remarkable progress has been made over the last two decades in conceptualizing, assessing and researching it. This research has attempted to answer many questions of interest to science and mathematics teachers. Does a class-

room's environment affect student learning and attitudes? Can teachers conveniently assess the climates of their own classrooms and can they change these environments? Is there a difference between actual and preferred classroom environment, as perceived by students, and does this matter in terms of student outcomes. Do teachers and their students perceive the same classroom environments similarly? What is the impact of a new curriculum or teaching method on classroom environment? Do students of different abilities, genders or ethnic backgrounds perceive the same classroom differently? These questions represent the thrust of the work on classroom environments over the past 20 years (see reviews by Fraser, 1986a, 1986b, 1989).

Although much research has been conducted on student perceptions of classroom learning environment, surprisingly little has been done to help science and mathematics teachers assess and improve the environments of their own classrooms. Consequently, the basic purpose of the present publication is to inform science and mathematics teachers about this work, and to make available to them a questionnaire for assessing classroom environment.

A description is given of a convenient classroom environment questionnaire which can be used by teachers to obtain a quick and easy assessment of their students' perceptions of classroom environment. A complete copy of this questionnaire, in a form that may be reproduced by teachers for use in their own classrooms, is provided. Also, a description is given of a case study of a teacher's successful application of a straightforward method for improving the environment of her classroom.

ASSESSMENT OF CLASSROOM ENVIRONMENT

DESPITE THE FACT that the original form of several instruments measuring student perceptions of classroom environment has proved useful for various research purposes, experience has shown that many teachers would prefer an assessment method which is more economical in terms of the time required for administration and scoring. Consequently, a short version of several scales was developed to satisfy two main criteria (Fraser & Fisher, 1983). First, the number of items is reduced to provide greater economy in testing and scoring time. Second, because many teachers do not have ready access to computerized scoring methods, the short form is amenable to easy hand scoring.

Supplement A contains the short version of one classroom environment questionnaire, called the *My Class Inventory (MCI)*, which is well-suited for use at the primary and lower secondary school levels because of the low reading levels of its items. This instrument is economical in that it measures five different dimensions, yet contains only 25 items altogether. The simple Yes-No response format makes the questionnaire easy for students to answer. Students' answers are recorded on the questionnaire itself to avoid

errors that can arise in transferring responses to a separate answer sheet. With a one-page questionnaire, printing costs are minimized and neither collation nor stapling are necessary.

The items shown in Supplement A are arranged in cyclic order and in blocks of five to enable ready hand scoring. The first item in each block assesses *Satisfaction (S)*; the second item in each block assesses *Friction (F)*; the third item assesses *Competitiveness (Cm)*; the fourth item assesses *Difficulty (D)*; and the last item in each block assesses *Cohesiveness (Ch)*. The meaning of these scales can be clarified simply by examining the items they contain.

In order to score most items, 3 is given for the Yes response and 1 is given for the No response. But, for the items with *R* in the *For Teacher's Use* column, reverse scoring is used so that 3 is given for No and 1 is given for Yes. Omitted or incorrectly answered items are given a score of 2. The score for each of the 25 individual items can be written in the *For Teacher's Use* column.

The total score for a particular scale is simply the sum of the scores for the five items belonging to that scale. For example, the Satisfaction scale total is obtained by adding the scores given to Items 1, 6, 11, 16 and 21, whereas the Cohesiveness total is the sum of the scores obtained for the last item in each block. The bottom of the questionnaire provides some spaces where the teacher can record the student's total score for each scale. Figure 1 shows how the questionnaire was scored to obtain a total of 10 for the Satisfaction scale and 12 for the Cohesiveness scale.

In addition to a form which measures perceptions of *actual* environment, the MCI has an additional form which measures *preferred* environment. The preferred form is concerned with goals and value orientations as it measures

FIGURE 1. Illustration of Hand Scoring Procedures

<i>Remember you are describing your actual classroom</i>		Circle Your Answer	For Teacher's Use
1.	The pupils enjoy their schoolwork in my class.	<input checked="" type="radio"/> Yes <input type="radio"/> No	<u>3</u>
2.	Pupils are always fighting with each other.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
3.	Pupils often race to see who can finish first.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
4.	In my class the work is hard to do.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
5.	In my class everybody is my friend.	Yes <input checked="" type="radio"/> No <input type="radio"/>	<u>1</u>
6.	Some pupils are not happy in my class.	<input checked="" type="radio"/> Yes <input type="radio"/> No	R <u>1</u>
7.	Some pupils in my class are mean.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
8.	Most pupils want their work to be better than their friend's work.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
9.	Most pupils can do their schoolwork without help.	Yes <input type="radio"/> No <input type="radio"/>	R <u> </u>
10.	Some pupils in my class are not my friends.	Yes <input checked="" type="radio"/> No <input type="radio"/>	R <u>3</u>
11.	Pupils seem to like my class.	Yes <input type="radio"/> <input checked="" type="radio"/> No	<u>1</u>
12.	Many pupils in my class like to fight.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
13.	Some pupils feel bad when they don't do as well as the others.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
14.	Only the smart pupils can do their work.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
15.	All pupils in my class are close friends.	<input checked="" type="radio"/> Yes <input checked="" type="radio"/> No	<u>2</u>
16.	Some pupils don't like my class.	Yes <input type="radio"/> <input checked="" type="radio"/> No	R <u>3</u>
17.	Certain pupils always want to have their own way.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
18.	Some pupils always try to do their work better than the others.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
19.	Schoolwork is hard to do.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
20.	All pupils in my class like one another.	<input checked="" type="radio"/> Yes <input type="radio"/> No	<u>3</u>
21.	My class is fun.	Yes <input type="radio"/> No <input type="radio"/>	<u>2</u>
22.	Pupils in my class fight a lot.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
23.	A few pupils in my class want to be first all of the time.	Yes <input type="radio"/> No <input type="radio"/>	<u> </u>
24.	Most pupils in my class know how to do their work.	Yes <input type="radio"/> No <input type="radio"/>	R <u> </u>
25.	Pupils in my class like each other as friends.	<input checked="" type="radio"/> Yes <input type="radio"/> No	<u>3</u>

For Teacher's Use Only: S 10 F Cm D Ch 12

perceptions of the environment ideally liked or preferred. As the proposed method for attempting to change classrooms involves students' perceptions of preferred environment, a preferred form of the short version of the MCI was needed. Although item wording is almost identical for actual and preferred forms, the directions for answering the two forms need to instruct students clearly as to whether they are rating what their class is actually like or what they would prefer it to be like. Supplement B contains the preferred form. It can be seen that an item such as "My class is fun" in the actual form is changed to "My class *would be* fun" in the preferred form.

Information about the reliability of the short form of MCI scales is available for an Australian sample consisting of 758 third grade students in 32 classes in eight schools located in the Sydney metropolitan area (Fraser & O'Brien, 1985). Both the actual and preferred forms were administered orally to these students by a research assistant (because it was thought that reading difficulties could be experienced by students at this age level). For this sample, reliabilities for class means (alpha coefficients) for the actual form were 0.68 for Satisfaction, 0.78 for Friction, 0.70 for Competitiveness, 0.58 for Difficulty and 0.81 for Cohesiveness, and for the preferred form were 0.75 for Satisfaction,

0.82 for Friction, 0.77 for Competitiveness, 0.60 for Difficulty and 0.78 for Cohesiveness. These values indicate that the short form of the MCI has satisfactory reliability for scales containing only five items each.

A METHOD FOR IMPROVING CLASSROOM ENVIRONMENT

FRASER (1981) has proposed a simple approach by which teachers can use information obtained from classroom environment questionnaires to guide attempts to improve their classrooms. The basic approach involves two aspects. First, assessments of student perceptions of both their actual and preferred classroom environment are used to identify differences between the actual classroom environment and that preferred by students. Second, strategies aimed at reducing these differences are implemented. An example of the use of these methods in a secondary science class is described by Fraser and Fisher (1986) and an example involving a mathematics class is contained in Fraser, Malone and Neale (1989).

In the paragraphs below, a case study is reported of the use of the actual and preferred forms of the short version of the MCI by a teacher who was attempting to improve the environment of her classroom. This class consisted of 26 Grade 6 students of lower ability at a coeducational government school in a suburb of Sydney. This teacher took the class for science and mathematics, as well as for other subjects.

The procedure followed by the teacher of this class incorporated the following five fundamental steps:

1. Assessment. The MCI was administered to all students in the class. The preferred form was answered first, while the actual form was administered

a couple of days later. Students in this sixth grade sample found the MCI easy to read.

2. Feedback. The teacher generated feedback information based upon student responses. Student responses were hand scored and class mean scores were used to construct the profiles shown in Figure 2, which represent the means of students' actual and preferred environment scores. The teacher found that these profiles provided a particularly useful and clear way of summarizing the data. In particular, the profiles permitted ready identification of which aspects of classroom environment needed to be changed in order to reduce major differences between the actual environment and preferred environment as currently perceived by students. Figure 2 shows that the larger differences occurred for Friction, Competitiveness and Cohesiveness. Students preferred less Friction, less Competitiveness and more Cohesiveness.

3. Reflection and Discussion. The teacher thought about the profiles and discussed them with colleagues. This further clarified the interpretation and implications of the profiles and helped her to decide whether to try to change the classroom environment in terms of some of the MCI's scales. The main criteria used for selection of dimensions for change were, first, that there should exist a sizeable actual-preferred difference on that variable and, second, that *the teacher should feel concerned about this difference and want to make an effort to reduce it*. These considerations led the teacher to decide to introduce an intervention aimed at reducing the level of Competitiveness and increasing the level of Cohesiveness in her classroom.

4. Intervention. The teacher introduced an intervention over a period of approximately two months in an

Fraser, B.J.:

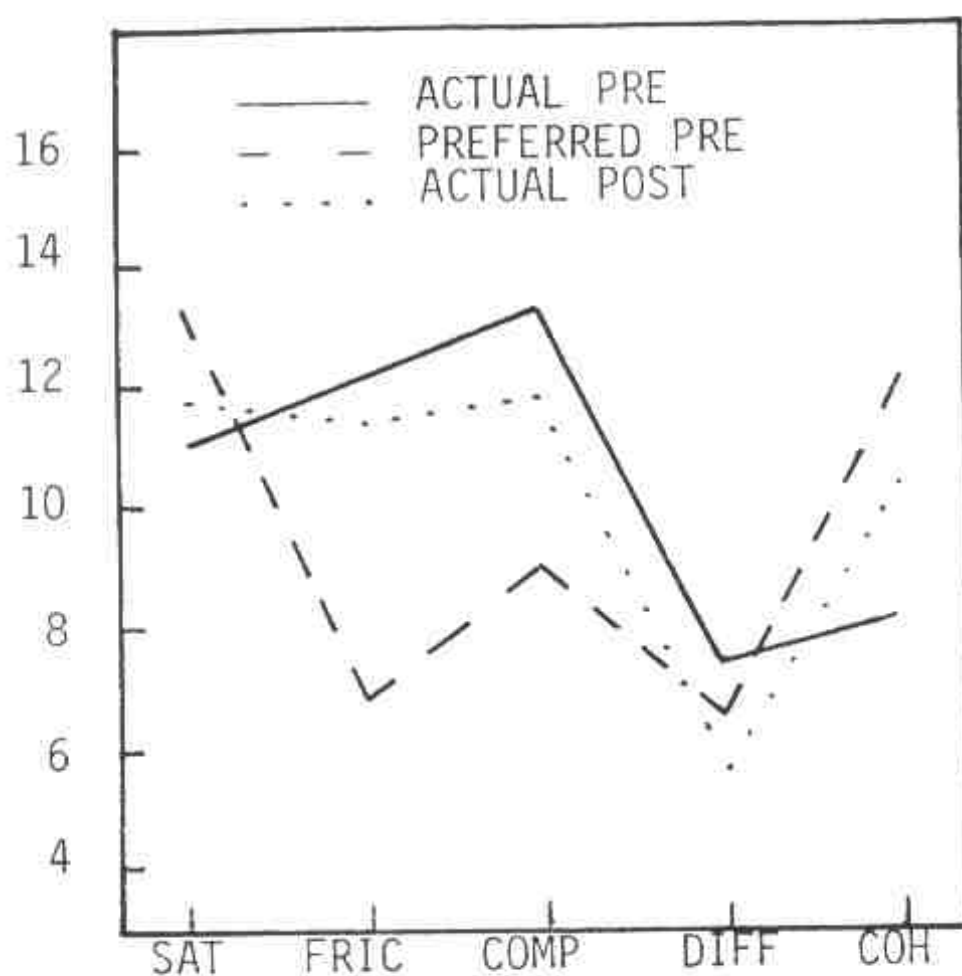
Science learning environments: Assessment, effects and determinants

Fraser, B.J. (1998). Science learning environments: Assessment, effects and determinants. In B.J. Fraser & K. Tobin (Eds.), *International handbook of science education* (pp. 527-564). Dordrecht, The Netherlands: Kluwer.

attempt to change the classroom environment. The intervention consisted of a variety of strategies, some of which originated during meetings between teachers, and others of which were suggested by examining ideas contained in individual MCI items. The strategies used to reduce Competitiveness and enhance classroom Cohesiveness involved the teacher in talking privately to students with problems, avoiding criticism of students in front of their peers, and generally being more sympathetic and helpful to students. As well, the teacher tried to encourage the class as a whole to adopt a more positive attitude towards their fellow students, especially those who were experiencing difficulties.

5. Reassessment. The actual form of the questionnaire was readministered at the end of the intervention to see whether students were perceiving their classroom environments differently from before. Again, questionnaires were hand scored and mean scores were graphed to form the posttest profile included in Figure 2.

FIGURE 2. Profiles of Mean Classroom Environment Scores



The results in Figure 2 include a dotted line to indicate the class mean score for students' perceptions of actual environment on each of the MCI's five scales at the time of posttesting. Figure 2 clearly shows that some change in actual environment occurred during the time of the intervention on all five dimensions of the MCI. Comparison of the dotted line (posttest actual scores) with the unbroken line (pretest actual scores) indicates that, after the intervention, students perceived somewhat more Satisfaction, less Friction, less Competitiveness, less Difficulty and more Cohesiveness. Differences between pretest and posttest were appreciable for Competitiveness and Cohesiveness. In fact, the change was 1.3 raw score points for Competitiveness (about one standard deviation for class means) and was 2.1 raw score points for Cohesiveness (about two standard deviations). Moreover, when tests of statistical significance were performed, it was found that pretest-posttest differences were significant only for Competitiveness and Cohesiveness. These findings are especially noteworthy because the two dimensions on which appreciable changes were recorded were those, and only those, on which the teacher had attempted to promote change.

Although the second administration of the environment scales marked the end of this teacher's formal attempt at changing her classroom environment, it might have been thought of as simply the beginning of another cycle. That is, the five steps could be repeated cyclically one or more times until changes in classroom environment reached the desired levels.

CONCLUSION

THIS PUBLICATION describes a method for assessing classroom environment and using these assessments as a basis

for improving classroom environment. This approach to improving classrooms, which is based on information about student perceptions of their actual and preferred environment, is illustrated by reporting a case study of a successful application of these techniques. The promising findings from this case study and others are that, first, the assessment method was found to be reliable and very convenient, and, second, that appreciable changes in environment were perceived for those dimensions, and only those dimensions, for which improvement had been attempted by the teacher.

A major purpose in producing this publication is to encourage science and mathematics teachers to assess the environments of their own classrooms. Because classroom environment instruments can provide meaningful information about classrooms and a tangible basis to guide improvements, an economical, easily-administered, hand-scorable questionnaire is provided as part of this publication. Hopefully science and mathematics teachers will make use of this classroom environment instrument in evaluating new curricula or teaching methods, checking whether the same classroom is seen differently by students of different genders, abilities or ethnic backgrounds, etc.

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EXTRA COPIES OF WHAT RESEARCH SAYS

The present publication is part of the *What Research Says to the Science and Mathematics Teacher* series. The issues available to date in this series are:

- No. 1: Exemplary Science and Mathematics Teachers (by Barry J. Fraser and Kenneth Tobin)
- No. 2: Assessing and Improving Classroom Environment (by Barry J. Fraser)

Any document in this series may be purchased for \$1 each, which includes surface postage. For orders of less than six copies, there is an additional handling charge of \$1. Discounts are available for orders of more than 12 copies. Send cheques (payable to the "Key Centre for School Science and Mathematics") or purchase orders to the Key Centre at the address shown at the bottom of this page.

OTHER PUBLICATIONS ON CLASSROOM ENVIRONMENT

Would you like to obtain other publications containing further information about a variety of classroom environment instruments and how they have been used in research? The following two publications may be ordered by sending a cheque (payable to "Key Centre for School Science and Mathematics") or purchase order to the Key Centre at the address shown on the bottom of this page.

The Study of Learning Environments Cost: \$20
(Edited by Barry J. Fraser)

This monograph contains a comprehensive review of the field of classroom environment by Barry Fraser, together with seven other chapters on classroom environment written by researchers

from around the world. (Published by Assessment Research in Salem, Oregon in 1986).

Assessment of Classroom Psychosocial Environment: Workshop Manual Cost: \$5
(By Barry J. Fraser and Darrel L. Fisher)

This monograph is based on a workshop presented at an annual conference of the National Association for Research in Science Teaching in the USA. It contains background and validity information for several different classroom environment questionnaires. The questionnaires themselves are included in their entirety together with scoring instructions. (Published by Curtin University in 1983).

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This document was produced by the Key Centre for Teaching and Research in School Science and Mathematics (Particularly for Women) at Curtin University of Technology. This Key Centre, which is funded by the Commonwealth Government, recognizes and builds upon the exceptional strengths in science and mathematics education already existing at Curtin, and it involves collaboration between staff of the Science and Mathematics Education Centre and colleagues in Curtin's Faculties of Education and Science and at other institutions in Perth. The Key Centre sponsors extensive educational research, publications and national ISBN 0 908155 158

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MY CLASS INVENTORY

STUDENT ACTUAL SHORT FORM

DIRECTIONS

This is not a test. The questions are to find out what your class is **actually** like.

Each sentence is meant to describe what your actual classroom is like. Draw a circle around

YES if you AGREE with the sentence
NO if you DON'T AGREE with the sentence.

EXAMPLE

27. Most pupils in our class are good friends.

If you agree that most pupils in the class actually are good friends, circle the Yes like this:

☒ Yes ☐ No

If you don't agree that most pupils in the class actually are good friends, circle the No like this:

Yes ☒ No

Please answer all questions. If you change your mind about an answer, just cross it out and circle the new answer. Don't forget to write your name and other details below.

NAME _____ SCHOOL _____ CLASS _____

Remember you are describing your <i>actual</i> classroom		Circle Your Answer	For Teacher's Use
1.	The pupils enjoy their schoolwork in my class.	Yes No	_____
2.	Pupils are always fighting with each other.	Yes No	_____
3.	Pupils often race to see who can finish first.	Yes No	_____
4.	In my class the work is hard to do.	Yes No	_____
5.	In my class everybody is my friend.	Yes No	_____
6.	Some pupils are not happy in my class.	Yes No	R _____
7.	Some pupils in my class are mean.	Yes No	_____
8.	Most pupils want their work to be better than their friend's work.	Yes No	_____
9.	Most pupils can do their schoolwork without help.	Yes No	R _____
10.	Some pupils in my class are not my friends.	Yes No	R _____
11.	Pupils seem to like my class.	Yes No	_____
12.	Many pupils in my class like to fight.	Yes No	_____
13.	Some pupils feel bad when they don't do as well as the others.	Yes No	_____
14.	Only the smart pupils can do their work.	Yes No	_____
15.	All pupils in my class are close friends.	Yes No	_____
16.	Some pupils don't like my class.	Yes No	R _____
17.	Certain pupils always want to have their own way.	Yes No	_____
18.	Some pupils always try to do their work better than the others.	Yes No	_____
19.	Schoolwork is hard to do.	Yes No	_____
20.	All pupils in my class like one another.	Yes No	_____
21.	My class is fun.	Yes No	_____
22.	Pupils in my class fight a lot.	Yes No	_____
23.	A few pupils in my class want to be first all of the time.	Yes No	_____
24.	Most pupils in my class know how to do their work.	Yes No	R _____
25.	Pupils in my class like each other as friends.	Yes No	_____

For Teacher's Use Only: S _____ F _____ Cm _____ D _____ Ch _____

MY CLASS INVENTORY

STUDENT PREFERRED SHORT FORM

DIRECTIONS

This is not a test. The questions are to find out what you would **like or prefer** your class to be like.

Each sentence is meant to describe what your preferred class is like. Draw a circle around

YES if you AGREE with the sentence
NO if you DONT AGREE with the sentence.

EXAMPLE

27. Most pupils in our class would be good friends.

If you **agree** that you'd prefer that most pupils in the class would be good friends, circle the Yes like this:

(Yes) No

If you **don't agree** that you would prefer that most pupils in the class would be good friends, circle the No like this:

Yes (No)

Please answer all questions. If you change your mind about an answer, just cross it out and circle the new answer. Don't forget to write your name and other details below.

NAME _____ SCHOOL _____ CLASS _____

Remember you are describing your preferred classroom		Circle Your Answer	For Teacher's Use
1.	The pupils would enjoy their schoolwork in my class.	Yes No	_____
2.	Pupils would be always fighting with each other.	Yes No	_____
3.	Pupils often would race to see who can finish first.	Yes No	_____
4.	In my class the work would be hard to do.	Yes No	_____
5.	In my class everybody would be my friend.	Yes No	_____
6.	Some pupils wouldn't be happy in my class.	Yes No	R _____
7.	Some pupils in my class would be mean.	Yes No	_____
8.	Most pupils would want their work to be better than their friend's work.	Yes No	_____
9.	Most pupils would be able to do their schoolwork without help.	Yes No	R _____
10.	Some pupils in my class would not be my friends.	Yes No	R _____
11.	Pupils would seem to like my class.	Yes No	_____
12.	Many pupils in my class would like to fight.	Yes No	_____
13.	Some pupils would feel bad when they didn't do as well as the others.	Yes No	_____
14.	Only the smart pupils would be able to do their work.	Yes No	_____
15.	All pupils in my class would be close friends.	Yes No	_____
16.	Some pupils wouldn't like my class.	Yes No	R _____
17.	Certain pupils always would want to have their own way.	Yes No	_____
18.	Some pupils always would try to do their work better than the others.	Yes No	_____
19.	Schoolwork would be hard to do.	Yes No	_____
20.	All pupils in my class would like one another.	Yes No	_____
21.	My class would be fun.	Yes No	_____
22.	Pupils in my class would fight a lot.	Yes No	_____
23.	A few pupils in my class would want to be first all of the time.	Yes No	_____
24.	Most pupils in my class would know how to do their work.	Yes No	R _____
25.	Pupils in my class would like each other as friends.	Yes No	_____

For Teacher's Use Only: S F Cm D Ch

Fraser, B.J., Giddings, G.G., & McRobbie, C.J.:
Assessing the climate of science laboratory classes

Fraser, B.J., Giddings, G.C., & McRobbie, C.J. (1992). Assessing the climate of science laboratory classes. *What research says. No. 8*. Perth: Curtin University of Technology.

ASSESSING THE CLIMATE OF SCIENCE LABORATORY CLASSES

Barry J. Fraser and Geoffrey J. Giddings
Curtin University of Technology

Campbell J. McRobbie
Queensland University of Technology

LABORATORY TEACHING is one of the unique features of education in the sciences, but there is a questioning of whether the great expense of maintaining and staffing laboratories is really justified (Hofstein & Lunetta, 1982), and whether or not many of the aims of laboratory teaching could be pursued more effectively and at less cost in non-laboratory settings (Pickering, 1980). Students' reactions to practical work often confirm the views of critics.

But, because research has not been comprehensive, we simply do not know enough about the effects of laboratory instruction upon student learning and attitudes. Consequently, it was timely to initiate the new line of research described here to help us obtain feedback about students' views of laboratory settings and to investigate the impact of laboratory classes on student outcomes.

Although classroom environment is a subtle concept, remarkable progress has been made over the last quarter of a century in conceptualizing, assessing and researching it. This research has attempted to answer many questions of interest to science teachers. Does a classroom's environment affect

student achievement and attitudes? Can teachers conveniently assess the climates of their own classrooms and can they change these environments? Do teachers and their students perceive the same classroom environments similarly? What is the impact of a new curriculum or teaching method on classroom environment? These questions represent the thrust of the work on classroom environments over the past 25 years (see Fraser, 1986; Fraser, 1989b; Fraser & Walberg, 1991).

Because of the importance of classroom environment, Issue 2 of *What Research Says to the Science and Mathematics Teacher* (Fraser, 1989a) was devoted to describing the *My Class Inventory* and to showing how teachers can use it to assess and improve the climate of their classrooms.

The present publication complements the previous one by focussing on a questionnaire designed especially for science laboratory classes. In particular, a description is given here of a convenient questionnaire which can be used by teachers to obtain a quick and easy assessment of their students' perceptions of their science laboratory classroom environment. A complete copy

of this questionnaire, in a form that may be reproduced by teachers for use in their own classrooms, is provided as lift-out Supplements A and B. In addition, a description is given of scoring procedures and potentially useful applications of the new instrument.

SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)

SUPPLEMENTS A AND B contain two forms of the new questionnaire, called the *Science Laboratory Environment Inventory (SLEI)*, which is well-suited for use at the upper secondary and higher education levels. It is important to note that the SLEI is intended for use in situations in which a separate laboratory class exists.

The SLEI is economical in that it measures five different dimensions, yet it contains only 35 items altogether. Therefore, printing and collation costs are minimized. Also, because many teachers do not have ready access to computerized scoring methods, the SLEI has been designed to enable easy hand scoring.

*The SLEI has been designed to
enable easy hand scoring.*

The response alternatives for each item are *Almost Never, Seldom, Sometimes, Often* and *Very Often*. The scoring direction is reversed for approximately half of the items. Students' answers are recorded on the questionnaire itself to avoid errors that can arise in transferring responses to a separate answer sheet.

The items shown in Supplements A and B are arranged in cyclic order and in blocks of five to enable ready hand scoring. The first item in each block assesses Student Cohesiveness (SC); the second item in each block assesses Open-Endedness (OE); the third item assesses Integration (I); the fourth

item assesses Rule Clarity (RC); and the last item in each block assesses Material Environment (ME). The meaning of these scales is clarified in Table 1 which contains a scale description and a sample item for each dimension.

Actual and Preferred Forms

In addition to a form which measures perceptions of *actual* environment, the SLEI has an additional form which measures *preferred* environment. The preferred form is concerned with goals and value orientations as it measures perceptions of the environment ideally liked or preferred. Although item wording is almost identical for actual and preferred forms, the directions for answering the two forms instruct students clearly as to whether they are rating what their class is actually like or what they would prefer it to be like. Supplement A contains the actual form and Supplement B contains the preferred form. It can be seen that an item such as "I work cooperatively in laboratory sessions" in the actual form is changed to "I *would* work cooperatively in laboratory sessions" in the preferred form.

Personal vs. Class Versions

Fraser and Tobin (1991) point out that there is potentially a major problem with nearly all existing classroom environment instruments when they are used to identify differences between subgroups within a classroom (e.g., boys and girls) or in the construction of case studies of individual students. The problem is that items in most scales are worded to obtain an individual student's perceptions of the class as a whole, as distinct from that student's perceptions of his/her own role within the classroom. Although such classroom environment scales have been used to advantage in case study research (Tobin, Kahle & Fraser, 1990), these studies underline the desirability of having a new version of instruments available which are better suited to identifying differences.

For the reasons above, we developed a personal version of the SLEI which parallels its class version. Whereas Fraser, Giddings and McRobbie (1991) contains both the class and personal versions of the SLEI, it is the personal form which provides the focus for the present publication and which is provided in Supplements A and B.

Scoring

In order to score some of the items, the responses *Almost Never*, *Seldom*, *Sometimes*, *Often* and *Very Often* are given the scores of 1, 2, 3, 4 and 5, respectively. But, for the items with *R* in the *For Teacher's Use* column, reverse scoring is used so that 5 is given for *Almost Never* and 1 is given for *Very Often*, etc. Omitted or incorrectly answered items are given a score of 3. The score for each of the 35 individual items can be written in the *For Teacher's Use* column.

The total score for a particular scale is simply obtained by adding the scores for the five items belonging to that scale. For example, the Student Cohesiveness scale total is obtained by adding the scores given to Items 1, 6, 11, 16, 21, 26 and 31, whereas the Material Environment total is the sum of the scores obtained for the last item in each block. The bottom of the questionnaire provides some spaces where the teacher can record the student's total score for each scale. Figure 1 shows how the questionnaire was scored to obtain a total of 23 for the Student Cohesiveness scale and 19 for the Material Environment scale.

Initial Development

The initial development of the SLEI was guided by the following criteria. A review of the literature was undertaken to identify dimensions that were considered important

TABLE 1. Descriptive Information for Each Scale

Scale Name	Description	Sample Item
Student Cohesiveness	Extent to which students know, help and are supportive of one another.	I get along well with students in this laboratory class. (+)
Open-Endedness	Extent to which the laboratory activities emphasize an open-ended divergent approach to experimentation.	In my laboratory sessions, the teacher decides the best way for me to carry out the laboratory experiments. (-)
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes.	I use the theory from my regular science class sessions during laboratory activities. (+)
Rule Clarity	Extent to which behaviour in the laboratory is guided by formal rules.	There is a recognized way for me to do things safely in this laboratory. (+)
Material Environment	Extent to which the laboratory equipment and materials are adequate.	I find that the laboratory is crowded when I am doing experiments. (-)

- + Items designated (+) are scored 1, 2, 3, 4 and 5, respectively, for the responses *Almost Never*, *Seldom*, *Sometimes*, *Often* and *Very Often*.
 - Items designated (-) are scored 5, 4, 3, 2 and 1, respectively, for the responses *Almost Never*, *Seldom*, *Sometimes*, *Often* and *Very Often*.

FIGURE 1. Illustration of Hand Scoring Procedures

Remember that you are describing your <i>actual</i> classroom.		Almost Never Seldom Sometimes Often Very Often	For Teacher's Use
1. I get on well with students in this laboratory class.	1 2 3 4 <u>5</u>		<u>5</u>
2. There is opportunity for me to pursue my own science interests in this laboratory class.	1 2 3 4 5		
3. What I do in our regular science class is unrelated to my laboratory work.	1 2 3 4 5	R	
4. My laboratory class has clear rules to guide my activities.	1 2 3 4 5		
5. I find that the laboratory is crowded when I am doing experiments.	1 2 3 4 <u>5</u>	R	<u>1</u>
6. I have little chance to get to know other students in this laboratory class.	<u>1</u> 2 3 4 5	R	<u>5</u>
7. In this laboratory class, I am required to design my own experiments to solve a given problem.	1 2 3 4 5		
8. The laboratory work is unrelated to the topics that I am studying in my science class.	1 2 3 4 5	R	
9. My laboratory class is rather informal and few rules are imposed on me.	1 2 3 4 5	R	
10. The equipment and materials that I need for laboratory activities are readily available.	1 <u>2</u> 3 4 5		<u>2</u>
11. Members of this laboratory class help me.	1 2 3 <u>4</u> 5		<u>4</u>
12. In my laboratory sessions, other students collect different data than I do for the same problem.	1 2 3 4 5		
13. My regular science class work is integrated with laboratory activities.	1 2 3 4 5		
14. I am required to follow certain rules in the laboratory.	1 2 3 4 5		
15. I am ashamed of the appearance of this laboratory.	1 2 <u>3</u> 4 5	R	<u>3</u>
16. I get to know students in this laboratory class well.	1 <u>2</u> 3 4 5		<u>2</u>
17. I am allowed to go beyond the regular laboratory exercise and do some experimenting of my own.	1 2 3 4 5		
18. I use the theory from my regular science class sessions during laboratory activities.	1 2 3 4 5		
19. There is a recognized way for me to do things safely in this laboratory.	1 2 3 4 5		
20. The laboratory equipment which I use is in poor working order.	1 <u>2</u> 3 4 5	R	<u>4</u>
21. I am able to depend on other students for help during laboratory classes.	1 2 <u>3</u> 4 5		<u>3</u>
22. In my laboratory sessions, I do different experiments than some of the other students.	1 2 3 4 5		
23. The topics covered in regular science class work are quite different from topics with which I deal in laboratory sessions.	1 2 3 4 5	R	
24. There are few fixed rules for me to follow in laboratory sessions.	1 2 3 4 5	R	
25. I find that the laboratory is hot and stuffy.	1 2 3 <u>4</u> 5	R	<u>2</u>
26. It takes me a long time to get to know everybody by his/her first name in this laboratory class.	1 2 3 <u>4</u> 5	R	<u>2</u>
27. In my laboratory sessions, the teacher/instructor decides the best way for me to carry out the laboratory experiments.	1 2 3 4 5	R	
28. What I do in laboratory sessions helps me to understand the theory covered in regular science classes.	1 2 3 4 5		
29. The teacher/instructor outlines safety precautions to me before my laboratory sessions commence.	1 2 3 4 5		
30. The laboratory is an attractive place for me to work in.	1 <u>2</u> 3 <u>4</u> 5		<u>3</u>
31. I work cooperatively in laboratory sessions.	1 <u>2</u> 3 4 5		<u>2</u>
32. I decide the best way to proceed during laboratory experiments.	1 2 3 4 5		
33. My laboratory work and regular science class work are unrelated.	1 2 3 4 5	R	
34. My laboratory class is run under clearer rules than my other classes.	1 2 3 4 5		
35. My laboratory has enough room for individual or group work.	1 2 3 <u>4</u> 5		<u>4</u>

For Teacher's Use Only: SC 23 OE _____ I _____ RC _____ ME 19

5.1 Science Learning Environments: Assessment, Effects and Determinants

BARRY J. FRASER

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Although research and evaluation in science education have relied heavily on the assessment of academic achievement and other valued learning outcomes, these measures cannot give a complete picture of the educational process. Because students spend up to 15,000 hours at school by the time they finish senior high school (Rutter, Maughan, Mortimore, Ouston & Smith 1979), students have a large stake in what happens to them at school and their reactions to and perceptions of their school experiences are significant. This chapter reviews the remarkable progress over the past 30 years in conceptualising, assessing and investigating the determinants and effects of social and psychological aspects of the learning environments of classrooms and schools.

This chapter falls into seven main parts. **First**, an introductory section provides background information about the field of **learning environment** (including alternative assessment approaches, historical perspectives on past work, the distinction between school and classroom environment, and the unit-of-analysis question). **Second**, a section is devoted to specific instruments for **assessing perceptions of classroom environment**. **Third**, some important developments with learning environment instruments are outlined (preferred forms, short versions, hand scoring, the distinction between Personal and Class forms). **Fourth**, the validation of learning environment scales is discussed. **Fifth**, assessment instruments for school environment are considered. **Sixth**, an **overview** is given of several lines of past research involving environment assessments in science classrooms (including associations between outcomes and environment, use of environment dimensions as criterion variables, and person-environment fit studies of whether students achieve better in their preferred environment). **Seventh**, consideration is given to teachers' use of **classroom and school environment instruments in practical attempts to improve their own classrooms and schools**. **Eighth**, **current trends and future desirable directions** in research on educational environments are identified (e.g., combining quantitative and qualitative methods, school-level environments, school psychology, links between educational environments, cross-national studies, transition between primary and secondary schooling, teacher education and teacher assessment).

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in the unique environment of the science laboratory class. Guidance in identifying dimensions also was obtained by examining all scales contained in existing classroom environment instruments for non-laboratory settings (Fraser, 1986). By interviewing numerous science teachers and students at the upper secondary and university levels and asking them to comment on draft versions of sets of items, an attempt was made to ensure that the SLEI's dimensions and individual items were considered salient by teachers and students. In order to achieve economy in terms of the time needed for answering and scoring, the SLEI was designed to have a relatively small number of reliable scales, each containing a fairly small number of items.

VALIDITY AND RELIABILITY

A SET OF ITEMS was written and passed through several successive revisions based on reactions solicited from colleagues with expertise in questionnaire construction and science teaching at the secondary and higher education levels. Careful attention was paid to making each item suitable for measuring both actual and preferred classroom environment. A series of item and factor analyses reported by Fraser, Giddings and McRobbie (1991) was used to improve the preliminary form and obtain the 35-item final form described in this publication.

Information about the reliability of SLEI scales is reported by Fraser, Giddings and McRobbie (1991) for the Australia-only sample, consisting of 1 875 senior high school students and 298 university students, described in Table 2. As well, reliability has been estimated for the larger six-country sample (Australia, USA, Canada, England, Israel, Nigeria) of 3 727 senior high school students and 1 720 university students also described in Table 2. Both the actual and preferred forms were administered to these samples.

TABLE 2. Description of Australian and Six-Country Samples of School and University Students

Schools/ Universities	Country	Sample Size	
		Students	Classes
Schools	Australia only	1 875	111
	All 6 countries combined	3 727	198
Universities	Australia only	298	24
	All 6 countries combined	1 720	71

When the actual form of the SLEI shown in Supplement A was administered to a new sample consisting of 516 senior high school chemistry students in 56 classes in Queensland, reliabilities (alpha coefficients) for class means were 0.80 for Student Cohesiveness, 0.80 for Open-Endedness, 0.91 for Integration, 0.76 for Rule Clarity and 0.74 for Material Environment. Similar values for the reliability occurred for the preferred form of the SLEI for the Australian sample, and for both the actual and preferred forms for the six-country samples described previously. These values indicate that the SLEI has satisfactory reliability for scales containing only seven items each.

USES OF SLEI

FRASER (1989a) has proposed a simple approach by which teachers can use information obtained from classroom environment questionnaires to guide attempts to improve their classrooms. The basic approach involves three aspects. First, assessments of student perceptions of both their actual and preferred classroom environment are used to identify differences between the actual classroom environment and that preferred by students. Second, strategies aimed at reducing these differences are implemented. Third, the

classroom environment scales can be readministered to assess the success of the strategies in promoting changes. It is recommended that science teachers use this strategy in conjunction with the SLEI in attempts at improving laboratory class environments.

In particular, the proposed method for improving the climate of science laboratory classes can be especially useful as a basis for school-based staff development. Experience has shown that the administration and scoring of the SLEI can provide an excellent foundation for stimulating fruitful discussion and guiding improvement attempts as part of school-based professional development initiatives.

In past classroom environment research, it has been common to investigate associations between student outcomes and the nature of the classroom environment (Fraser, 1986). In order to permit investigation of the predictive validity (i.e., the ability to predict student outcomes) of the actual form of the SLEI, a large sample of Australian senior high school students responded to some scales which assessed attitudes toward science. Generally, the dimensions of the SLEI were found to be positively related with student attitude scores (Fraser, Giddings & McRobbie, 1991). In particular, students' attitude scores were higher in classrooms in which students perceived the presence of greater student cohesiveness, integration and rule clarity and a better material environment.

Previously, both researchers and teachers have found it useful to employ classroom climate dimensions as criteria of effectiveness in the evaluation of innovations, new curricula and new teaching methods (Fraser, 1986). Because of the high cost of laboratory teaching and the doubts expressed about its effectiveness, it is desirable that science teachers make use of the SLEI to monitor students' views of their

laboratory classes, investigate the impact that different laboratory environments have on student outcomes, and provide a basis for guiding systematic attempts to improve these learning environments.

*Teachers are likely to see their
science laboratory classes
'through rose-coloured glasses'.*

In previous research in several countries, students' and teachers' perceptions were compared. It has been found that, first, both students and teachers preferred a more positive classroom environment than they perceived as being actually present and, second, teachers tended to perceive the classroom environment more positively than did their students in the same classrooms. These findings have been replicated for the SLEI (Giddings & Fraser, 1990). These results are important because they suggest that teachers are likely to see their science laboratory classes 'through rose-coloured glasses' in the sense that teachers' perceptions typically are more positive than their students' perceptions.

CONCLUSION

THIS PUBLICATION describes a new questionnaire for assessing the climate of science laboratory classes either at the senior high school or the university level. A major purpose in producing this publication is to encourage science teachers to assess the environments of their own laboratory classrooms. Because classroom environment instruments can provide meaningful information about classrooms and a tangible basis to guide improvements, an economical, easily-administered, hand-scorable questionnaire is provided as part of this publication. Hopefully science teachers will make use of this classroom environment instrument in evaluating new curricula or teaching methods, checking whether the same classroom is seen differently by

students of different genders, abilities or ethnic backgrounds, etc.

Noteworthy features of the SLEI include its consistency with the literature, its specific relevance to science laboratory classes and its salience to science teachers and students. Also, the SLEI has a personal version (involving a student's perception of his/her own role in the classroom), in contrast to most other existing instruments which exist only in a class version (involving a student's perceptions of the class as a whole).

A major limitation of most past research which has investigated differences in the environment scores of different subgroups of students within a class (e.g., students varying in gender, ethnicity or socioeconomic status), is that the traditional class version of instruments is not ideally suited to this research aim. Consequently, the existence of a personal version of the SLEI opens up the possibility of conducting more meaningful and sensitive investigations of the environments existing within a class for different subgroups of students.

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SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLED)

ACTUAL FORM

Directions

This questionnaire contains statements about practices which could take place in this laboratory class. You will be asked **how often** each practice **actually takes place**.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

Think about how well each statement describes what this laboratory class is actually like for you. Draw a circle around

1	if the practice actually takes place	ALMOST NEVER
2	if the practice actually takes place	SELDOM
3	if the practice actually takes place	SOMETIMES
4	if the practice actually takes place	OFTEN
5	if the practice actually takes place	VERY OFTEN

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Practice Example. Suppose that you were given the statement: "I choose my partners for laboratory experiments." You would need to decide whether you thought that you **actually** choose your partners *Almost Never*, *Seldom*, *Sometimes*, *Often* or *Very Often*. For example, if you selected *Very Often*, you would circle the number 5 on your Answer Sheet.

Don't forget to write your name and other details at the top of the reverse side of this page.

NAME _____ SCHOOL _____ CLASS _____

Remember that you are describing your actual classroom.		Almost Never Seldom Sometimes Often Very Often	For Teacher's Use
1. I get on well with students in this laboratory class.	1 2 3 4 5	_____	
2. There is opportunity for me to pursue my own science interests in this laboratory class.	1 2 3 4 5	_____	
3. What I do in our regular science class is unrelated to my laboratory work.	1 2 3 4 5	R _____	
4. My laboratory class has clear rules to guide my activities.	1 2 3 4 5	_____	
5. I find that the laboratory is crowded when I am doing experiments.	1 2 3 4 5	R _____	
6. I have little chance to get to know other students in this laboratory class.	1 2 3 4 5	R _____	
7. In this laboratory class, I am required to design my own experiments to solve a given problem.	1 2 3 4 5	_____	
8. The laboratory work is unrelated to the topics that I am studying in my science class.	1 2 3 4 5	R _____	
9. My laboratory class is rather informal and few rules are imposed on me.	1 2 3 4 5	R _____	
10. The equipment and materials that I need for laboratory activities are readily available.	1 2 3 4 5	_____	
11. Members of this laboratory class help me.	1 2 3 4 5	_____	
12. In my laboratory sessions, other students collect different data than I do for the same problem.	1 2 3 4 5	_____	
13. My regular science class work is integrated with laboratory activities.	1 2 3 4 5	_____	
14. I am required to follow certain rules in the laboratory.	1 2 3 4 5	_____	
15. I am ashamed of the appearance of this laboratory.	1 2 3 4 5	R _____	
16. I get to know students in this laboratory class well.	1 2 3 4 5	_____	
17. I am allowed to go beyond the regular laboratory exercise and do some experimenting of my own.	1 2 3 4 5	_____	
18. I use the theory from my regular science class sessions during laboratory activities.	1 2 3 4 5	_____	
19. There is a recognized way for me to do things safely in this laboratory.	1 2 3 4 5	_____	
20. The laboratory equipment which I use is in poor working order.	1 2 3 4 5	R _____	
21. I am able to depend on other students for help during laboratory classes.	1 2 3 4 5	_____	
22. In my laboratory sessions, I do different experiments than some of the other students.	1 2 3 4 5	_____	
23. The topics covered in regular science class work are quite different from topics with which I deal in laboratory sessions.	1 2 3 4 5	R _____	
24. There are few fixed rules for me to follow in laboratory sessions.	1 2 3 4 5	R _____	
25. I find that the laboratory is hot and stuffy.	1 2 3 4 5	R _____	
26. It takes me a long time to get to know everybody by his/her first name in this laboratory class.	1 2 3 4 5	R _____	
27. In my laboratory sessions, the teacher decides the best way for me to carry out the laboratory experiments.	1 2 3 4 5	R _____	
28. What I do in laboratory sessions helps me to understand the theory covered in regular science classes.	1 2 3 4 5	_____	
29. The teacher outlines safety precautions to me before my laboratory sessions commence.	1 2 3 4 5	_____	
30. The laboratory is an attractive place for me to work in.	1 2 3 4 5	_____	
31. I work cooperatively in laboratory sessions.	1 2 3 4 5	_____	
32. I decide the best way to proceed during laboratory experiments.	1 2 3 4 5	_____	
33. My laboratory work and regular science class work are unrelated.	1 2 3 4 5	R _____	
34. My laboratory class is run under clearer rules than my other classes.	1 2 3 4 5	_____	
35. My laboratory has enough room for individual or group work.	1 2 3 4 5	_____	

For Teacher's Use Only: SC _____ OE _____ I _____ RC _____ ME _____

SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)

PREFERRED FORM

Directions

This questionnaire contains statements about practices which could take place in this laboratory class. You will be asked **how often** you would **prefer** each practice to take place.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

Think about how well each statement describes what your preferred laboratory class is like. Draw a circle around

1	if you would prefer the practice to take place	ALMOST NEVER
2	if you would prefer the practice to take place	SELDOM
3	if you would prefer the practice to take place	SOMETIMES
4	if you would prefer the practice to take place	OFTEN
5	if you would prefer the practice to take place	VERY OFTEN

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Practice Example. Suppose that you were given the statement: "I would choose my partners for laboratory experiments." You would need to decide whether you thought that you would **prefer** to choose your partners *Almost Never*, *Seldom*, *Sometimes*, *Often* or *Very Often*. For example, if you selected *Very Often*, you would circle the number 5 on your Answer Sheet.

Don't forget to write your name and other details at the top of the reverse side of this page.

NAME _____ SCHOOL _____ CLASS _____

Remember that you are describing your <i>preferred</i> classroom.		Almost Never Seldom Sometimes Often Very Often	For Teacher's Use
1. I would get on well with students in this laboratory class.	1 2 3 4 5	_____	
2. There would be opportunity for me to pursue my own science interests in this laboratory class.	1 2 3 4 5	_____	
3. What I do in our regular science class would be unrelated to my laboratory work.	1 2 3 4 5	R _____	
4. My laboratory class would have clear rules to guide my activities.	1 2 3 4 5	_____	
5. I would find that the laboratory is crowded when I am doing experiments.	1 2 3 4 5	R _____	
6. I would have little chance to get to know other students in this laboratory class.	1 2 3 4 5	R _____	
7. In this laboratory class, I would be required to design my own experiments to solve a given problem.	1 2 3 4 5	_____	
8. The laboratory work would be unrelated to the topics that I am studying in my science class.	1 2 3 4 5	R _____	
9. My laboratory class would be rather informal and few rules would be imposed on me.	1 2 3 4 5	R _____	
10. The equipment and materials that I need for laboratory activities would be readily available.	1 2 3 4 5	_____	
11. Members of this laboratory class would help me.	1 2 3 4 5	_____	
12. In my laboratory sessions, other students would collect different data than I would for the same problem.	1 2 3 4 5	_____	
13. My regular science class work would be integrated with laboratory activities.	1 2 3 4 5	_____	
14. I would be required to follow certain rules in the laboratory.	1 2 3 4 5	_____	
15. I would be ashamed of the appearance of this laboratory.	1 2 3 4 5	R _____	
16. I would get to know students in this laboratory class well.	1 2 3 4 5	_____	
17. I would be allowed to go beyond the regular laboratory exercise and do some experimenting of my own.	1 2 3 4 5	_____	
18. I would use the theory from my regular science class sessions during laboratory activities.	1 2 3 4 5	_____	
19. There would be a recognized way for me to do things safely in this laboratory.	1 2 3 4 5	_____	
20. The laboratory equipment which I use would be in poor working order.	1 2 3 4 5	R _____	
21. I would be able to depend on other students for help during laboratory classes.	1 2 3 4 5	_____	
22. In my laboratory sessions, I would do different experiments than some of the other students.	1 2 3 4 5	_____	
23. The topics covered in regular science class work would be quite different from topics with which I deal in laboratory sessions.	1 2 3 4 5	R _____	
24. There would be few fixed rules for me to follow in laboratory sessions.	1 2 3 4 5	R _____	
25. I would find that the laboratory is hot and stuffy.	1 2 3 4 5	R _____	
26. It would take me a long time to get to know everybody by his/her first name in this laboratory class.	1 2 3 4 5	R _____	
27. In my laboratory sessions, the teacher would decide the best way for me to carry out the laboratory experiments.	1 2 3 4 5	R _____	
28. What I do in laboratory sessions would help me to understand the theory covered in regular science classes.	1 2 3 4 5	_____	
29. The teacher would outline safety precautions to me before my laboratory sessions commence.	1 2 3 4 5	_____	
30. The laboratory would be an attractive place for me to work in.	1 2 3 4 5	_____	
31. I would work cooperatively in laboratory sessions.	1 2 3 4 5	_____	
32. I would decide the best way to proceed during laboratory experiments.	1 2 3 4 5	_____	
33. My laboratory work and regular science class work would be unrelated.	1 2 3 4 5	R _____	
34. My laboratory class would be run under clearer rules than my other classes.	1 2 3 4 5	_____	
35. My laboratory would have enough room for individual or group work.	1 2 3 4 5	_____	

For Teacher's Use Only: SC _____ OE _____ I _____ RC _____ ME _____

Wubbels, T.:

Teacher-student relationships in science and mathematics classes

Wubbels, T. (1993). Teacher-student relationships in science and mathematics classes. *What research says. No. 11*. Perth: Curtin University of Technology.

TEACHER-STUDENT RELATIONSHIPS IN SCIENCE AND MATHEMATICS CLASSES

Theo Wubbels

University of Utrecht, The Netherlands

SOME TEACHERS can get on better with their students than others. But do students learn more from teachers with whom they relate well? Although teachers often have distinct opinions about what is the best way in which to relate to students, different teachers' opinions vary markedly.

In the school staff room, it sometimes can be heard that students need a strict, disciplined environment in which to learn. "Students will not engage in learning activities themselves if teachers do not control their work and demand a lot of them. If there is too much freedom in class, students will be distracted from the real work; a cosy atmosphere will not promote student outcomes." Other teachers, however, advocate student responsibility for their learning and a pleasant classroom atmosphere for promoting student outcomes. "If students like the lessons and if there is a pleasant stimulating atmosphere, they will be stimulated to study, which is an important prerequisite for learning, and consequently they will thrive. It is more important to reward students for their efforts and the things that they do well than it is to correct their mistakes."

The language that teachers use makes their position clear. The teacher who thinks that

students need tight rules will talk disapprovingly about a 'cosy classroom', whereas the one who takes the opposite position would talk about 'attractive, pleasant lessons'.

This publication presents research findings about the interpersonal relationships between science and mathematics teachers and their students. It also sheds some light on other questions such as: What preferences do students have about their relationships with their teachers? How would teachers like to behave towards students? What teacher-student relationships are common in Australian science and mathematics classrooms?

This research is based on studies that used the *Questionnaire on Teacher Interaction (QTI)* to gather students' and teachers' perceptions of interpersonal teacher behaviour. Readers who are interested in the details of the studies or the methods used are referred to Brekelmans, Wubbels and Créton (1990), Wubbels, Brekelmans and Hooymayers (1991) or Wubbels, Créton and Hooymayers (1992). Below, we first describe this questionnaire, which is yet another example of the range of instruments available for assessing classroom environments (Fraser, 1989).

BACKGROUND

Approaches to Studying Educational Environments

Using students' and teachers' perceptions to study educational environments can be contrasted with the external observer's direct observation and systematic coding of classroom communication and events (Brophy & Good 1986). Murray (1938) introduced the term *alpha press* to describe the environment as assessed by a detached observer and the term *beta press* to describe the environment as perceived by milieu inhabitants. Another approach to studying educational environments involves application of the techniques of naturalistic inquiry, ethnography, case study or interpretive research (see Erickson's chapter in this *Handbook*). Defining the classroom or school environment in terms of the shared perceptions of the students and teachers has the dual advantage of characterising the setting through the eyes of the participants themselves and capturing data which the observer could miss or consider unimportant. Students are at a good vantage point to make judgments about classrooms because they have encountered many different learning environments and have enough time in a class to form accurate impressions. Also, even if teachers are inconsistent in their day-to-day behaviour, they usually project a consistent image of the long-standing attributes of classroom environment. Later in this chapter, discussion focuses on the merits of combining quantitative and qualitative methods when studying educational environments (Fraser & Tobin 1991).

Historical Perspectives

Thirty years ago, Herbert Walberg and Rudolf Moos began seminal independent programs of research which form the starting points for the work reviewed in this chapter. Walberg developed the widely-used *Learning Environment Inventory* (LEI) as part of the research and evaluation activities of Harvard Project Physics (Walberg & Anderson 1968). Moos began developing the first of his social climate scales, including those for use in psychiatric hospitals and correctional institutions, which ultimately resulted in the development of the *Classroom Environment Scale* (CES) (Moos 1979; Moos & Trickett 1987). The way in which the important pioneering work of Walberg and Moos on perceptions of classroom environment developed into major research programs and spawned a lot of other research is reflected in books (Fraser 1986; Fraser & Walberg 1991; Moos 1979; Walberg 1979), literature reviews (Fraser 1994; MacAuley 1990; von Saldern 1992) and monographs sponsored by the American Educational Research Association's Special Interest Group (SIG) on the Study of Learning Environments (e.g., Fisher 1994).

The work on educational environments over the previous 30 years builds upon the earlier ideas of Lewin and Murray and their followers (such as Pace and Stern). Lewin's (1936) seminal work on field theory recognised that both the environment and its interaction with personal characteristics of the individual are potent

determinants of human behaviour. The familiar Lewinian formula, $B = f(P, E)$, was first enunciated to stress the need for new research strategies in which behaviour is considered to be a function of the person and the environment. Murray (1938) was first to follow Lewin's approach by proposing a needs-press model which allows the analogous representation of person and environment in common terms. Personal needs refer to motivational personality characteristics representing tendencies to move in the direction of certain goals, while environmental press provides an external situational counterpart which supports or frustrates the expression of internalised personality needs. Needs-press theory has been popularised and elucidated by Pace and Stern (e.g., Stern 1970).

School-Level vs. Classroom-Level Environment

It is useful to distinguish classroom or classroom-level environment from school or school-level environment, which involves psychosocial aspects of the climate of whole schools (Fraser & Rentoul 1982). School climate research owes much in theory, instrumentation and methodology to earlier work on organisational climate in business contexts. Two widely-used instruments in school environment research, namely, Halpin and Croft's (1963) *Organizational Climate Description Questionnaire* (OCDQ) and Stern's (1970) *College Characteristics Index* (CCI), relied heavily on previous work in business organisations. Two features of school-level environment work which distinguishes it from classroom-level environment research are that the former has tended to be associated with the field of educational administration and to involve the climate of higher education institutions. Despite their simultaneous development and logical linkages, the fields of classroom-level and school-level environment have remained remarkably independent. Although the focus of past research in science education has been primarily upon classroom-level environment, it would be desirable to break away from the existing tradition of independence of the two fields of school and classroom environment and for there to be a confluence of the two areas.

Level of Analysis: Private and Consensual Press

Murray's distinction between alpha press (the environment as observed by an external observer) and beta press (the environment as perceived by milieu inhabitants) has been extended by Stern, Stein and Bloom (1956) who distinguish between the idiosyncratic view that each person has of the environment (*private beta press*) and the shared view that members of a group hold about the environment (*consensual beta press*). Private and consensual beta press could differ from each other, and both could differ from the detached view of alpha press of a trained non-participant observer. In designing classroom environment studies, researchers must decide whether their analyses will involve the perception scores obtained

QUESTIONNAIRE ON TEACHER INTERACTION (QTI)

THE QUESTIONNAIRE on Teacher Interaction can be used to map students' and teachers' perceptions using a model for interpersonal teacher behaviour. In this model, teacher behaviour has a *Proximity Dimension* (Cooperation, C – Opposition, O) and an *Influence Dimension* (Dominance, D – Submission, S). These dimensions can be represented in a coordinate system divided into eight equal sections (see Figure 1). Every instance of interpersonal teacher behaviour can be placed within this system of axes. The closer the instances of behaviour are in the chart, the more closely they resemble each other.

The sectors are labelled DC, CD, etc. according to their position in the coordinate system. For example, the two sectors DC and CD are both characterised by Dominance and Cooperation. In the DC sector, however, the Dominance aspect prevails over the Cooperation aspect, whereas the adjacent sector CD includes behaviours of a more cooperative and less dominant character. To clarify the concepts covered by each sector, Figure 1 shows typical behaviours for each sector.

The long form of the Australian version of the Questionnaire on Teacher Interaction has 64 items which are answered on a five-point scale. The items belong to eight scales, each consisting of eight items and corresponding to one of the eight sections of the model. Examples of items are "This teacher is friendly" (CD) and "This teacher gets angry unexpectedly" (OD). The scores for each item within the same sector are added to obtain a total scale score. The higher the scale score, the more a teacher shows behaviours from that sector. Scale scores can be obtained for individual students, or can be combined to form the mean of all students in a class.

The questionnaire has satisfactory reliability.

Information about the reliability of the questionnaire is presented in Appendix A for American, Australian and Dutch samples. It appears that all scales have satisfactory reliability. Information about the validity of

the QTI is reported in Wubbels and Levy (1991, 1993).

An economical short version of the QTI is available for use by teachers to gather information about students' (or the teacher's) perceptions of classes. This version has 48 items, six for every sector of the model of interpersonal teacher behaviour in Figure 1. A complete copy of this short version of the QTI, in a form that may be reproduced by teachers for use in their own classrooms, is provided as a Supplement.

In order to facilitate hand scoring, the items are arranged in cyclic order and in blocks of four. Items 1 to 24 in the Supplement assess the four scales called *Leadership* behaviour, *Understanding* behaviour, *Uncertain* behaviour and *Admonishing* behaviour, whereas Items 25 to 48 assess the scales *Helpful/Friendly* behaviour, *Student Responsibility and Freedom* behaviour, *Dissatisfied* behaviour and *Strict* behaviour.

In the top half of the questionnaire in the Supplement, the first item in every block assesses *Leadership* behaviour (Lea), the second one *Understanding* behaviour (Und), the third one *Uncertain* behaviour (Unc) and the fourth one *Admonishing* behaviour (Adm). The items in the lower half of the questionnaire in the Supplement are also grouped in blocks of four to assess *Helpful/Friendly* behaviour (HFr), *Student Responsibility and Freedom* behaviour (SRe), *Dissatisfied* behaviour (Dis) and *Strict* behaviour (Str).

The total score for a particular scale is simply the sum of the circled numbers for the six items belonging to that scale. Omitted or invalid responses are scored 3. For example, the *Uncertain* behaviour scale total is obtained by adding the scores given to Items 3, 7, 11, 15, 19 and 23. Figure 2 gives an example of how the top half of the questionnaire (Items 1-24) was scored to obtain a total score of 19 for *Leadership* behaviour, etc.

A STUDY IN AUSTRALIA

WE GATHERED data about Australian secondary school students' perceptions of the interpersonal behaviour of their science

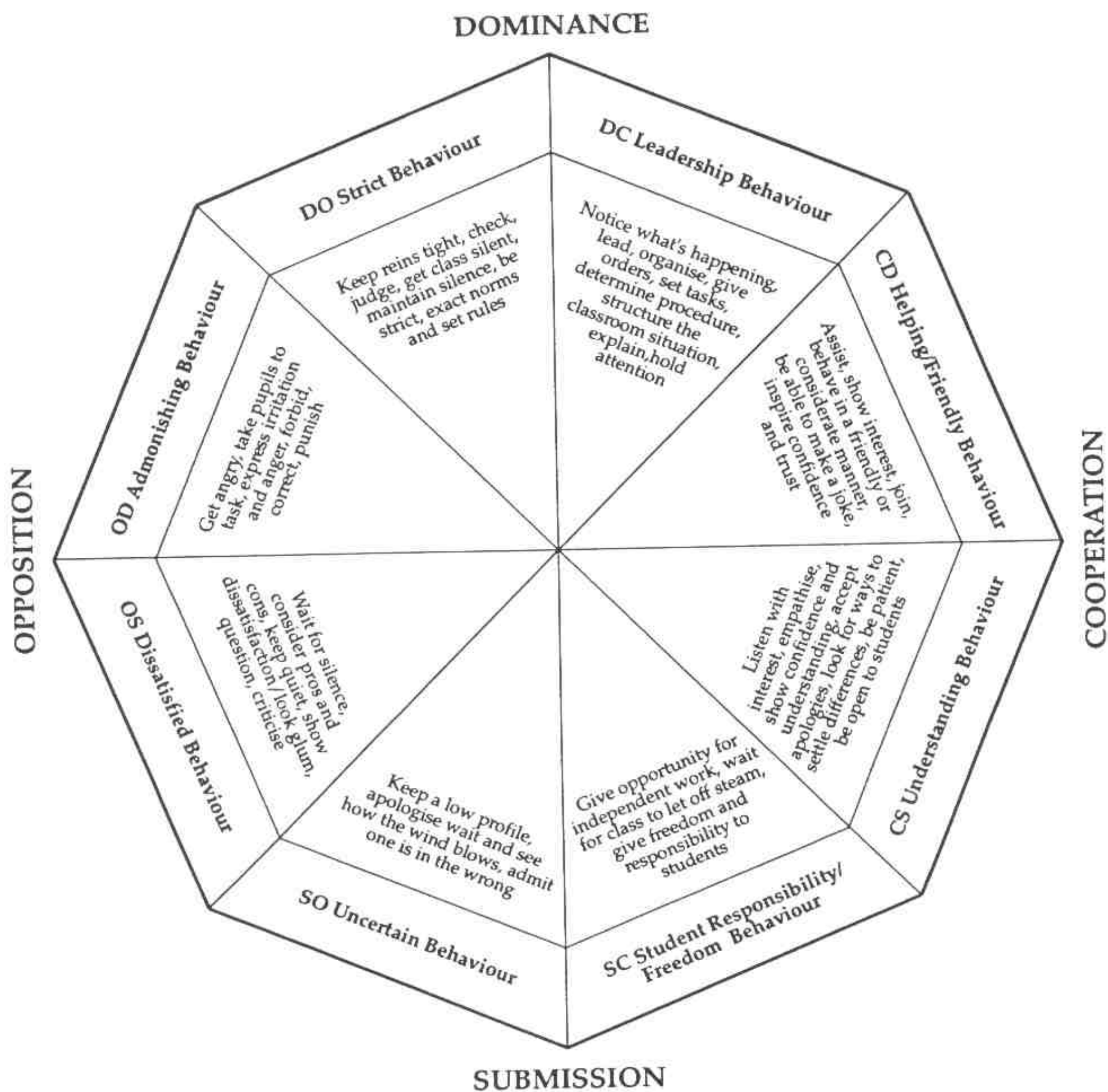


FIGURE 1: The Model for Interpersonal Teacher Behaviour

	Never	Always	Teacher Use
1. This teacher talks enthusiastically about her/his subject.	0	1 2 3 ④	Lea
2. This teacher trusts us.	0	1 2 ③ 4	Und
3. This teacher seems uncertain.	0 ① 2 3 4		Unc
4. This teacher gets angry unexpectedly.	① 1 2 3 4		Adm
5. This teacher explains things clearly.	0	1 2 ③ 4	Lea
6. If we don't agree with this teacher, we can talk about it.	0	1 ② 3 4	Und
7. This teacher is hesitant.	① 1 2 3 4		Unc
8. This teacher gets angry quickly.	0 ① 2 3 4		Adm
9. This teacher holds our attention.	0	1 2 ③ 4	Lea
10. This teacher is willing to explain things again.	0	1 ② 3 4	Und
11. This teacher acts as if she/he does not know what to do.	0	1 ② 3 4	Unc
12. This teacher is too quick to correct us when we break a rule.	0	1 ② 3 4	Adm
13. This teacher knows everything that goes on in the classroom.	0	1 ② 3 4	Lea
14. If we have something to say, this teacher will listen.	0	1 2 ③ 4	Und
15. This teacher lets us boss her/him around.	0 ① 2 3 4		Unc
16. This teacher is impatient.	0 ① 2 3 4		Adm
17. This teacher is a good leader.	0	1 2 ③ 4	Lea
18. This teacher realises when we don't understand.	0	1 2 3 ④	Und
19. This teacher is not sure what to do when we fool around.	① 1 2 3 4		Unc
20. It is easy to pick a fight with this teacher.	0	1 2 3 4	Adm
21. This teacher acts confidently.	0	1 2 3 ④	Lea
22. This teacher is patient.	0	1 2 ③ 4	Und
23. It's easy to make a fool out of this teacher	① 1 2 3 4		Unc
24. This teacher is sarcastic.	0 ① 2 3 4		Adm

For Teacher's Use Only: Lea 19 Und 17 Unc 4 Adm 7

FIGURE 2. Illustration of Hand Scoring Procedures for the Four Scales in the QTI Assessed by Items 1-24

and mathematics teachers and perceptions of the behaviour of teachers that students consider to be their best teacher. Teachers were asked for their perceptions of their behaviour and of the behaviour that they would like to display (their ideal). A total of 792 students and their 46 teachers were involved in the study. The sample came from 46 typical Year 11 science and mathematics classes in Western Australia and Tasmania.

Actual Classroom Behaviour

In Figure 3, the average teachers' perceptions and the average students' perceptions of the teachers' behaviour in the classroom are shown graphically as profiles. These profiles for the Australian sample closely resemble those previously found in other countries.

According to the teachers themselves and to their students, these teachers are rather high on Leadership, Friendly and Understanding behaviour. Uncertain, Dissatisfied and Admonishing behaviours are far less prominent.

However, there were some important differences between the teachers' and students' perceptions. Teachers on average had higher scores on Leadership, Helpful/Friendly and Understanding behaviours than their students.

Best Teachers and Teacher Ideals

The teachers' actual behaviour can be compared with the students' perceptions of their best teachers and the teachers' ideals (Figure 3). On average, the teachers do not

reach their ideal. Also they differ from the best teachers as perceived by students. Best teachers, according to their students, are stronger leaders, more friendly and understanding and less uncertain, dissatisfied and admonishing than teachers on average. Best teachers also give students a little bit more responsibility.

The average teachers' perceptions of their behaviour take a position between the students' perceptions of actual behaviour and the teachers' ideal: the teachers on average think that they behave somewhat more according to their ideal than what their students think. So, they tend to see the learning environment a little more favourably than do their students.

A closer look at the ideals of individual teachers revealed two distinct types of ideals. In the first type, there is a lot of cooperative

behaviour and a fair amount of leadership and strictness. The second type, however, shows a lot of behaviour that allows responsibility and freedom for the students in addition to cooperative behaviour. Among students' perceptions of best teachers, two similar types were found. Apparently some students prefer a strict teacher, whereas others prefer to have a lot of responsibility and freedom. From studies in The Netherlands, we know that by and large younger students prefer a teacher who holds the reins tight, whereas older students want to have more responsibility themselves.

A STUDY IN THE NETHERLANDS

WE INVESTIGATED relations between interpersonal teacher behaviour and student achievement and attitudes in the Dutch option of the Second International Science

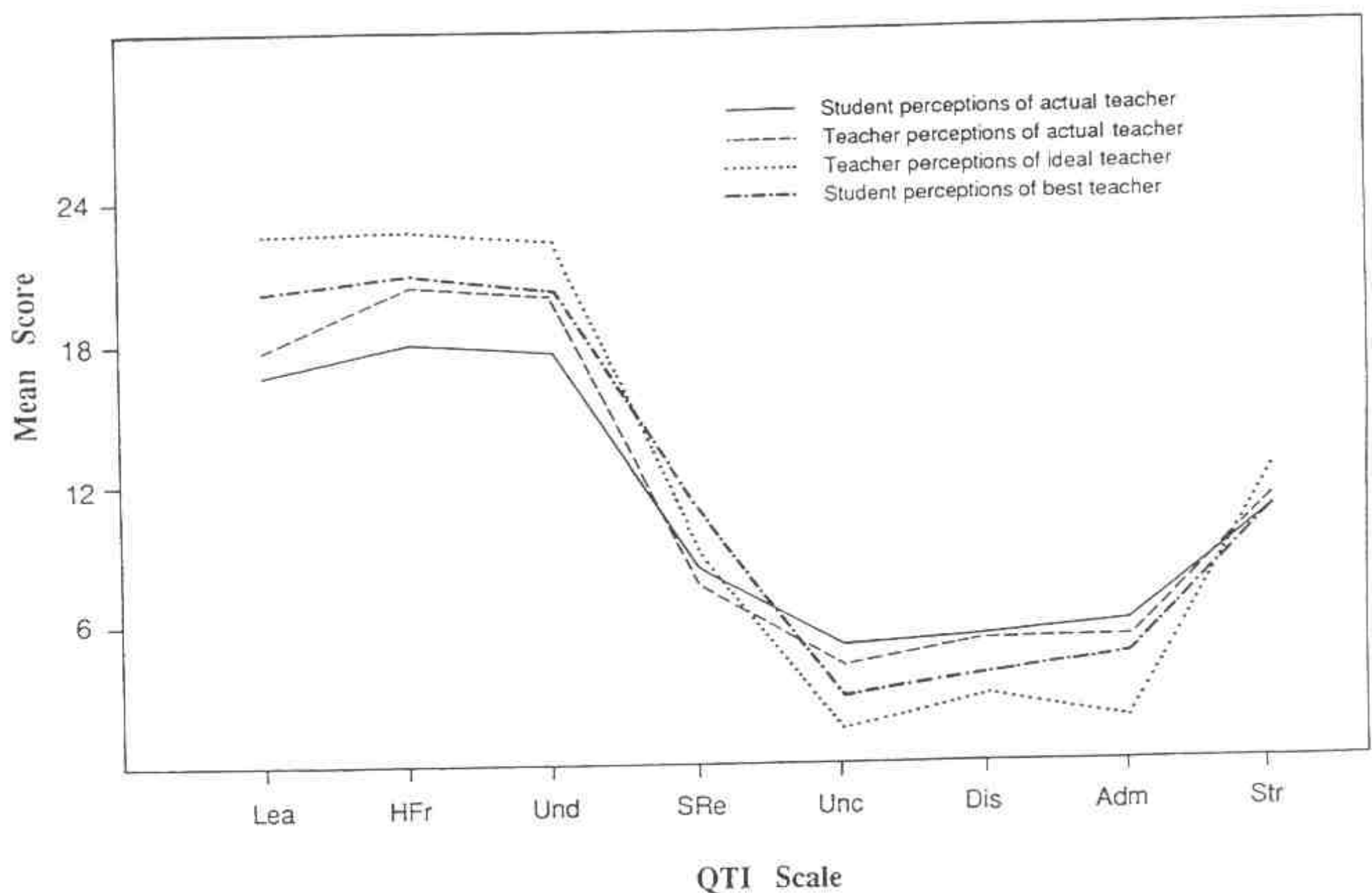


FIGURE 3. Profiles of Mean QTI Scores for Australian Teachers

Study. Teacher characteristics and opinions, teachers' perceptions of their interpersonal behaviour, and different curricula were incorporated into this study. Data were gathered in 66 Grade 9 physics classes. Student achievement was measured with a 23-item standardised and internationally developed test of physics subject matter. Attitudes were assessed with questionnaire items involving the students' experience of and motivation for physics and physics lessons.

Students' perceptions of interpersonal teacher behaviour appear to account for a large amount of the differences in outcomes between classes of the same ability level. The perceptions account for 70% of the variability in student achievement and 55% for attitude outcomes. So, at the class level, interpersonal teacher behaviour is an important factor related to student outcomes. The analyses also showed that the differences between the outcomes of teachers displaying different types of behaviours are far larger than differences in outcomes between teachers using different curricula or teachers of different age or teaching experience.

What interpersonal teacher behaviour is most favourable for student outcomes? When this question was addressed in several ways, the different analyses all pointed in the same direction.

Attitude Outcomes

The Cooperation scales of the model of interpersonal teacher behaviour (SC Student Responsibility and Freedom behaviour, CS Understanding behaviour, CD Helpful/Friendly behaviour, DC Leadership behaviour) are positively related to student attitudes. The more that teachers show behaviours from these sectors, the more positive are their students' attitudes. The Opposition scales (DO Strict behaviour, OD Admonishing behaviour, OS Dissatisfied behaviour, SO Uncertain behaviour) are all negatively related to attitudes. In terms of the model of interpersonal teacher behaviour, this means that students taught by teachers who show more than the 'average teacher' behaviour in the sectors on the right of the D-S axis and less in the sectors on the left of this axis on average viewed their physics lessons more positively.

Achievement Outcomes

Of the Dominance scales of the model, three scales (DO Strict behaviour, DC Leadership behaviour and CD Friendly behaviour) are positively related to student achievement, whereas three Submission scales (SC Student Responsibility behaviour, SO Uncertain behaviour and OS Dissatisfied behaviour) are negatively related to achievement.

The results presented are in keeping with those from other research, such as Haertel, Walberg and Haertel's (1981) finding that better achievement is found in classes perceived by students as having greater cohesiveness, satisfaction and goal-directedness and less disorganisation and friction.

We can relate the Australian students' perceptions of their best teachers and the teachers' perceptions of the ideal teacher to the results presented about Dutch students' outcomes. Looking at the average profile of the best and ideal teacher, we can expect that this kind of teacher will have superior student outcomes, because they have high scores on scales related positively to student outcomes and low scores on the negatively related scales.

CONCLUSION

THE STUDIES described in this publication show that interpersonal teacher behaviour is an important aspect of the learning environment. It is strongly related to student outcomes. However, strong relations between the curriculum that a teacher uses and student outcomes were not found, thus suggesting that the importance of the curriculum factor in science teaching should not be overestimated. To improve student outcomes, the introduction of new curriculum materials probably has to be accompanied by appropriate changes in teacher behaviour.

Interpersonal teacher behaviour is related to student outcomes.

Most Australian science and mathematics teachers in our sample displayed a lot of interpersonal behaviours that foster student outcomes. Emphasising behaviours from

the leadership, friendly and understanding sectors of the model is likely to promote student outcomes. For uncertain, dissatisfied and admonishing behaviours, the relation is in the opposite direction. If teachers aim to promote both student achievement and attitudes, they are pulled in opposite directions by the conflicting demands of the sectors DO and SC. In order to promote higher achievement, teachers have to be stricter but, to promote better attitudes, they have to be less strict. The other six sectors of the model do not present conflicting demands.

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APPENDIX A

Reliability (Alpha Coefficient) for QTI Scales for Students and Teachers in Three Countries

QTI Scale	Reliability					
	Students			Teachers		
	USA	Australia	The Netherlands	USA	Australia	The Netherlands
DC Leadership	0.80	0.83	0.83	0.75	0.74	0.81
CD Helpful/friendly	0.88	0.85	0.90	0.74	0.82	0.78
CS Understanding	0.88	0.82	0.90	0.76	0.78	0.83
SC Student responsibility/freedom	0.76	0.68	0.74	0.82	0.60	0.72
SO Uncertain	0.79	0.78	0.79	0.79	0.78	0.83
OS Dissatisfied	0.83	0.78	0.86	0.75	0.62	0.83
OD Admonishing	0.84	0.80	0.81	0.81	0.67	0.71
DO Strict	0.80	0.72	0.78	0.84	0.78	0.61
Sample Size	1 606	792	1 105	66	46	66

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STUDENT QUESTIONNAIRE

This questionnaire asks you to describe the behaviour of your teacher. This is NOT a test. Your opinion is what is wanted.

This questionnaire has 48 sentences about the teacher. For each sentence, circle the number corresponding to your response. For example:

	Never				Always
This teacher expresses himself/herself clearly.	0	1	2	3	4

If you think that your teacher always expresses himself/herself clearly, circle the 4. If you think your teacher never expresses himself/herself clearly, circle the 0. You also can choose the numbers 1, 2 and 3 which are in between. If you want to change your answer, cross it out and circle a new number. Thank you for your cooperation.

Don't forget to write the name of the teacher and other details at the top of the reverse side of this page.

©Theo Wubbels and Jack Levy, 1993. Teachers may reproduce this questionnaire for use in their own classrooms.

This page is a supplement to a publication entitled *Teacher and Student Relationships in Science and Mathematics Classes* authored by Theo Wubbels and published by the national Key Centre for School Science and Mathematics at Curtin University of Technology.

Teacher's Name _____ Class _____ School _____

	Never	Always	Teacher Use
1. This teacher talks enthusiastically about her/his subject.	0 1 2 3 4		Lea
2. This teacher trusts us.	0 1 2 3 4		Und
3. This teacher seems uncertain.	0 1 2 3 4		Unc
4. This teacher gets angry unexpectedly.	0 1 2 3 4		Adm
5. This teacher explains things clearly.	0 1 2 3 4		Lea
6. If we don't agree with this teacher, we can talk about it.	0 1 2 3 4		Und
7. This teacher is hesitant.	0 1 2 3 4		Unc
8. This teacher gets angry quickly.	0 1 2 3 4		Adm
9. This teacher holds our attention.	0 1 2 3 4		Lea
10. This teacher is willing to explain things again.	0 1 2 3 4		Und
11. This teacher acts as if she/he does not know what to do.	0 1 2 3 4		Unc
12. This teacher is too quick to correct us when we break a rule.	0 1 2 3 4		Adm
13. This teacher knows everything that goes on in the classroom.	0 1 2 3 4		Lea
14. If we have something to say, this teacher will listen.	0 1 2 3 4		Und
15. This teacher lets us boss her/him around.	0 1 2 3 4		Unc
16. This teacher is impatient.	0 1 2 3 4		Adm
17. This teacher is a good leader.	0 1 2 3 4		Lea
18. This teacher realises when we don't understand.	0 1 2 3 4		Und
19. This teacher is not sure what to do when we fool around.	0 1 2 3 4		Unc
20. It is easy to pick a fight with this teacher.	0 1 2 3 4		Adm
21. This teacher acts confidently.	0 1 2 3 4		Lea
22. This teacher is patient.	0 1 2 3 4		Und
23. It's easy to make a fool out of this teacher	0 1 2 3 4		Unc
24. This teacher is sarcastic.	0 1 2 3 4		Adm
25. This teacher helps us with our work.	0 1 2 3 4		HFr
26. We can decide some things in this teacher's class.	0 1 2 3 4		SRe
27. This teacher thinks that we cheat.	0 1 2 3 4		Dis
28. This teacher is strict.	0 1 2 3 4		Str
29. This teacher is friendly.	0 1 2 3 4		HFr
30. We can influence this teacher.	0 1 2 3 4		SRe
31. This teacher thinks that we don't know anything.	0 1 2 3 4		Dis
32. We have to be silent in this teacher's class.	0 1 2 3 4		Str
33. This teacher is someone we can depend on.	0 1 2 3 4		HFr
34. This teacher lets us fool around in class.	0 1 2 3 4		SRe
35. This teacher puts us down.	0 1 2 3 4		Dis
36. This teacher's tests are hard.	0 1 2 3 4		Str
37. This teacher has a sense of humour.	0 1 2 3 4		HFr
38. This teacher lets us get away with a lot in class.	0 1 2 3 4		SRe
39. This teacher thinks that we can't do things well.	0 1 2 3 4		Dis
40. This teacher's standards are very high.	0 1 2 3 4		Str
41. This teacher can take a joke.	0 1 2 3 4		HFr
42. This teacher gives us a lot of free time in class.	0 1 2 3 4		SRe
43. This teacher seems dissatisfied.	0 1 2 3 4		Dis
44. This teacher is severe when marking papers.	0 1 2 3 4		Str
45. This teacher's class is pleasant.	0 1 2 3 4		HFr
46. This teacher is lenient.	0 1 2 3 4		SRe
47. This teacher is suspicious.	0 1 2 3 4		Dis
48. We are afraid of this teacher	0 1 2 3 4		Str

For Teacher's Use Only: Lea ____ Und ____ Unc ____ Adm ____ HFr ____ SRe ____ Dis ____ Str ____

Maor, D.M., & Fraser, B.J.:

Use of classroom environment perceptions in evaluating inquiry-based
computer-assisted learning

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from individual students (private press) or whether these will be combined to obtain the average of the environment scores of all students within the same class (consensual press).

A growing body of literature acknowledges the importance and consequences of the choice of level or unit of statistical analysis and considers the hierarchical analysis and multilevel analysis of data (Bock 1989; Bryk & Raudenbush 1992; Goldstein 1987). The choice of unit of analysis is important because measures having the same operational definition can have different substantive interpretations with different levels of aggregation; relationships obtained using one unit of analysis could differ in magnitude and even in sign from relationships obtained using another unit; the use of certain units of analysis (e.g., individuals when classes are the primary sampling units) violates the requirement of independence of observations and calls into question the results of any statistical significance tests because an unjustifiably small estimate of the sampling error is used; and the use of different units of analysis involves the testing of conceptually different hypotheses. Although the unit of analysis problem has received considerable attention in the context of testing hypotheses using already-developed learning environment instruments, Sirotnik (1980) considers it ironic that concerns about analytic units have been virtually nonexistent at the stage of developing and empirically investigating the dimensionality of new instruments.

INSTRUMENTS FOR ASSESSING CLASSROOM ENVIRONMENT

This section describes the following historically important and contemporary instruments: Learning Environment Inventory (LEI); Classroom Environment Scale (CES); Individualised Classroom Environment Questionnaire (ICEQ); My Class Inventory (MCI); College and University Classroom Environment Inventory (CUCEI); Questionnaire on Teacher Interaction (QTI); Science Laboratory Environment Inventory (SLEI); Constructivist Learning Environment Survey (CLES); and What Is Happening In This Class (WHIC) questionnaire. Table 1 shows the name of each scale in each instrument, the level (primary, secondary, higher education) for which each instrument is suited, the number of items contained in each scale, and the classification of each scale according to Moos's (1974) scheme for classifying human environments. Moos's three basic types of dimension are Relationship Dimensions (which identify the nature and intensity of personal relationships within the environment and assess the extent to which people are involved in the environment and support and help each other), Personal Development Dimensions (which assess basic directions along which personal growth and self-enhancement tend to occur) and System Maintenance and System Change Dimensions (which involve the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change).

Table 1: Overview of scales contained in nine classroom environment instruments (LEI, CES, ICEQ, MCI, CUCEI, QTI, SLEI, CLES and WHIC)

Instrument	Level	Items per scale	Scales Classified According to Moos's Scheme			
			Relationship dimensions	Personal development dimensions	System maintenance and change dimensions	
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Friction Favouritism Cliques Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal Direction Disorganisation Democracy	
Classroom Environment Scale (CES)	Secondary	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order and Organisation Rule Clarity Teacher Control Innovation	
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalisation Participation	Independence Investigation	Differentiation	
My Class Inventory (MCI)	Elementary	6-9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness		
College and University Classroom Environment Inventory (CUCEI)	Higher Education	7	Personalisation Involvement Student Cohesiveness Satisfaction	Task Orientation	Innovation Individualisation	
Questionnaire on Teacher Interaction (QTI)	Secondary/Primary	8-10	Helpful/Friendly Understanding Dissatisfied Admonishing		Leadership Student Responsibility and Freedom Uncertain Strict	
Science Laboratory Environment Inventory (SLEI)	Upper Secondary/Higher Education	7	Student Cohesiveness	Open-Endedness Integration	Rule Clarity Material Environment	
Constructivist Learning Environment Survey (CLES)	Secondary	7	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation	
What Is Happening In This Classroom (WHIC)	Secondary	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity	

Use of classroom environment perceptions in evaluating inquiry-based computer-assisted learning

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This paper examines the perceptions held by 120 students and seven teachers of the learning environment in their inquiry-based, computer classrooms. The subjects responded to a classroom environment instrument before and after using a computerized database which has the potential for promoting inquiry skills. Generally, there was an increase in student-perceived investigation and open-endedness. Although teachers' and students' perceptions showed a similar trend, teachers' perceptions generally were more positive than those of the students.

Introduction

Inquiry learning arose from a fundamental need in science education to teach science as an active process involving inquiry and knowledge, rather than relying on exposition of content alone (Schwab 1963). Scientific inquiry has been defined in operational terms as involving a set of specific processes or skills, including planning experiments, collecting information, organizing and interpreting information, and drawing conclusions (Fulrman *et al.* 1978), which are believed to be used by scientists.

In spite of its promise, inquiry-based science teaching has been largely disappointing. Classroom observations reveal examples of the absence of inquiry teaching and learning or opportunities for higher-level learning (i.e. understanding and inquiry skills) (Tobin *et al.* 1990). Weiss (1987) and Tobin and Gallagher (1987) report that most science curricula emphasize the learning of facts and place little emphasis on higher-level cognitive learning. Many programs that claim to be inquiry-based show little evidence of inquiry on the part of students (National Research Council 1989, Stake and Easley 1978, Tobin and Gallagher 1987). Instead they emphasize whole-class activities led by the teacher and make use of textbooks and worksheets that stress the learning of facts and the application of algorithms. Moreover, evaluations of inquiry-based programs usually have revealed a failure to promote higher-level cognitive outcomes. Even when teachers use inquiry approaches to teaching science, there is often not enough emphasis on conceptual understanding (Anderson and Smith 1987).

Nevertheless, the call for inquiry teaching continues to be made (Bell 1991, Fosnot 1989, Tahir 1989). According to *Project 2061*, for example, the teaching of science should be consistent with the spirit and character of scientific inquiry;

students should begin their investigations of phenomena with questions rather than with answers to be learned. 'The emphasis in the learning should be on students' curiosity and creativity' (American Association for the Advancement of Science 1989). In addition, the introduction of the personal computer into school science classrooms and the increasing availability of 'problem-solving software' in order to explore and develop further ideas in science (Nachmias and Linn 1987, Oliver and Olley 1986, River and Vockell 1987) provide opportunities for inquiry teaching and learning.

However, practical constraints still exist in the classroom and should not be ignored. Teachers are not free agents. There are inherent management problems associated with inquiry teaching when the teacher has a class of approximately 30 students to look after. It is difficult to cater for students with different prior knowledge, to offer genuine inquiry experiences, and to provide opportunities to engage in class discussions and sense making as part of the learning. Consequently, inquiry-based approaches are likely to continue to fail to promote higher-level cognitive learning until a way is found to alleviate the management problems associated with offering genuine inquiry learning experiences to whole classes of students.

Computerized classroom learning environments have the potential to overcome these management difficulties and therefore to promote the goal of higher-level cognitive learning. In the past, however, the majority of students have characterized their experiences of computers in schools as giving them a strong negative attitude towards using a computer. Students recall drill-and-practice exercises, where they keyed in computer programs from books or played what, in their eyes, were trivial computer games (Bigum 1987).

The present study involved an attempt to promote inquiry skills by using a computerized database within an inquiry-oriented teaching approach. The main purpose of the research was to investigate the extent to which students' inquiry skills can be facilitated by the use of the database and the curriculum materials. Students in this study had the opportunity to engage in computer-based experiences which could enable them to be creative and develop higher-level thinking skills. 'The students were engaged in making sense, inquiring by asking questions, generating hypotheses and constructing understanding by negotiating their own meaning with the teacher and the other members of the class. The information transmitted by the computer served as a basis for students to 'construct the computer' (Papert 1988) by reflecting, making sense and generating more questions.

Purpose

The purpose of this paper is to examine students' and teachers' learning environment perceptions in their inquiry-based computer classrooms as a result of interacting with a computerized database and curriculum materials. This was part of a larger study which examined the effectiveness of the use of a computerized database in promoting inquiry skills. The research question: *Can a computerized database contribute to the development of an inquiry-oriented classroom learning environment?* was investigated with a sample of 120 students and their teachers who provided their perceptions of the classroom learning environment.

Students' perceptions of the learning environment

Learning environment was one of the major foci of an evaluation of the computerized learning environment in this study. 'The research was conducted in secondary school classes in which previously an inquiry approach to learning was not given priority, and teachers were now trying unsuccessfully to promote students' development of inquiry skills. Also the use of computers enabled a different and more innovative use of a computer database. Students' perceptions of their school experiences are educationally significant and can guide teachers who are trying to improve the classroom learning environment in schools. It is especially important to take into consideration students' perceptions of the learning environment when evaluating a new curriculum or learning approach' (Fraser 1989).

In the past 25 years, classroom environment research has focused on the assessment and improvement of teaching and learning in traditional classroom settings (Fraser 1986, 1989, 1994, Fraser and Walberg 1991). Over two decades ago, Moos (1968) developed the first social climate scales for use in psychiatric hospitals and other human environments. This resulted in the development of the Classroom Environment Scale for school settings (Moos and Tuckett 1987). Since then, much research has been carried out involving measurement and investigation of perceptions of psychosocial characteristics of the learning environment of classrooms at the elementary, secondary and higher education levels (Fraser 1994).

Fraser and O'Brien (1985) investigated student and teacher perceptions of the environment of primary school classrooms. At the secondary level, Fraser (1990) developed an instrument to assess teachers' and students' perceptions of individualized classroom environments. At the university and college level, Fraser *et al.* (1986) developed and used an instrument to assess the psychosocial environment in higher education classes. Recently, new classroom environment instruments have been developed to assess specific learning environments, such as science laboratory classrooms (Fraser *et al.* 1993) and constructivist learning environments (Taylor *et al.* 1994).

Most of these studies used instruments that dealt with the actual and preferred learning environment in a specific setting. The preferred form is concerned with goals and value orientations and it measures perception of the environment ideally liked or preferred (Fraser 1991). On the other hand, the actual form is concerned with the perceptions which students have of the classroom. Having two different forms of an instrument enables a wide range of research to be conducted. For example, comparison between students' and teachers' perceptions of actual and preferred learning environments (Fraser 1982, 1985, Hofstein and Lazarowitz 1986, Moos 1979) revealed that students and teachers are likely to differ in the way in which they perceive the actual environment of the same classroom, and that the environment actually presented in classrooms commonly falls short of that preferred by students.

In their work with students and teachers in the Project for Enhancing Effective Learning (PEEL), Baird and Mitchell (1986) describe different factors which have been shown to influence the classroom environment and sustain learning. However, the teachers and to a greater extent the students, 'had difficulty in recognizing the extent of their own change' (293).

The actual and preferred forms can be used in a practical way by teachers to assess and to facilitate improvements in classroom environment. The teacher could

introduce an intervention in an attempt to promote changes which reduce differences between actual and preferred perceptions, and then administer the learning environment instrument again to assess changes in perceptions as a result of the intervention (Fraser and Fisher 1986).

Research in different countries has established consistent relationships between the nature of the classroom environment and various student cognitive and affective outcomes (Hartel *et al.* 1981). In these studies, student perception of actual classroom environment was used as a predictor of cognitive and affective outcomes. For example, Fraser and Fisher's study (1982) of science classes established sizeable associations between several inquiry skills, science-related attitudes, and classroom environment dimensions measured by the Classroom Environment Scale and the Individualized Classroom Environment Questionnaire. Furthermore, research based on a person-environment fit framework has shown that students achieve better when in their preferred classroom environment (Fraser and Fisher 1983).

Examples of studies which involved learning environment scales in the evaluation of educational innovations and curriculum include Fraser *et al.*'s (1987) Harvard Project Physics and Fraser's (1979) evaluation of the Australian Science Education Project. Clearly, this past work involving the use of classroom environment measures in evaluation had important implications for the design of the learning environment aspect of the present study.

Design and procedures

Sample

One hundred and twenty students and seven teachers responded to a classroom environment inventory at the beginning and at the end of the program. Seven grade 11 applied computing classes in four schools in the metropolitan area of Perth, Australia were involved.

The curriculum materials

In contrast to previous studies in which computers were used mainly for drill-and-practice, this study involved the use of the computer as a tool for investigation which enables students to engage in inquiry learning. The introduction of computers into the science classroom and the creation of a 'computerized learning environment' confront teachers and students with a new social environment to which they must adapt. Students' and teachers' perceptions of how they indeed adapt to this new environment draw the focus of the study away from the computer as a technological innovation to the learning process itself and how students learn with understanding.

Use was made of a computerized database *Birds of Antarctica* (National Information Technology Committee 1984), which was chosen because of its potential for helping students to develop a wide range of inquiry skills. The software has the specific aim of demonstrating the application of information technology with a specific focus on databases. As part of the Australian Antarctic Research Expedition, one scientist's task was to record all sightings of bird life. The database consists of observational records of a range of behaviours of 26 species of sea birds

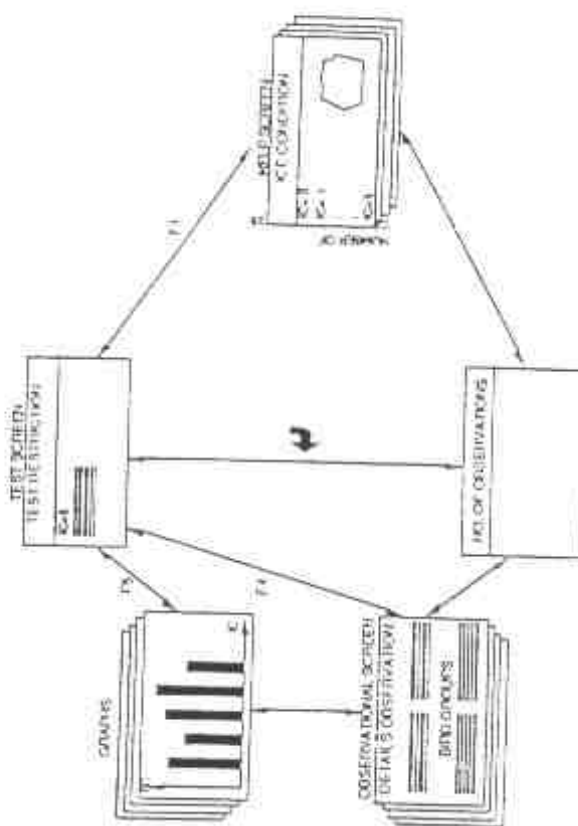


Figure 1. Structure of the database.

(e.g. Antarctic petrel, Adelic penguin), together with meteorological information, time, date, and the ship's position and activities. The data can be accessed by students and presented in several ways including tables and graphs (see Figure 1). This information creates an artificial laboratory in which students can conduct investigations.

In addition, students used a booklet, designed by the researchers specifically for the study (Maor 1993); it facilitated use of the database and helped students to focus on specific inquiry skills such as generating questions and designing investigations. The booklet provides a series of carefully structured and graded worksheets to guide students towards the attainment of scientific inquiry skills ranging from the ability to conduct relatively simple investigations based on a single variable to the ability to design and conduct complex investigations involving multiple variables. For example, in the worksheets, students are asked:

How often were groups of birds sitting on the water when observed?
What was the most common behaviour of Antarctic petrels?
Which species were observed when the sea state was 'very rough'?

In the final worksheet, students are given an opportunity to generate scientific questions concerning the ecology of birds in Antarctica, and to design and conduct their own research incorporating the different functions of the database in order to answer their questions.

In addition to students interacting individually with the database guided by the use of the booklet, the teachers in the classrooms provided students with opportunities to construct their own understanding when they exchanged ideas, and explored and reinforced their ideas by means of class discussions and negotiations (Solomon 1987). Interrogation of the database enables students to engage in scientific inquiry, and also to develop understanding of the 'real world' while using data which is of recent origin. The database takes computers into the science classroom and provides useful information about the ecology of Antarctica.

Table 1. Descriptive information for each scale.

Scale name	Description	Sample item
Investigation	Extent to which the student is encouraged to engage in inquiry learning.	In these computer sessions, I find out the answers to questions by investigation. (+)
Open-endedness	Extent to which the computer activities emphasize an open-ended approach to inquiry.	In this class, the teacher decides the best way for me to proceed with my work. (-)
Organization	Extent to which classroom activities are planned and well organized.	I find that the computer sessions are well organized. (+)
Material environment	Extent to which the computer hardware and software are adequate and user friendly.	The computers are not suitable for running the program I use. (-)
Satisfaction	Extent to which the student is interested in using the computer and in conducting investigations.	In this class, I like using computers to learn. (+)

Items designated (+) are scored 1, 2, 3, 4 and 5, respectively, for the responses 'Never, Seldom, Sometimes, Often, and Very Often'. Items designated (-) are scored in the reverse manner. Omitted or invalid responses are scored 3.

Development of a learning environment instrument for computer classrooms

The *Computer Classroom Environment Inventory* (CCEI) (Appendix A) was developed to assess students' changing perceptions of their learning environments as they engaged in inquiry learning. It is distinctive because it assesses students' perceptions of a learning environment that involves both an inquiry learning approach and the use of a computerized database. The instrument measures students' and teachers' perceptions on five scales: *Investigation*, *Open-endedness*, *Organization*, *Material Environment* and *Satisfaction*. Table 1 clarifies the meaning of each of the five scales and gives descriptions and sample items, together with information about scale allocation and scoring.

The design of the instrument was guided by several criteria. For example, the literature on inquiry learning served as a criterion to select the scales for the instrument. Guidance in identifying dimensions was obtained from scales contained in existing classroom environment instruments for non-computer settings (see Fraser 1986). CCEI scales included modifications of the Satisfaction scale from the Learning Environment Inventory (LEI) (Fraser *et al.* 1982); investigation from the Individualized Classroom Environment Questionnaire (ICEQ) (Fraser 1990) and Open-endedness from the Science Laboratory Environment Inventory (SLEI) (Fraser *et al.* 1993). Also the instrument was constructed in such a way that it would require a relatively short time to complete and hand score. Thus, it included a relatively small number of scales, each containing a fairly small number of items. Finally, in order to ensure that the CCEI's scales and items were considered salient by teachers and students, interviews were conducted by the researchers with three science teachers and five students of grades 10 and 11 at a government school in the metropolitan area of Perth. The science teachers and students were asked to comment on preliminary versions of the instrument for face validity, clarity of language and suitability for the age level concerned. As a result of this, modifications were made to the language of some of the items.

Table 2. Number of items, alpha reliability and discriminant validity for the refined version of the Computer Classroom Environment Inventory (CCEI).

Scale	No. of items	Alpha reliability	Mean correlation with other scales
Investigation	6	0.77	0.37
Open-endedness	6	0.62	0.34
Organization	6	0.69	0.47
Material environment	6	0.74	0.39
Satisfaction	6	0.91	0.45

The initial version of the CCEI contained 40 items which passed through a process of refinement and validation. In the first step, the items were revised based on the reactions of the three science teachers about suitability and clarity of language. Then each of the panel members independently classified the items into the *a priori* categories.

In order to optimize the reliability and validity of the original instrument, item analysis was conducted for the 40 items based on data from the 120 grade 11 students. As a result of the successive deletion of a total of 10 items, the reliability of the refined instrument was improved for most of the scales. At the same time, deletion of the 10 items resulted in higher discriminant validity for most scales.

Table 2 reports two validity statistics—the internal consistency (alpha reliability coefficient) and the discriminant validity (using the mean correlation of a scale with other four scales as a convenient index)—for the final 30-item version of the CCEI. The reliability data in Table 2 suggests that the refined version of each CCEI scale has acceptable internal consistency, especially for scales containing a relatively small number of items. Discriminant validity data suggest that the CCEI measures distinct although somewhat overlapping aspects of classroom environment.

A teacher form of the questionnaire also was designed. The teacher version is almost identical to the student version except that the items that required the students to reflect on their own personal experience were reworded and the teacher was asked to refer to the class as a whole. For example, the student item 'I am able to pursue my own interests in this computer class' was modified in the corresponding teacher version to 'Students are able to pursue their own interests in this computer class'.

Results: students' and teachers' perceptions

In this section, quantitative data derived from students' responses to the learning environment questionnaire are presented together with some evidence from classroom observations and interviews with students and teachers. The whole sample's mean score for students' perceptions of the classroom environment before and after implementing the program is presented in tabular and graphical form. Then the following profiles of the learning environment perceptions are presented and discussed: two individual selected classes; teachers' perceptions; and a comparison of teachers' and students' perceptions.

One hundred and twenty students were involved in the study in which a computerized database and the student booklet were used during two school terms.

Twice a week, when students interacted with the computerized database in order to conduct investigations, they were using their student booklet for instruction on how to retrieve information from the database. However, observational notes indicate that most students experienced difficulty at the beginning of the program in translating the questions in the student booklet into the database terminology. For example, students were required to match concepts such as 'bird feeding' with the scientists' biological classification system of bird behaviour $bb = 1$, which means 'bird behaviour is feeding'. Therefore, most of the time students interacted individually with the database and conducted their own investigations. However, whenever problems associated with understanding of the technical language or the steps of inquiry arose, students were negotiating with other students in the class or with the teacher.

Classroom observations suggested that the use of a computerized database in this study freed students from having to collect and organize data before undertaking an investigation. It enabled them to focus on their problem-solving techniques and promoted the development of higher-level thinking skills such as analysing relationships, discovering commonalities or differences between groups and events, and looking for trends or patterns. As some of the students became aware of a variety of strategies for handling different tasks, they began to articulate problems and found ways of explaining their thinking to each other. The data in the computerized database were used to help students to test hypotheses and to clarify their thinking to themselves and to each other.

The teacher's role in this type of computerized learning environment was one of guide and facilitator; that is, the teacher could guide students to focus on developing higher-level thinking skills while creating a non-threatening environment in which students felt comfortable about asking questions and testing hypotheses.

Student's perceptions of the learning environments for the whole sample

To investigate changes in students' perceptions of their classroom environment between the beginning of the program and the end, *t*-tests for matched pairs were conducted. Mean scale scores and standard deviations are reported separately for the pretest and post-test administrations of the five scales of the CCT to the whole sample. A summary of the results of the two-tailed tests for the significance of differences between pretest and post-test perceptions are reported in Table 3. It reveals three main patterns.

First, a significant increase ($p < 0.001$) in the mean score occurred for Investigation (approximately 0.7 of a standard deviation) and Open-endedness (approximately 0.4 of a standard deviation). These effect sizes are at least comparable to the average effect size of 0.4 of a standard deviation found by Fraser *et al.* (1987) in a synthesis of meta-analyses of 7827 post studies.

Second, a very small but statistically significant decrease ($p < 0.05$) in the mean score occurred for the Organization scale (approximately 0.1 of a standard deviation). A change as small as this cannot be considered educationally important. Third, a small nonsignificant decrease occurred in the mean score for the Satisfaction and Material Environment scales.

The results are summarized graphically in Figure 2, it shows the whole sample's mean scores for students' perceptions of the classroom environment before and after

Table 3. Pretest and post-test mean and standard deviations and *t*-values for Computer Classroom Environment Inventory ($N = 120$).

Scale	Testing	No. of items	Mean	SD	Effect size ^a	<i>t</i>
Investigation	Pre	6	18.69	3.18	0.7	7.06***
	Post		20.85	3.12		
Open-ended	Pre	6	17.76	3.39	0.4	3.65***
	Post		18.86	3.23		
Organization	Pre	6	21.29	3.48	-0.1	-2.07*
	Post		20.75	3.29		
Material environment	Pre	6	24.16	3.35	-0.0	-0.54***
	Post		24.01	3.55		
Satisfaction	Pre	6	22.98	4.18	-0.1	-1.33
	Post		22.52	4.35		

* $p < 0.05$ *** $p < 0.001$

^aEffect size is the difference in pretest and post-test means expressed in standard deviation units.

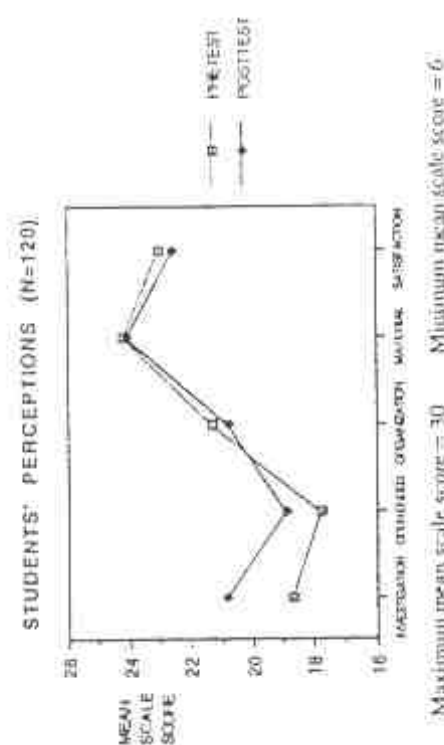


Figure 2. Students' perceptions of the learning environment ($N = 120$).

implementing the program. Figure 2 illustrates that the larger increases in students' perceptions scores occurred on the Investigation and Open-endedness scales. The graph captures students' responses to the learning environment that allowed more investigative and more open-ended work. Students' reactions to the program reflect its objective to promote inquiry skills. On the other hand, there was a small significant decline in the perceived level of Organization. This is to be expected as inquiry learning is likely to free students to investigate, enable them to interact freely with the computer database and with other students in the class, and to expect less authority and a less teacher-centred approach. These phenomena probably led some of the students to perceive a less organized environment. The changes occurring on each scale are described in more detail below.

Students' perceptions significantly changed by 0.7 standard deviations for the Investigation scale towards a more investigative type of learning environment (Figure 2). At the end of the program, students perceived that they were engaged more often in inquiry learning and had an opportunity to develop their inquiry skills as a result of interacting with the program. At the beginning of the program, students

stated their hypotheses but did not try to support them. As the study progressed, students tried to give support to their initial hypotheses by designing new investigations. For example, students tried to find the relationship between birds' behaviour, their locations, and the ice conditions in the observation area. Based on their own experience with the database, students were able to formulate hypotheses about bird species that they expected to find in particular latitudes and particular ice conditions.

Data supporting the inquiry-oriented nature of the class came from the interpretative part of the research. In an interview, a student reflected on his ability to investigate using the database:

As it [the program] progressed, I found myself analysing the information more, because I sort of got in tune with the question. I asked myself why would it ask that ... not for any other reason than that it wanted me to think and get by views, not just what I got out of the database.

The interviews provided examples of students' explicit perceptions about the investigative nature of the environment. Another student expressed his satisfaction at being able to conduct complex investigations through the database:

Basically I set myself a task to explore the living conditions of the South Polar skua, and I was sort of trying to work out things like how did it interact with other bird life forms, and draw conclusions from that as to its general capacity for living in the Antarctic and how it actually lived there.

Students generally perceived a change in the Open-endedness scale as shown in Figure 2. This change of 0.4 standard deviations was statistically significant and comparable with the average effect size of 0.4 found in past research (Fraser *et al.* 1987). It indicates that the computer activity emphasized a more open-ended approach to inquiry than the students experienced before the implementation of the computerized program. For example, entries in some students' booklets showed a transition from constructing narrow questions to formulating complex questions that were not confined to the content of the database. At the beginning of the program, students asked informative questions such as: Where were the Antarctic tern observed? How often were the birds observed following the ships? What wind speed do snow petrel prefer? Towards the end of the program, some students demonstrated an increase in the variety of the questions and in their complexity. Questions included: What is the relationship between the ice condition and the latitude? Which bird is the most tame of all the 26 species? At the completion of the program, students were asked to 'act' as researchers on the voyage and conduct their own investigation using the database as a source of information. Students perceived this as an opportunity to conduct their own research and draw their own conclusions, as illustrated by one student's comments:

At the beginning of the program, I had picked up more ideas on what questions to ask by looking at the questions in the booklet ... I think the questions that I ask now will be deeper than the [previous] ones and have more meaning than the ones I asked before.

This student clearly demonstrated his development of inquiry skills by being able to reflect on his ability to generate questions in the different stages on the study. Another student expressed his views about the open-endedness of the learning environment by saying:

When I'm given information [from the database], I'm not just saying "That's the information. I'll put it down [on the screen]". I'm sort of thinking "But why is that so?"

... Now, I can actually draw my own conclusions from the information that I'm presented with.

Generally, students perceived a negligible decrease of 0.1 standard deviations in the Organization scale. Students did not perceive a significant change in the Material Environment; in fact, they generally perceived the facilities, hardware and software to be in good working condition. There were enough computers for each student to work individually, students were familiar with the hardware, and they showed confidence in using the computers. This could explain the high mean score in Material Environment of the whole sample.

Students' perceptions generally indicated a relatively high degree of satisfaction both at the beginning and the end of the program. Although students were slightly less satisfied at the completion of the program after intensive interactions with the computerized database, this difference in satisfaction was neither statistically nor educationally important.

Students' perceptions of the learning environment in two selected classes

Students' perceptions of the learning environment within each particular class revealed a slightly different profile for different classes. The results for Class 1 and Class 3 are presented here.

In Class 1, as depicted in Figure 3, the two greatest student-perceived changes in learning environment between pretest and post-test occurred for Investigation (1.5 standard deviations) and Open-endedness (1.0 standard deviations). This is similar to the general pattern for the whole sample (Figure 2). The differences were

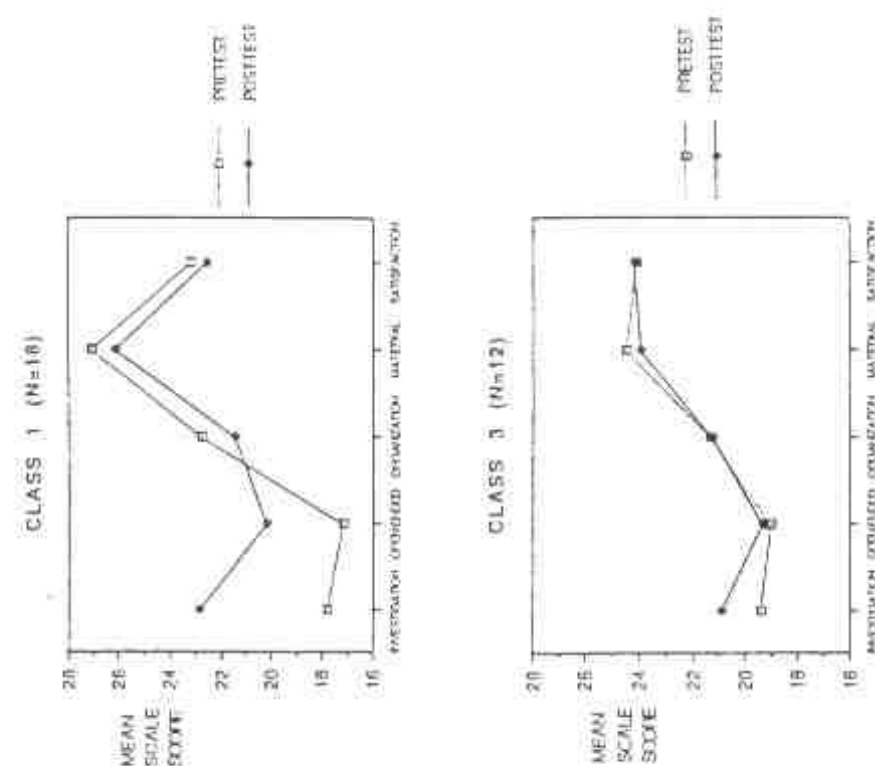


Figure 3. Students' perceptions of the learning environments: Class 1 and Class 3.

statistically significant at the 0.001 level for the two scales and larger than the average effect size of 0.4 found in past research (Fraser *et al.* 1987). These two scales had the lowest means at the beginning of the program, and this reflected the lack of an inquiry approach to learning in the normal computing class. The positive changes in the Investigation and Open-endedness scales were relatively large and compare favourably with changes in other classes. Figure 3 shows that almost no change occurred in students' perceptions on the Organization, Material Environment and Satisfaction scales. In this class, some students, who were less satisfied at the completion of the program, had problems at the initial stages of the study manipulating the database and this constrained their development of inquiry skills. Also students who found the program difficult because it was cognitively demanding tended to be less satisfied. Some dissatisfactions were expressed by Class 1 students:

Student 1: Get rid of the codes. It will be easier without the codes. Just have words instead of codes.

Student 2: Using the codes and back to the screen is very difficult.

Figure 3 also shows that, in Class 3, there was a positive change in students' perceptions on the Investigation scale. Negligible changes were perceived in the learning environment in terms of Open-endedness, Satisfaction, Organization and Material Environment.

The positive changes in the Investigation and Open-endedness scales for Class 3 reflected the change towards a more inquiry-based learning approach. The high level of Satisfaction, both prior to and at the end of the program, could be associated with the good relationships between the students and the teacher, and the high-level discussions and social interactions in this class.

Student 1: The discussions helped me... I got ideas from other people.

Student 2: You clarify it in your mind while you're arguing because you have to back up what you're saying and, through having to back it up, you are made to think about it. In that way, I suppose it helps to investigate the database.

Teachers' perceptions of the learning environment

The teachers had a very important role in implementing the program, and they influenced the nature of the learning environment. From this point of view, it seemed important to ascertain how the teachers in this study perceived the learning environment, and whether they saw the program as supportive of inquiry learning. Consequently, a comparison of teachers' and students' perceptions of the same learning environments is discussed in this section.

Figure 4 depicts the mean perceptions of the group of seven teachers on the learning environment scales. The graph shows that teachers perceived positive changes on the Investigation and Open-endedness scales (of approximately 0.9 and 0.7 standard deviations, respectively) during the use of the program. Teachers perceived only negligible changes in the way in which the classes were organized and saw a slight decrease in terms of Material Environment and Satisfaction.

Generally, teachers perceived the activities in the classes to be inquiry oriented. During the program, teachers saw their role change from providing the answers to the problems and deciding the best way for the students to proceed with their work, to guiding and facilitating. The teachers clearly perceived that there were opportunities for students to investigate, to initiate information retrieval based on

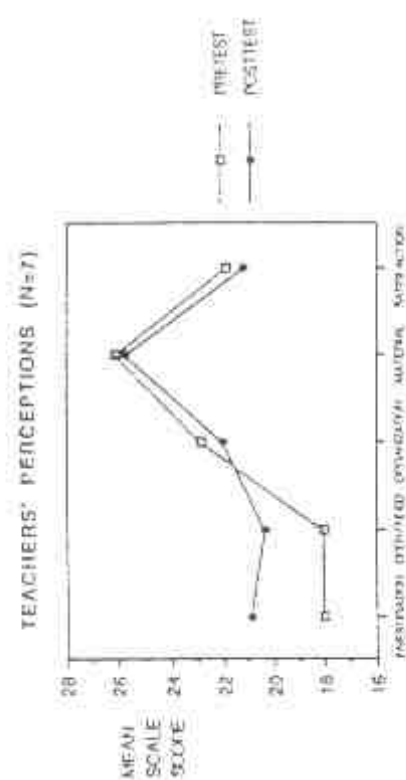


Figure 4. Teachers' perceptions of the learning environment ($N=7$).

their own ideas, to collect different data and use different approaches for the same problem, and to think about the data which supported their conclusions.

One of the teachers perceived how students developed abilities to make effective use of the database and, subsequently, to conduct investigations during the first few lessons:

'Today some of the students were quite happy because they figured out better ways of using the database. They are starting to get used to it but still think about the database rather than the question. They now are starting to be able to use the database... Some of them are able to use the data quite well, so they can spend time thinking about the questions... As these kids become better at using the database, they'll be able to develop the other type of thought [higher-level thinking skills].

An interview with another teacher supports the positive changes in teachers' perceptions on the Investigation and Open-endedness scales, as shown in Figure 4:

I noticed that they [low ability students] asked very simple questions; and on the other end you had someone like Alan who asked complex questions and extracted real complex answers out of it as well.

The same teacher expressed his satisfaction at the end of the program:

'The majority of them were able to extract the questions from the database quite efficiently towards the end of the program, that's for sure.

Another teacher expressed satisfaction with students' ability to generate questions:

'The students were not just questioning the database. They had to start thinking about what question they are going to ask... They would have to achieve this sort of higher-level questioning.

This teacher was satisfied that, 'apart from manipulation of the database, which is a complex one, most students were able to interrogate the database based on their own original questions'.

One of the teachers explained that the decrease in Satisfaction scale reflected the fact that students were used to structure and organization in the computing classroom and, when they were given independence to investigate on their own, some of them did not know how to handle the independence and therefore could become a little confused and dissatisfied.

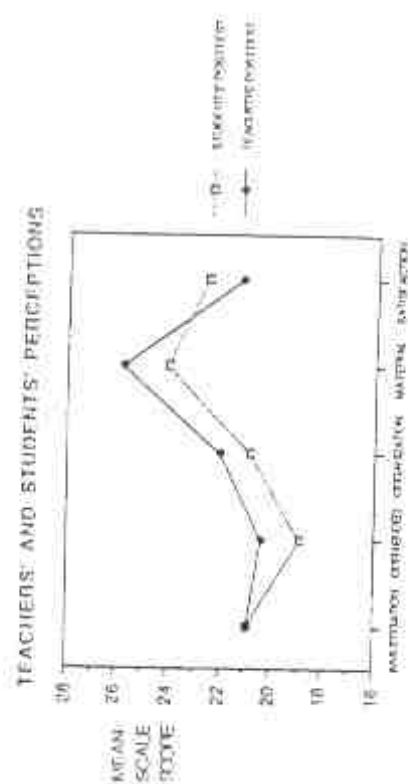


Figure 5. A comparison of teachers' and students' perceptions of the learning environment.

Teachers' and students' perceptions

Teachers' and students' profiles of the learning environment were compared in order to investigate the extent to which there is a correspondence between the two groups' perceptions. If there was a mismatch in perceptions, this could indicate a problem in the specific learning environment.

Comparison between the seven teachers' perceptions and the corresponding seven class means of students' perceptions at the completion of the program (Figure 5) revealed a similar trend. However, teachers perceived the actual classroom environment more positively than the students on three scales: Open-endedness, Organization and Material Environment. Both groups perceived a similar environment on the Investigation scale, and only on the Satisfaction scale were teachers' perceptions less positive than the students'. The teachers' main concerns were that it took too long for the students to complete the program and that the task seemed too difficult for some students. However, the students themselves were more positive than the teachers anticipated, and students felt that they benefited from this learning experience.

The results, which showed that the teachers perceived the classroom more positively on several scales of the learning environment than did their students in the same classrooms, replicate the pattern emerging in other studies in school classrooms in Australia (Fraser 1982, 1985), the USA (Moos 1979), The Netherlands (Wubbels *et al.* 1991) and Israel (Hofstein and Lazarowitz 1986, Raviv *et al.* 1990). These studies inform educators that students and teachers are likely to differ in the way in which they perceive the actual environment of the same classroom.

Discussion and conclusion

The results based on the use of the Computer Classroom Environment Inventory mainly gave an indication of whether students and teachers perceived opportunities to investigate in this new learning environment and whether the program encouraged open-ended settings for students to conduct their investigations. Overall, the results indicated the positive effect of the program in promoting perceptions of a more investigative and open-ended learning environment. This environment is one step further in preparing students for 'tomorrow's society' (Yeany *et al.* 1986) by

providing opportunities to be inquirers and to design investigations, as recommended by science curriculum reformers (American Association for the Advancement of Science 1989, Shymansky and Kyle 1991). The increase in students' perception scores on the Investigation and Open-ended scales suggests that the program created a supportive learning environment for the development of inquiry learning and also the promotion of higher-level thinking skills as studied in detail in the interpretative component of the study. The general reactions of students and teachers to the program reflected the objective of the program to promote inquiry skills. However, there were variations in students' perceptions between the classes and these reflected differences in the learning processes and teachers' epistemologies. The computerized learning environment in this study permitted students to develop scientific literacy, which is advocated by science curriculum reformers. One teacher, in particular, changed his role to become a facilitator who guided students to use the opportunities to develop their inquiry skills and higher-level thinking skills. The change in the teacher's role from lecturer and conclusion-drawer to initiator and facilitator while using the computer to teach science has been recommended by Kellogg and Leonard (1987) and Ryba and Anderson (1990).

The Investigation and Open-endedness scales are the two scales that best reflect whether the program achieved its objectives. Although the differences in pretest and post-test means seem somewhat small at first sight, the effect size for the whole sample (approximately 0.7 standard deviations for Investigation and 0.4 standard deviations for Open-endedness) are comparable to, or larger than, the average effect size of 0.4 standard deviations found in past educational research by Fraser *et al.* (1987) based on a synthesis of 7827 past studies. Consequently, the present results can be considered educationally meaningful.

Teachers' responses revealed that they perceived improvement in the same aspects of the learning environment (i.e., more investigative and open-ended in nature) as did the students. Both groups perceived the computerized learning environment to be inquiry-oriented and open-ended in nature. However, the teachers recognized the potential and value of the database for overcoming the lack of inquiry learning in high school science classrooms and, therefore, they perceived the classroom environment to be more open-ended and more organized than did the students. They perceived positive changes on the Investigation and Open-ended scales (of approximately 0.9 and 0.7 standard deviations, respectively). The teachers in this study realized the opportunities for the students to develop inquiry skills, although each teacher utilized the opportunities differently.

The change to more inquiry-oriented learning environments indicates that to a large extent the program achieved its objectives of providing opportunities to be engaged in inquiry skills. Furthermore, another aspect of the evaluation (Maor 1991), revealed that, after five months of interaction with the computerized database, an improvement of 0.5 standard deviations occurred in students' inquiry skills.

The contributions of the students, the computerized database, and the teacher's role in the development of inquiry skills was investigated further during an interpretive component of the study involving classroom observations and interviews with teachers and students (Maor 1991). The major outcomes from this part of the study suggested that interaction with a computerized database provides students with enhanced opportunities to develop inquiry skills such as interpreting graphs, constructing hypotheses and testing their viability, and generating creative

questions. In addition, teacher epistemology was found to influence the nature of student development on inquiry skills and higher-level thinking skills (Maor and Taylor 1995).

Overall, the different aspects of the study provided complementary insights into learning in a context which was designed to emphasize an inquiry approach in a computerized learning environment.

One of the study's distinctive features is that it involved the development and validation of a new instrument for assessing students' and teachers' perceptions of the psychosocial environment of inquiry-based computer classrooms. It is hoped that this widely applicable instrument will be used to replicate many of the successful lines of past classrooms environment research, including evaluations of the use of computers to enhance inquiry learning.

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Appendix A: Computer Classroom Environment Inventory (CCEI) Student questionnaire

DIRECTIONS

- This questionnaire asks you to describe this classroom which you are in right now. There are no right or wrong answers. This is just a test. Your opinion is what is wanted.
For example:
- On the next few pages you find 30 sentences. For each sentence, circle one number corresponding to your answer.
For example:

Never	Seldom	Some-times	Often	Very Often
1	2	3	4	5

The work in this class is easy

- If you think that the work never is easy, circle the 1.
- If you think that the work very often is easy, circle the 5.
- Or you can choose the number 2, 3 or 4 if this seems like a more accurate answer.

- If you want to change your answer, cross it out and circle a new number.
- Please provide details in the box below.

a. Student's Name: _____	b. School: _____
c. Grade/Level: _____	d. Subject: _____
e. Sex (please circle): Male or Female _____	f. Teacher's Name: _____

- Now turn the page and please give an answer for every question.

Learning Environment Inventory (LEI)

The initial development and validation of a preliminary version of the LEI began in the late 1960s in conjunction with the evaluation and research related to Harvard Project Physics (Fraser, Anderson & Walberg 1982; Walberg & Anderson 1968). The final version contains a total of 105 statements (or seven per scale) descriptive of typical school classes. The respondent expresses degree of agreement or disagreement with each statement using the four response alternatives of Strongly Disagree, Disagree, Agree and Strongly Agree. The scoring direction (or polarity) is reversed for some items. A typical item in the Cohesiveness scale is: 'All students know each other very well' and in the Speed scale is: 'The pace of the class is rushed'.

Classroom Environment Scale (CES)

The CES was developed by Rudolf Moos at Stanford University (Fisher & Fraser 1983c; Moos 1979; Moos & Trickett 1987) and grew out of a comprehensive program of research involving perceptual measures of a variety of human environments including psychiatric hospitals, prisons, university residences and work milieus (Moos 1974). The final published version contains nine scales with 10 items of True-False response format in each scale. Published materials include a test manual, a questionnaire, an answer sheet and a transparent hand scoring key. Typical items in the CES are: 'The teacher takes a personal interest in the students' (Teacher Support) and 'There is a clear set of rules for students to follow' (Rule Clarity).

Individualised Classroom Environment Questionnaire (ICEQ)

The ICEQ assesses those dimensions which distinguish individualised classrooms from conventional ones. The initial development of the ICEQ (Rentoul & Fraser 1979) was guided by: the literature on individualised open and inquiry-based education; extensive interviewing of teachers and secondary school students; and reactions to draft versions sought from selected experts, teachers and junior high school students. The final published version of the ICEQ (Fraser 1990) contains 50 items altogether, with an equal number of items belonging to each of the five scales. Each item is responded to on a five-point scale with the alternatives of Almost Never, Seldom, Sometimes, Often and Very Often. The scoring direction is reversed for many of the items. Typical items are: 'The teacher considers students' feelings' (Personalisation) and 'Different students use different books, equipment and materials' (Differentiation). The published version has a progressive copyright arrangement which gives permission to purchasers to make an unlimited number of copies of the questionnaires and response sheets.

My Class Inventory (MCI)

The LEI has been simplified to form the MCI for use among children aged 8–12 years (Fisher & Fraser 1981; Fraser, Anderson & Walberg 1982; Fraser & O'Brien 1985). Although the MCI was developed originally for use at the primary school level, it also has been found to be very useful with students in the junior high school, especially those who might experience reading difficulties with other instruments. The MCI differs from the LEI in four important ways. First, in order to minimise fatigue among younger children, the MCI contains only five of the LEI's original 15 scales. Second, item wording has been simplified to enhance readability. Third, the LEI's four-point response format has been reduced to a two-point (Yes-No) response format. Fourth, students answer on the questionnaire itself instead of on a separate response sheet to avoid errors in transferring responses from one place to another. The final form of the MCI contains 38 items altogether, with typical items being: 'Children are always fighting with each other' (Friction) and 'Children seem to like the class' (Satisfaction). Although the MCI traditionally has been used with a Yes-No response format, Goh, Young and Fraser (1995) have successfully used a three-point response format (Seldom, Sometimes and Most of the Time) with a modified version of the MCI which includes a Task Orientation scale.

College and University Classroom Environment Inventory (CUCEI)

Although some notable prior work has focused on the institutional-level or school-level environment in colleges and universities (e.g., Halpin & Croft 1963; Stern 1970), surprisingly little work has been done in higher education classrooms which is parallel to the traditions of classroom environment research at the secondary and primary school levels. Consequently, the CUCEI was developed for use in small classes (say up to 30 students) sometimes referred to as 'seminars' (Fraser & Treagust 1986; Fraser, Treagust & Dennis 1986). The final form of the CUCEI contains seven seven-item scales. Each item has four responses (Strongly Agree, Agree, Disagree, Strongly Disagree) and the polarity is reversed for approximately half of the items. Typical items are: 'Activities in this class are clearly and carefully planned' (Task Orientation) and 'Teaching approaches allow students to proceed at their own pace' (Individualisation).

Questionnaire on Teacher Interaction (QTI)

Research which originated in The Netherlands focuses on the nature and quality of interpersonal relationships between teachers and students (Créton, Hermans & Wubbels 1990; Wubbels, Brekelmans & Hooymaners 1991; Wubbels & Levy 1993). Drawing upon a theoretical model of proximity (cooperation-opposition) and influence (dominance-submission), the QTI was developed to assess student

	Never	Seldom	Some- times	Often	Very Often
1. In these computer sessions, I find out the answers to questions by investigation.	1	2	3	4	5
2. I am able to pursue my own interests in this computer class.	1	2	3	4	5
3. I find that the computer sessions are well organized.	1	2	3	4	5
4. I find the computer programs to be user friendly.	1	2	3	4	5
5. After this class, I feel satisfied.	1	2	3	4	5
6. In this class, I carry out computer investigations to test my ideas.	1	2	3	4	5
7. In this computer class, I'm encouraged to design my own ways of solving the problems.	1	2	3	4	5
8. At the beginning of the computer sessions, I begin work without delay.	1	2	3	4	5
9. The computers are in good working condition.	1	2	3	4	5
10. In this class learning to use the computer is not enjoyable.	1	2	3	4	5
11. I use computer investigations to answer questions.	1	2	3	4	5
12. I am not allowed to make up any of my own projects in this class.	1	2	3	4	5
13. I am confused about what to do during these computer sessions.	1	2	3	4	5
14. The computers are not suitable for running the programs I use.	1	2	3	4	5
15. I am not happy with what is done in this computer class.	1	2	3	4	5

	Never	Seldom	Some- times	Often	Very Often
16. I am asked to think about the data which supports my conclusions.	1	2	3	4	5
17. There is opportunity for me to collect different data and use different approaches for the same problem in this class.	1	2	3	4	5
18. There are times when I have to wait for the teacher to help me.	1	2	3	4	5
19. There are not enough computers for me to use.	1	2	3	4	5
20. The work with computers is boring in this class.	1	2	3	4	5
21. I carry out computer investigations to answer questions coming from new information.	1	2	3	4	5
22. In this class, I can go beyond the regular instruction and do some problems on my own.	1	2	3	4	5
23. My work in this computer class is interrupted by students who have nothing to do.	1	2	3	4	5
24. The computer programs enable me to make effective use of the computer.	1	2	3	4	5
25. The work with computers in this class is enjoyable.	1	2	3	4	5
26. In this class, there is opportunity for me to carry out computer investigations to answer questions which puzzle me.	1	2	3	4	5
27. In this class, the teacher decides the best way for me to proceed with my work.	1	2	3	4	5
28. The activities in this computer session are carefully planned.	1	2	3	4	5
29. The computer programs run for me without problems.	1	2	3	4	5
30. The computer classes are a waste of time.	1	2	3	4	5

Newby, M., & Fisher, D.L.:

An instrument for assessing the learning environment of a computer laboratory

Newby, M., & Fisher, D.L. (1997). An instrument for assessing the learning environment of a computer laboratory. *Journal of Educational Computing Research*, 16 (2), 179-190.

Word Processing for Technical Writers

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AN INSTRUMENT FOR ASSESSING THE LEARNING ENVIRONMENT OF A COMPUTER LABORATORY

MICHAEL NEWBY
DARRELL FISHER

Curtin University of Technology, Australia

ABSTRACT

Computers have been used in higher education for over thirty years both as a subject of study and as a tool to assist in the learning process within other disciplines. In that time, computer laboratory classes have played a major role in the teaching of computing subjects. Despite the perceived importance of laboratory classes little research has been done on computer laboratory environments and their effect upon learning. This article describes two instruments. One was designed to assess students' perceptions of various aspects of their computer laboratory environments and the other to measure attitudes toward computers and computing courses. These instruments were used to determine associations between laboratory environment and student attitudes.

INTRODUCTION

International research efforts involving the conceptualization, assessment, and investigation of perceptions of psychosocial aspects of learning environments have firmly established classroom environment as a thriving field of study [1, 2]. In the past twenty-five years, much attention has been given to the development and use of instruments to assess qualities of the classroom learning environment from the perspective of the student [1-3]. The association between learning environment variables and student outcomes has provided a rationale and focus for the application of these learning environment instruments. Haertel, Walberg, and Haertel carried out a meta-analysis which encompassed 823 classes in eight subject areas and represented the perceptions of 17,805 students in four nations [4]. They found that student achievement was enhanced in those classes which students felt had greater cohesiveness, satisfaction and goal direction, and less disorganization and friction. Other literature reviews since then have supported

the existence of associations between classroom environment variables and student outcomes [2].

Recent classroom environment research has focused on science laboratory classroom environments [5], constructivist classroom environments [6], personal perspectives of classroom environments [7], and cultural effects on classroom environments [8]. There have been studies of computer-based environments but these have tended to be in high school classrooms where computers have been used as an aid to learning [9-11]. This study describes the adaptation of an instrument so that it can be used to assess the learning environment of a computing laboratory in higher education. The article gives results arising from an initial use of the instrument in an investigation of associations between students' perceptions of aspects of their computing laboratory environment and student attitudinal outcomes.

COMPUTING LABORATORIES

Computing has been a subject of academic study since the mid 1960s. Initially it was taught in courses with titles such as Computer Science, Computer Studies, or Electronic Data Processing. Computer Science has established itself firmly as a discipline in most universities and in such courses the emphasis is on the study of computer systems themselves. The other terms mentioned have, in general, been replaced by Business Computing or Information Systems, which is now emerging as a discipline in its own right. Courses under these titles concentrate on the application of computers to business problems. In addition, many universities offer programs in Software Engineering and Computer Engineering. All the courses mentioned involve the study of programming as the means by which computer based systems are developed. The advent of the microcomputer in the 1980s led to a much greater use of computer technology within all aspects of business, education, and the community at large. This in turn led to the inclusion of some form of computer education in most disciplines. The one aspect that most computing courses have in common is the use of computer laboratories. This aspect is understandable given that programming is perceived as a skill which cannot be learned by simply reading a book and needs practice in order for it to be acquired [12]. The joint ACM-IEEE Curriculum Task Force recommended that introductory computer science courses should be supported by extensive laboratory work [13, 14]. More recently the ACM SIGCSE Working Group on Computing Laboratories published guidelines for the use of laboratories in Computer Science education [15]. Their report was predicated on a number of assumptions, one of which was that laboratory experiences are relevant in most Computer Science courses across all levels. It discusses a number of topics in detail, and these include the relationship between lecture and laboratory, teacher interaction, and the use of technology. Currently, there is a great interest in the use of closed laboratories in courses [16, 17], as opposed to open laboratories which

seem to be the traditional way of providing students with practical experience. As far as the technology is concerned, it has been recognized that some software is extremely complex [15]. This applies particularly to commercial software, and it often means that the learning curve for its use is too extensive for such software to be included in a single course [18]. This difficulty, together with the high cost of commercial software, makes the provision of realistic laboratory assignments problematic. In some cases, this situation is exacerbated by an unrealistic use of software. For example, in a laboratory class where students access a multi-user system, there may be as many as thirty students performing similar tasks using the same software whereas in a practical (commercial) environment there would be only two or three at any one time. In the student environment, this may lead to poor performance with slow response time, giving the impression that the software is inadequate, an attitude that may remain with students after they graduate.

Despite the apparent importance of laboratories to computing courses and the impact it can have on students' attitudes, the authors have found no reference to quantitative studies of computer laboratory environments in this context. This contrasts with the research that has been carried out over the past twenty years into learning environments in general [1], and science laboratory environments [5] in particular.

CLASSROOM ENVIRONMENTS

Most of the early research studies into classroom environments [19] were quantitative in nature, and led to the development of a number of instruments. One of the first of these instruments was used during an evaluation of Harvard Project Physics which required the development of a questionnaire to assess learning environments in physics classrooms. This instrument was the *Learning Environment Inventory* which asked students for their perceptions of the whole-class environment [20]. At about the same time, Trickett and Moos had been developing a series of environment measures that was included in *Classroom Environment Scale* (CES), which also asked students for their perceptions of the learning environment [21]. These two questionnaires provided considerable impetus for the study of classroom learning environments, were used extensively for a variety of research purposes, and provided models for the development of a range of instruments over the next two decades or so [2]. The most widely used instruments other than the Learning Environment Inventory and Classroom Environment Scale are the *Individualized Classroom Environment Questionnaire* [22], *My Class Inventory* [23], *College and University Classroom Environment Inventory* [24], and the *Science Laboratory Environment Inventory* [5]. Two instruments have been developed for use in high school classrooms with computer-assisted learning, the *Geography Classroom Environment Inventory* [11] and the *Computer Classroom Environment Inventory* [10]. Both of these

instruments were used to investigate computer laboratory environments in which the computer was used as a tool to assist learning in another discipline.

There have been many studies involving classroom environments and course outcomes and these have demonstrated a relationship between the nature of the classroom environment and both cognitive and affective outcomes [4]. These outcomes include achievement, satisfaction, attitude to a discipline, understanding of a subject and many others [3].

Computer Laboratory Environment Inventory (CLEI)

Following an examination of a number of existing instruments the researchers concluded that an instrument for assessing computer laboratory environment could be based on the Science Laboratory Environment Inventory (SLEI) designed by Fraser, Giddings, and McRobbie [5]. The initial development of the SLEI was guided by the following criteria. A review of the literature was undertaken to identify dimensions that were considered important in the unique environment of the science laboratory class. Guidance in identifying dimensions also was obtained by examining all scales contained in existing classroom environment instruments for non-laboratory settings [2]. By interviewing numerous science teachers and students at the senior high school level and asking them to comment on draft versions of sets of items, an attempt was made to ensure that the SLEI's dimensions and individual items were considered salient by teachers and students. In order to achieve economy in terms of the time needed for answering and scoring, the SLEI was designed to have a relatively small number of scales, each containing a fairly small number of items.

A set of items was written and was subjected to several successive revisions based on reactions solicited from people with expertise in questionnaire construction and science teaching at the senior high school level. Item and factor analysis yielded a thirty-five-item form of the instrument which has five scales, Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment, using seven items per scale.

Of the scales from the SLEI, all except Rule Clarity were viewed as being relevant to computer laboratories. The nature of a computer laboratory class is such that rules are concerned with acceptable behavior and acceptable use rather than with safety issues which are important in science laboratories. The Material Environment dimension of SLEI covers the physical laboratory environment and clearly this could be an aspect of a computer laboratory environment.

One dimension of a computer laboratory environment, not covered by the SLEI, is the suitability of the technical facilities which in the case of computer classes means the technology, both hardware and software. This could be ascertained by answers to questions such as, "Is the software suitable for the specified tasks?" and "Is the hardware powerful enough to handle the number of users?" Thus, a new scale, named Technology Adequacy, was designed to assess the

suitability of the technology for the task required. This scale would assist in answering the concerns raised at the end of the previous section regarding students' perceptions of the performance of the hardware and software. It is noteworthy that both the Geography Classroom Environment Inventory [11] and the Computer Classroom Environment Inventory [10] used a single scale for measuring the adequacy of resources, and this incorporated both the physical environment and technology adequacy. In the former instrument it is called Resource Adequacy and in the latter Material Environment. However, the researchers believed that Technology Adequacy and Material Environment are separate scales and both are necessary in an instrument to measure the environment of a computer laboratory. A description of the scales used in the modified version of the instrument is given in Table 1 with a sample item from each scale.

Table 1. Description of CLEI Scales

Scale	Description	Sample Item
Student Cohesiveness	Extent to which students know, help, and are supportive of each other	I get on well with students in this laboratory class (+)
Open-Endedness	Extent to which the laboratory activities encourage an open-ended divergent approach to use of computers	There is opportunity for me to pursue my own computing interests in this laboratory class (+)
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes	The laboratory work is unrelated to the topics that I am studying in my lecture (-)
Technology Adequacy	Extent to which the hardware and software is adequate for the tasks required	The computers are suitable for running the software I am required to use (+)
Material Environment	Extent to which the laboratory is suitable and available for use	I find that the laboratory is crowded when I am using the computer (-)

+Items designated (+) are scored 1, 2, 3, 4, and 5, respectively for responses Almost Never, Seldom, Sometimes, Often, Almost Always.

-Items designated (-) are scored 5, 4, 3, 2, and 1, respectively for responses Almost Never, Seldom, Sometimes, Often, Almost Always.

ATTITUDE TOWARD COMPUTERS

There have been a considerable number of studies of attitudes toward computers, covering determination of factors, development of conceptual models, and empirical studies [25]. These studies have led to the development of various instruments for measuring attitude toward computers. In one of the earliest studies, Lee identified two independent attitudinal dimensions, namely, the belief that computers are beneficial tools and the belief that computers are autonomous entities capable of supplanting individuals [26]. An alternative view was given by Gressard and Loyd who asserted that computer attitudes may be classified into three main types: anxiety or fear of computers, confidence in one's ability to use or learn about computers, and a liking for or enjoyment of computers [27]. Another scale was added to these three by Koochang [28], that of perception of computer usefulness.

The relationship between gender and attitude toward computers has been investigated widely mainly because Computer Science is seen as a male domain and there would appear to be some stereotyping [29, 30]. Indeed, Campbell used an instrument that included stereotyping as one of four scales, the other three being usefulness, effectiveness motivation, and anxiety [31].

In terms of populations, the research contains samples of both high school [32] and university students [33]. At both levels, the main focus has been within those fields where computers are used as a tool, such as education and business [34], and not where they are a field of study in their own right. Similarly, studies involving laboratories have been in those situations where the computer is used as an aid to teaching using Computer Based Learning techniques [35]. None of these studies examined associations between attitude toward computers and computer laboratory environments.

Attitude toward Computers and Computer Courses (ACCC)

For assessing attitude toward computers, an instrument was developed based on the scales Anxiety, Enjoyment, and Perceived Usefulness of Computers. These first two scales were taken from Gressard and Loyd [27], who also included a Confidence scale but differentiating between lack of confidence and anxiety proved difficult so the Confidence scale was omitted. A third scale was adapted from Koochang [28]. A fourth scale was included to measure the student's perception of the usefulness of the course. As with the CLEI, all the scales have seven items and a description of the scales used in the instrument is given in Table 2 together with a sample item from each scale.

METHOD

Both of the instruments, one for assessing the computer laboratory environment and the other for assessing students' attitudes toward computers and

Table 2. Description of ACCC Scales

Scale	Description	Sample Item
Lack of Anxiety	Extent to which the student feels comfortable using a computer	Working with a computer makes me very nervous (-)
Enjoyment	Extent to which the student enjoys using a computer	I enjoy learning on a computer (+)
Usefulness of Computers	Extent to which the student believes computers are useful	Computers are an important factor in the success of a business (+)
Usefulness of Course	Extent to which the student found the course useful	This class provided me with skills I expect to use in the future (+)

+Items designated (+) are scored 1, 2, 3, 4, and 5, respectively for responses Strongly Disagree, Disagree, Not Sure, Agree, Strongly Agree.

-Items designated (-) are scored 5, 4, 3, 2, and 1, respectively for responses Strongly Disagree, Disagree, Not Sure, Agree, Strongly Agree.

computer courses, were administered to students taking courses within the Curtin University Business School at both undergraduate and postgraduate levels. All of these courses involved using a computer to develop information systems. The Computer Laboratory Environment Inventory initially was administered in a pilot run with a class of twenty-six postgraduate students and the results in terms of reliability seemed satisfactory. In order to investigate relationships between the students' perceptions of their computer laboratory environment and their attitudes toward computers and computer courses the CLEI and the ACCC questionnaires were administered to another sample of fifty-four students. In the following section of this article, the results presented for the CLEI are for the combined sample of eighty students. For the ACCC and relationships between the variables assessed by the two questionnaires, the sample is fifty-four students.

RESULTS

Table 3 provides some statistical information about the CLEI when used with a group of eighty students taking a higher educational computing course. The Cronbach alpha reliability measures the internal consistency of the scale and the figures presented in the table show that for the seven-item scales the alpha reliability figures ranged from 0.54 to 0.94 indicating that the scales are

Table 3. Internal Consistency (Cronbach Alpha Coefficient) and Mean Correlation Coefficient of the Scales of the CLEI

Scale	Sample Size	Alpha Reliability	Mean Correlation
Student Cohesiveness	73	0.75	0.06
Open-Endedness	72	0.54	0.14
Integration	74	0.94	0.09
Technology Adequacy	73	0.73	0.22
Material Environment	69	0.70	0.18

satisfactory in terms of their internal consistency. The mean correlation of a scale with the other scales of the questionnaire is accepted as a measure of discriminant validity and is the extent to which the scales are unique in what they are measuring. Table 3 indicates that the mean correlations of the scales of the CLEI ranged from 0.06 to 0.22, indicating that there is little overlap in what they measure. However, it was found that the correlation between Technology Adequacy and Material Environment was significant ($p < 0.01$), and this explained most of the mean correlation for both of these scales. This significant correlation would suggest that there is an overlap between the two scales and further refinement of one of these scales may be necessary. One observation based on the authors' experience with computer laboratories at the higher education level is that students are less concerned with the physical environment and more with access to the computers or terminals.

Table 4 shows some statistical information for the four ACCC scales when the instrument was administered to fifty-four students taking a computing course. The alpha reliabilities ranged from 0.73 to 0.92, and mean correlations between scales ranged from 0.22 to 0.52. The mean correlations indicate there is an overlap in what each of the scales is measuring, although it should be noted that the mean correlation is considerably less than the internal consistency, suggesting that the scales do measure distinct attitudinal aspects.

AN APPLICATION OF THE USE OF THE TWO INSTRUMENTS

Associations between the computer laboratory environment and student attitudes toward computers and their computing class were investigated by examining simple correlations between the scales of the CLEI and the ACCC. Table 5 depicts the results of this application. An examination of the simple correlation figures indicates that there were nine significant relationships, out of twenty possible, between computer laboratory environment variables and student attitude variables.

Table 4. Internal Consistency (Cronbach Alpha Coefficient) and Mean Correlation Coefficient of the Scales of Attitude toward Computers and Computer Courses

Scale	Sample Size	Alpha Reliability	Mean Correlation
Usefulness of course	51	0.73	0.22
Usefulness of computers	51	0.73	0.45
Lack of anxiety	51	0.84	0.38
Enjoyment	47	0.92	0.52

Table 5. Correlation Coefficients between Scales of the CLEI and the ACCC

	Lack of Anxiety	Enjoyment	Usefulness of Computers	Usefulness of Class
Student Cohesiveness	-0.20	-0.29	-0.32*	0.30*
Open-Endedness	0.41**	0.48**	0.31*	0.30*
Integration	0.03	0.35*	0.20	0.27
Technology Adequacy	0.48**	0.27	0.12	0.24
Material Environment	0.22	0.31*	0.15	0.10

* $p < 0.05$

** $p < 0.01$

Open-Endedness correlates with all attitudinal variables, with stronger associations between it and both Lack of Anxiety and Enjoyment. This could imply that less anxious students go beyond given class work and find computers more enjoyable. There is a strong association between Technology Adequacy and Lack of Anxiety, indicating the importance of using hardware and software that are suitable for the required tasks.

Student Cohesiveness correlates negatively with Usefulness of Computers and positively with Usefulness of the Class. One possible interpretation of the former is that those who find computers useful get on with their work and have little need of social interaction in the class. The latter could imply that students find a class more useful if their fellow students are more supportive.

There are associations between Enjoyment and both Integration and Material Environment. These would suggest that students enjoy using computers more in those courses in which the laboratory classes are integrated with the lectures,

where the purpose of the laboratory class is clear and where the laboratories themselves are suitably equipped.

CONCLUSION

This article has described two instruments, which are now available to tertiary educators. One measures the Computer Laboratory Environment (CLEI) for those courses in which the computer is a fundamental tool, and the second measures Attitude to Computers and Computing Courses (ACCC). The scales on the CLEI were shown to be reliable, although it is felt that further refinement of the Technology Adequacy or Material Environment may be desirable. For the ACCC, the four scales were shown to be reliable but had high mean correlations with the other three, indicating a degree of overlap in what was being assessed. Further work with both instruments is required, particularly with larger samples, however researchers could use either instrument in their studies with some confidence.

There are a number of associations between the computer environment scales and the attitudinal scales. One of the most interesting is the strong association between Technology Adequacy and Lack of Anxiety. One interpretation of this is that students will be less anxious with computers provided that the technology being used is suitable in all senses for the laboratory work set for the students. From a teacher's viewpoint, it means that both the hardware and the software capabilities must be taken into account when designing the laboratory component of a course.

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ENGAGING PRESERVICE TEACHERS IN HYPERMEDIA AUTHORING: PROCESS AND OUTCOMES*

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ABSTRACT

This article presents the methods and outcomes of a semester-long course in hypermedia authoring and instructional strategies for preservice teachers. Participants were required to learn a hypermedia authoring program and work in cooperative learning groups to produce a hypermedia software product for use with children with special needs. Data were collected from process logs; semi-structured, open-ended interviews; questionnaires; and pretest and posttest measures of computer anxiety. During the development of their projects, participants spent nearly an equal amount of time planning their software as they did in the mechanics of producing the software. Posttest findings revealed that participants showed a decrease in computer anxiety through their involvement in the course, and the lowest levels of anxiety were associated with graduate rank and prior teaching experience. Following the course, participants expressed confidence in their abilities to author hypermedia software and an interest in future involvement in hypermedia authoring as teachers.

With technology playing an increasing role in present-day classrooms, teachers are now expected to go beyond traditional applications of computer-assisted instruction (CAI) and use technology for teaching in new and different ways [1]. With new, easy-to-learn and easy-to-use authoring programs, teachers have recently become involved in learning to-author software as a means of creating

*Portions of this work were presented at the Annual Meeting of the Council for Exceptional Children-Teacher Education Division (TIED), Washington, D.C., November 8, 1996; and the Annual Meeting of the Council for Exceptional Children-Technology and Media Conference (TAM), San Jose, California, February 14, 1997.

perceptions of eight behaviour aspects. Each item has a five-point response scale ranging from Never to Always. Typical items are 'She/he gives us a lot of free time' (Student Responsibility and Freedom behaviour) and 'She/he gets angry' (Admonishing behaviour).

Although research with the QTI began at the senior high school level in The Netherlands, cross-validation and comparative work has been completed at various grade levels in the USA (Wubbels & Levy 1993), Australia (Fisher, Henderson & Fraser 1995), Singapore (Goh & Fraser 1996) and Brunei (Riah, Fraser & Rickards 1997), and a more economical 48-item version has been developed and validated (Goh & Fraser 1996). Also, Cresswell and Fisher (1997) modified the QTI to form the *Principal Interaction Questionnaire* (PIQ) which assesses teachers' or principals' perceptions of the same eight dimensions of a principal's interaction with teachers. Further information about research involving the QTI can be found in Wubbels and Brekelmans (1997) and Wubbels and Brekelmans' chapter in this *Handbook*.

Science Laboratory Environment Inventory (SLEI)

Because of the critical importance and uniqueness of laboratory settings in science education, an instrument specifically suited to assessing the environment of science laboratory classes at the senior high school or higher education levels was developed (Fraser, Giddings & McRobbie 1995; Fraser & McRobbie 1995; Fraser, McRobbie & Giddings 1993). The SLEI has five scales (each with seven items) and the five response alternatives are Almost Never, Seldom, Sometimes, Often and Very Often. Typical items are 'I use the theory from my regular science class sessions during laboratory activities' (Integration) and 'We know the results that we are supposed to get before we commence a laboratory activity' (Open-Endedness). The Open-Endedness scale was included because of the importance of open-ended laboratory activities often claimed in the literature (e.g., Hodson 1988). The SLEI was field tested and validated simultaneously with a sample of over 5,447 students in 269 classes in six different countries (the USA, Canada, England, Israel, Australia and Nigeria), and cross-validated with 1,594 Australian students in 92 classes (Fraser & McRobbie 1995), 489 senior high school biology students in Australia (Fisher, Henderson & Fraser 1997) and 1,592 grade 10 chemistry students in Singapore (Wong & Fraser 1995).

Constructivist Learning Environment Survey (CLES)

According to the constructivist view, meaningful learning is a cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed, and this sense-making process involves active negotiation and consensus building. The CLES (Taylor, Dawson & Fraser 1995; Taylor, Fraser & Fisher 1997) was developed to assist researchers and teachers to

assess the degree to which a particular classroom's environment is consistent with a constructivist epistemology, and to assist teachers to reflect on their epistemological assumptions and reshape their teaching practice. Appendix A contains a complete copy of the CLES's 'actual' form (see a later section for a clarification of the distinction between 'actual' and 'preferred' forms). Recent studies that have used the CLES include Dryden and Fraser (1996) and Roth and Roychoudhury (1994).

What Is Happening In This Class (WHIC) Questionnaire

The WHIC questionnaire brings parsimony to the field of learning environment by combining modified versions of the most salient scales from a wide range of existing questionnaires with additional scales that accommodate contemporary educational concerns (e.g., equity and constructivism). Also, the WHIC has a separate Class form (which assesses a student's perceptions of the class as a whole) and Personal form (which assesses a student's personal perceptions of his or her role in a classroom), as discussed in detail later in this chapter.

The original 90-item nine-scale version was refined by both statistical analysis of data from 355 junior high school science students, and extensive interviewing of students about their views of their classroom environments in general, the wording and salience of individual items and their questionnaire responses (Fraser, Fisher & McRobbie 1996). Only 54 items in seven scales survived these procedures, although this set of items was expanded to 80 items in eight scales for the field testing of the second version of the WHIC, which involved junior high school science classes in Australia and Taiwan. Whereas the Australian sample of 1,081 students in 50 classes responded to the original English version, a Taiwanese sample of 1,879 students in 50 classes responded to a Chinese version that had undergone careful procedures of translation and back translation (Huang & Fraser 1997). This led to a final form of the WHIC containing the seven eight-item scales. The WHIC has been used successfully in its original form or in modified form in studies involving 250 adult learners in Singapore (Khoo & Fraser 1997) and 2,310 high school students in Singapore (Chionh & Fraser 1998).

Other Instruments

Many studies have drawn on scales and items in existing questionnaires to develop modified instruments which better suit particular research purposes and research contexts. For a study of the classroom environment of Catholic schools, Dorman, Fraser and McRobbie (1997) developed a 66-item instrument which drew on the CES, CUCI and ICEQ but made important modifications. The seven scales in this study (Student Application, Interactions, Cooperation, Task Orientation, Order and Organisation, Individualisation and Teacher Control) were validated using a sample of 2,211 grade 9 and 12 students in 104 classes.

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The Computer Laboratory Environment Inventory

The Computer Laboratory Environment Inventory (CLEI) consists of questions 1-35 and measures the students' perceptions of their computer laboratory environment on five scales:

Scale	Description	Questions
Student Cohesiveness	Extent to which students know, help, and are supportive of each other	1,6(-),11,16,21,26(-),31
Open-Endedness	Extent to which the laboratory activities emphasise an open-ended, divergent approach to experimentation	2,7,12,17,22,27(-),32
Integration	Extent to which the laboratory activities are integrated with non-laboratory and theory classes	3(-),8(-),13,18,23(-),28,33(-)
Technology Adequacy	Extent to which the hardware and software is adequate for the tasks required	4(-),9,14,19,24,29,34
Availability	Extent to which the laboratory is suitable and available for use	5(-),10,15(-),20,25,30(-),35

The Attitude towards Computers and Computer Courses Questionnaire

The Attitude towards Computers and Computer Courses Questionnaire (ACCC) consists of questions 36-63 and measure the students' attitudes on four scales:

Scale	Description	Questions
Usefulness of Course	Extent to which the student found the course useful	36(-),40,44,48(-),52(-),56,60
Anxiety	Extent to which the student feels nervous or uncomfortable using a computer	37(-),41(-),45,49,53(-),57,61
Usefulness of Computers	Extent to which the student believes computers are useful	38(-), 42,46,50,54,58,62
Enjoyment	Extent to which the student enjoys using a computer	39,43,47,51(-),55,59,63(-)

The questions marked (-) are scored negatively.

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		Almost Never	Seldom	Sometimes	Often	Almost Always
1	I get on well with students in this laboratory class.	1	2	3	4	5
2	There is opportunity for me to pursue my own computing interests in this laboratory class.	1	2	3	4	5
3	What I do in the lecture is unrelated to my laboratory work.	1	2	3	4	5
4	The computer software is difficult to use.	1	2	3	4	5
5	I find that the laboratory is crowded when I am using the computer.	1	2	3	4	5
6	I have little chance to get to know other students in this laboratory class.	1	2	3	4	5
7	In this laboratory class, I am required to design my own solutions to a given problem.	1	2	3	4	5
8	The laboratory work is unrelated to the topics that I am studying in my lecture.	1	2	3	4	5
9	The computer software runs without any problems.	1	2	3	4	5
10	The laboratory room is readily available.	1	2	3	4	5
11	Members of this laboratory class help me.	1	2	3	4	5
12	In my laboratory sessions, other students produce different solutions than I do for the same problem.	1	2	3	4	5
13	My lecture material is integrated with laboratory activities.	1	2	3	4	5
14	The computers are powerful enough to cope with the demands	1	2	3	4	5
15	Outside my normal laboratory classes, I have to wait if I want to use a terminal or a computer.	1	2	3	4	5
16	I get to know students in this laboratory class well.	1	2	3	4	5
17	I am encouraged to go beyond the regular laboratory exercise and do some investigations of my own.	1	2	3	4	5
18	I use the theory from my lecture sessions during laboratory activities.	1	2	3	4	5
19	The computer software available enables students to make good use of the computer	1	2	3	4	5
20	I can gain access to the laboratory outside my normal classes	1	2	3	4	5
21	I am able to depend on other students for help during laboratory classes.	1	2	3	4	5
22	In my laboratory sessions, I solve different problems than some of the other students.	1	2	3	4	5
23	The topics covered in lectures are quite different from topics with which I deal in laboratory sessions.	1	2	3	4	5
24	The computers are in good working condition	1	2	3	4	5
25	There is enough free laboratory time during the week for me to complete all my laboratory work comfortably.	1	2	3	4	5
26	It takes me a long time to get to know everybody by his/her first name in this laboratory class.	1	2	3	4	5
27	In my laboratory sessions, the instructor decides the best way for me to solve a given problem.	1	2	3	4	5
28	What I do in laboratory sessions helps me to understand the theory covered in lectures.	1	2	3	4	5
29	The computers are suitable for running the software I am required to use	1	2	3	4	5
30	It is difficult for me to find a terminal / computer free when I want to use one.	1	2	3	4	5
31	I work cooperatively in laboratory sessions.	1	2	3	4	5
32	I decide the best way to proceed when developing a solution to a problem given in the laboratory class	1	2	3	4	5
33	My laboratory work and lecture material are unrelated.	1	2	3	4	5
34	When I make a mistake, the computer software behaves satisfactorily (i.e. the computer does not 'hang')	1	2	3	4	5
35	There are enough computers / terminals for students to use	1	2	3	4	5

		Strongly Disagree	Disagree	Not Sure	Strongly Agree	Strongly Agree
36	I do not think I will ever use what I learned in this class	1	2	3	4	5
37	I feel comfortable when a conversation turns to computers	1	2	3	4	5
38	Studying about computers is a waste of time	1	2	3	4	5
39	It is fun to find out how computer systems work	1	2	3	4	5
40	This class provided me with skills I expect to use in the future	1	2	3	4	5
41	I feel at ease when I am around computers	1	2	3	4	5
42	My future career will require a knowledge of computers	1	2	3	4	5
43	I enjoy using a computer	1	2	3	4	5
44	This class has increased my technical skills	1	2	3	4	5
45	Working with a computer makes me very nervous.	1	2	3	4	5
46	I cannot imagine getting a job that does not involve using computers	1	2	3	4	5
47	I think working with computers would be enjoyable and stimulating	1	2	3	4	5
48	I gained few useful skills from this class	1	2	3	4	5
49	I get a sinking feeling when I think about trying to use a computer	1	2	3	4	5
50	Computers are an important factor in the success of a business.	1	2	3	4	5
51	The challenge of solving problems using a computer does not appeal to me	1	2	3	4	5
52	The skills gained in this class are too specific to be generally useful in the future	1	2	3	4	5
53	Computers make me feel uncomfortable.	1	2	3	4	5
54	The use of computers will increase in my discipline in the future	1	2	3	4	5
55	I would like to work with computers.	1	2	3	4	5
56	This class helped develop my problem-solving skills	1	2	3	4	5
57	Computers make me feel uneasy and confused.	1	2	3	4	5
58	All university students need a course about using computers	1	2	3	4	5
59	I enjoy learning on a computer	1	2	3	4	5
60	As a result of this class I feel confident about tackling unfamiliar problems involving computers	1	2	3	4	5
61	I feel aggressive and hostile towards computers	1	2	3	4	5
62	Knowledge of the use of computers will help me get a job	1	2	3	4	5
63	Learning about computers is boring	1	2	3	4	5

Fisher, D.L., Rickards, T., & Fraser, B.J.:

Assessing teacher-student interpersonal relationships in science classes

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Assessing teacher-student interpersonal relationships in science classes

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Abstract

This article describes a convenient questionnaire designed to allow science teachers to assess teacher-student interpersonal relationships in their classrooms. The article discusses the various forms of the *Questionnaire of Teacher Interaction (QTI)*, and reports its use in past research. The article also describes how science teachers can and have used the questionnaire to assess perceptions of their own teacher-student interpersonal behaviour and used this as a basis for reflecting on and guiding systematic attempts to improve their own teaching and thus providing a basis for teaching practice.

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and Director of the National Key Centre for School Science and Mathematics. His research centres on student and teacher perceptions of the psychosocial learning environment and he has authored a number of books on this topic.



Most science teachers believe that good relationships with their students are important. But are the students' perceptions of teacher-student interpersonal behaviour the same as their teachers? Is there a difference in science teachers' perceptions of their actual teacher-student interpersonal behaviour in the classroom and what they perceive to be ideal?

The purposes of this article are to outline a convenient questionnaire designed to assess teacher-student interpersonal behaviour and to report its use in answering such questions as these. The article describes various forms of the *Questionnaire on Teacher Interaction (QTI)* and reports its use in past research. Finally, the article describes how science teachers have used the questionnaire to assess perceptions of their own teacher-student interpersonal behaviour and used this as a basis for reflecting on their own teaching.

The questionnaire on teacher interaction

International research efforts involving the conceptualisation, assessment and investigation of perceptions of psychosocial aspects of the classroom environment have firmly established classroom environment as a thriving field of study (Fraser, 1994; Fraser & Walberg, 1991).

Recently, a team of researchers in The Netherlands extended this research by focusing specifically on the interpersonal relationships between teachers and their students as assessed by the QTI (Wubbels, Cr  ton & Hoomayers, 1992; Wubbels & Levy, 1993). The Dutch researchers (Wubbels, Cr  ton & Holvast, 1988) investigated teacher behaviour in a classroom from a systems perspective, adapting a theory on communications processes developed by Watzlawick, Beavin and Jackson (1967). Within the systems perspective of

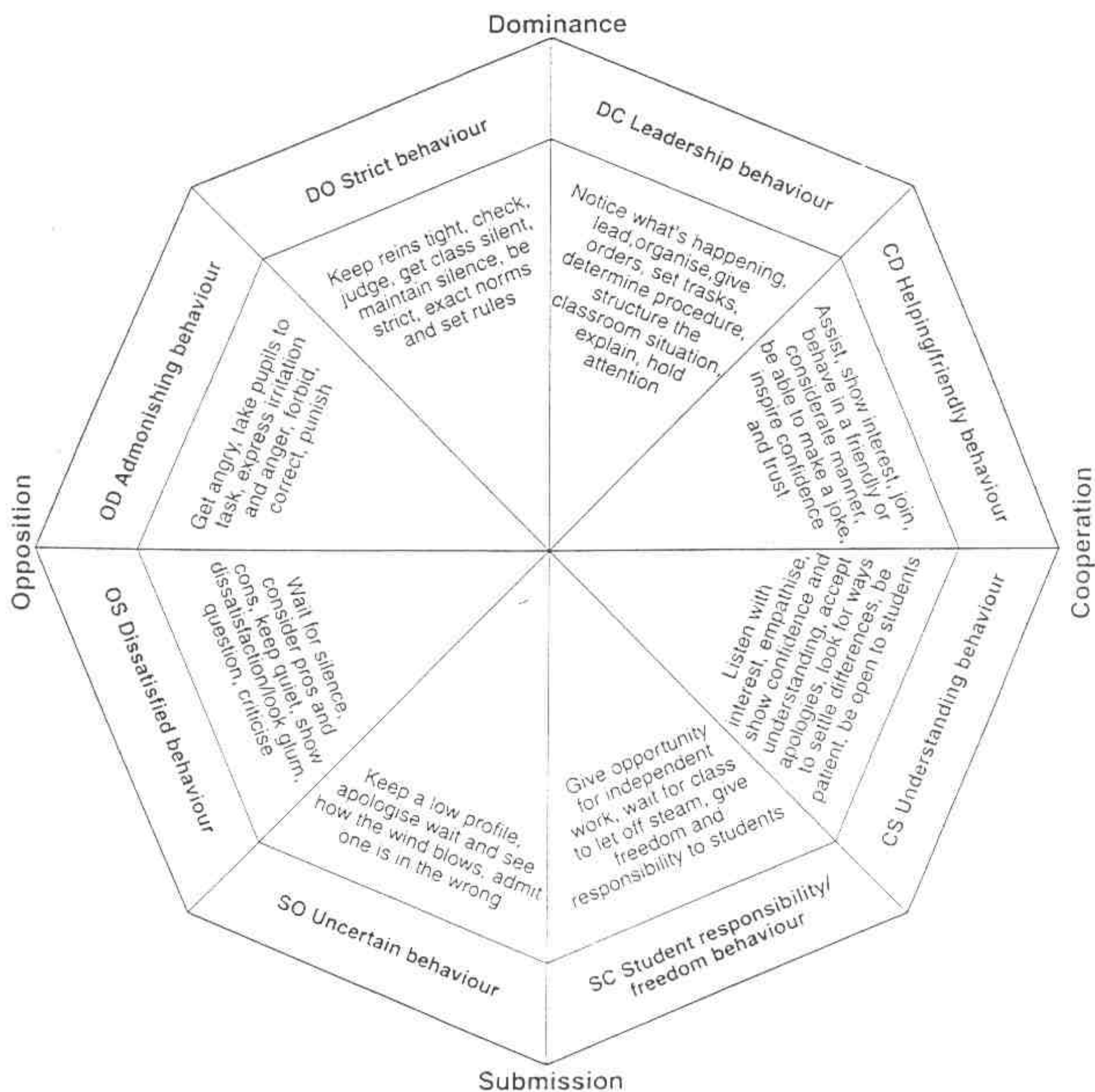


Figure 1. The model for interpersonal teacher behaviour.

communication, it is assumed that the behaviours of participants mutually influence each other. The behaviour of the teacher is influenced by the behaviour of the students and in turn influences the student behaviour. Thus, a circular communication process develops which not only consists of behaviour, but determines behaviour as well.

With the systems perspective in mind, Wubbels, Créton and Hooymayers (1985) developed a model to map interpersonal teacher behaviour using an adaptation of the work of Leary (1957). In the adaptation of the Leary model, teacher behaviour is mapped with a Proximity dimension (Cooperation, C - Opposition, O) and an Influence dimension (Dominance, D - Submission, S) to form eight sectors, each describing different behaviour aspects: Leadership, Helpful/Friendly, Understanding, Student Responsibility and Freedom, Uncertain, Dissatisfied, Admonishing and Strict behaviour. Figure 1 shows typical behaviours for each sector. The Questionnaire on Teacher Interaction (QTI) is based on this model.

The items of the QTI belong to eight scales, each consisting of six items and corresponding to one of the eight sections in the model. Examples of items are 'This teacher is friendly' (Helping/Friendly), 'This teacher is patient' (Understanding), 'This teacher thinks that we can't do things well' (Dissatisfied) and 'This teacher gets angry unexpectedly' (Admonishing). The scores for each item within the same sector are added to obtain a total scale score. The higher the scale score the more a teacher shows behaviours from that sector. Scale scores can be obtained for individual

students, or can be combined to form the mean of all students in a class. The higher the scale score, the more prominent is the behaviour. These values can then be plotted on sector profile diagrams (see Figure 2) to reveal diagrammatically the degree to which students perceive each behaviour of the model is exhibited by the teacher.

An Australian version of the QTI

The original version of the QTI developed in the early 1980s in The Netherlands had 77 items (Wubbels, Créton, & Hooymayers, 1985). The Australian version of the QTI described in this article, is more economical and has 48 items which are answered using a five-point response scale. This version of the QTI is available from the authors for use by science teachers to gather their own perceptions and the perceptions of their students about their science classrooms.

One advantage of the QTI is that it can be used to obtain either students' or teachers' perceptions of interpersonal behaviour. When the QTI is administered to both science teachers and their students, information is provided about the perceptions of teachers and the perceptions of their students of the interpersonal behaviour of that teacher. The information obtained by means of the questionnaire includes perceptions of the behaviour of the teacher towards the students as a class, and reflects relatively stable patterns of behaviour over a considerable period. Similarly, teachers can be asked for their perceptions of their own behaviour or the behaviour that they consider to be ideal. The wording of the questionnaire is varied slightly when used to obtain teachers' self-perceptions

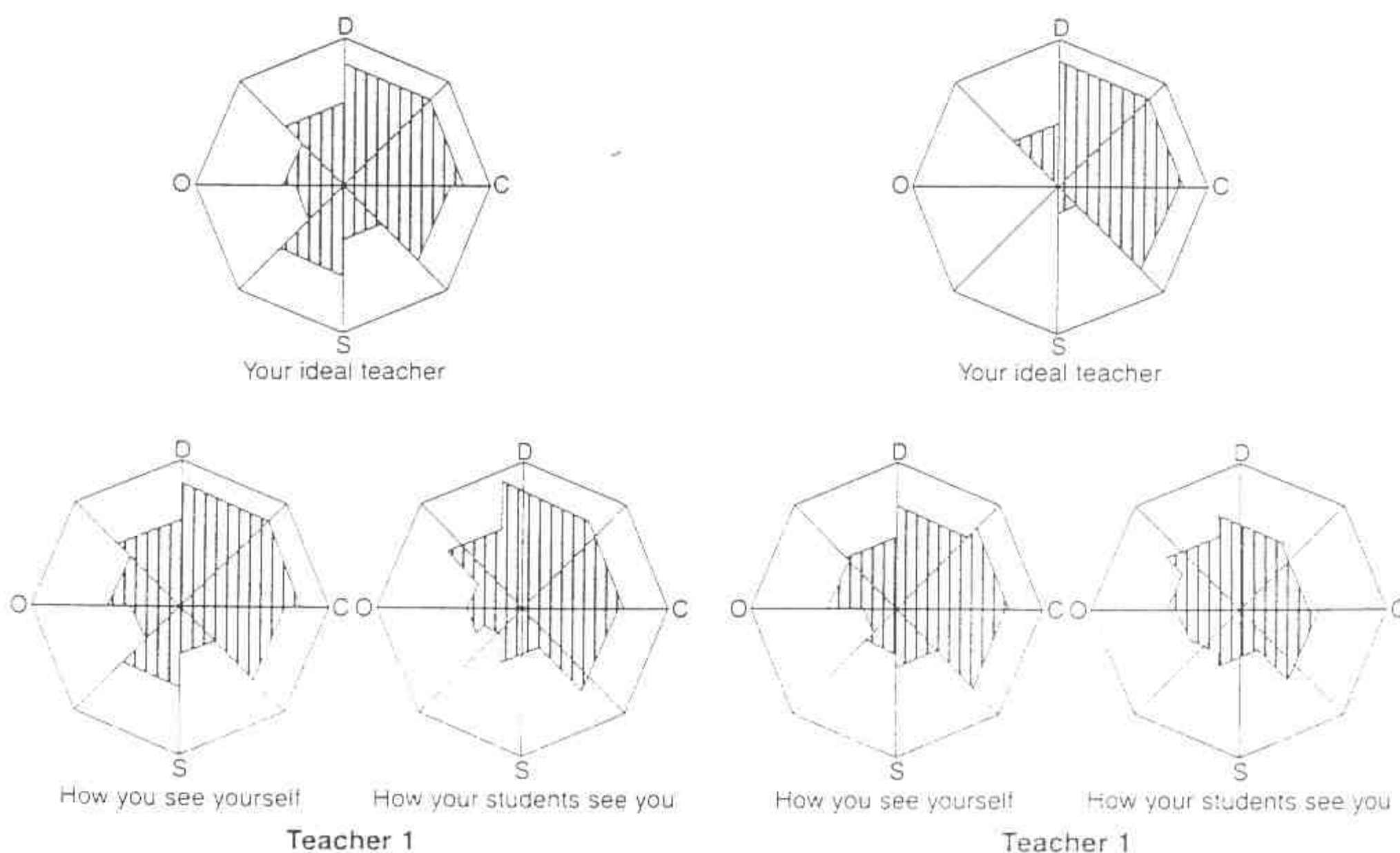


Figure 2. Sector profile of two science teachers.

and ideals. For example the question "This teacher talks enthusiastically about his/her subject", becomes "I talk enthusiastically about my subject" in the teacher self-perception version, and "This teacher would talk enthusiastically about his/her subject" in the teacher ideal version. These latter two versions are also available from the authors.

By using these three separate forms of the QTI it is possible to collect data on students' perceptions of teacher-student interpersonal behaviour, teachers' perceptions of their actual teacher-student interpersonal behaviour in the classroom, and what they perceive to be ideal? These three sets of data can be represented graphically for ease of analysis by participants. For example, Figure 2 depicts the information that was provided to two science teachers and visually indicates differences between the teachers' self-perceptions, perceptions of an ideal teacher and how they are perceived by their students.

Past uses of the QTI

The QTI has been shown to be a valid and reliable instrument when used in The Netherlands (Wubbels & Levy, 1993). When the 64-item USA version of the QTI was used with 1,606 students and 66 teachers in the USA, the cross-cultural validity and usefulness of the QTI were confirmed. Using the Cronbach alpha coefficient, Wubbels and Levy (1991) reported acceptable internal consistency reliabilities for the QTI scales ranging from 0.76 to 0.84 for student responses and from 0.74 to 0.84 for teacher responses.

Wubbels (1993) used the QTI with a sample of 792 students and 46 teachers in Western Australia and Tasmania. The results of this study were similar to previous Dutch and American research in that, generally, teachers did not reach their ideal and differed from the best teachers as perceived by students. It is noteworthy that the best teachers, according to students, are stronger leaders, more friendly and understanding, and less uncertain, dissatisfied and admonishing than teachers on average.

When teachers described their perceptions of their own behaviours, they tended to see it a little more favourably than did their students. On average, the teachers' perceptions were between the students' perceptions of actual behaviour and the teachers' ideal behaviour. An interpretation of this is that teachers think that they behave closer to their ideal than their students think that they do.

Another use of the QTI in The Netherlands involved investigation of relationships between perceptions on the QTI scales and student learning outcomes (Wubbels, Brekelmans & Hooyman, 1991). Regarding students' cognitive outcomes, the more that teachers demonstrated strict, leadership and helpful/friendly behaviour, then the higher were cognitive outcomes scores. Conversely, student responsibility and freedom, uncertain and dissatisfied behaviours were related negatively to achievement.

Variations in the students' attitudes toward the subject and the lessons have been characterised on the basis of the proximity dimension: the more cooperative the behaviour

displayed, the higher the affective outcome scores (Wubbels, Brekelmans & Hooyman, 1991). That is, student responsibility and freedom, understanding, helpful/friendly and leadership behaviours were related positively to student attitudes. Uncertain, dissatisfied, admonishing and strict behaviours were related negatively to student attitudes. Overall, previous studies have indicated that interpersonal teacher behaviour is an important aspect of the learning environment and that it is related strongly to student outcomes.

Levy, Créton and Wubbels (1993) analysed data from studies in The Netherlands, the USA and Australia involving students being asked to use the QTI to rate their best and worst teachers. Students rated their best teachers as being strong leaders and as friendly and understanding. The characteristics of the worst teachers were that they were more admonishing and dissatisfied.

Australian applications of the QTI

In one of the first uses of the QTI in Australia (Fisher, Fraser & Wubbels, 1993), associations were investigated between teachers' perceptions of their work environment, using the *School Level Environment Questionnaire (SLEQ)*, and students' and teachers' perceptions of their classroom interactions (Fisher & Fraser, 1990). Results from this study indicated that relationships between SLEQ and QTI scores generally were weak, thus suggesting that teachers believed that they had considerable freedom to shape their own classrooms, regardless of their school environment.

Recently, a team of researchers in Australia completed the first use of the 48 item QTI in senior biology classes with a sample of 489 students in 28 biology classes (Fisher, Henderson & Fraser, 1995). Although past studies have examined associations between student perceptions of the learning environment in science classes and student outcomes, this Australian study was unique in that it examined student outcomes in three distinct areas: student attitude, achievement in a written examination, and performance on practical tests.

This study confirmed the validity and reliability of the QTI when used in senior secondary biology classes. The alpha reliability figures for the different QTI scales ranged from 0.63 to 0.83 when the individual student was used as the unit of analysis and from 0.74 to 0.95 when the class mean was used (Fisher, Henderson & Fraser, 1995).

Generally, the dimensions of the QTI were found to be associated significantly with student attitude scores. In particular, students' attitude scores were higher in classrooms in which students perceived greater leadership, helpful/friendly, and understanding in their teachers' interpersonal behaviours. Conversely, students' attitude scores were lower in classrooms in which students perceived greater uncertainty, dissatisfaction, admonishing, and strictness in their teachers' interpersonal behaviours. It was concluded that, if biology teachers want to promote favourable student attitudes in their class and laboratory work, they should ensure the presence of these interpersonal behaviours.

Because a limited number of classroom environment instruments have a reading level suitable for the primary school level, Sinclair and Fraser (1997) developed a questionnaire based on the MCI and WIHIC for use in teachers' action research attempts to improve their primary classroom environments in an urban school district. The instrument has the four scales of Cooperation, Teacher Empathy/Equity, Task Orientation and Involvement, and it was validated with a sample of 745 students in 43 grade 6-8 classes.

In evaluations of computer-assisted learning, Maor and Fraser (1996) and Teh and Fraser (1994, 1995b) drew on existing scales in developing specific-purpose instruments. Maor and Fraser developed a five-scale classroom environment instrument (assessing Investigation, Open-Endedness, Organisation, Material Environment and Satisfaction) based on the LEL, ICEQ and SLEI and validated it with a sample of 120 grade 11 students in Australia. Teh and Fraser developed a four-scale instrument to assess Gender Equity, Investigation, Innovation and Resource Adequacy, and validated it among 671 high school geography students in Singapore.

In the first learning environment study worldwide specifically in agricultural science classes, Idris and Fraser (1997) selected and adapted scales from CLES and ICEQ in developing a five-scale instrument to assess Negotiation, Autonomy, Student Centredness, Investigation and Differentiation. This instrument was validated with a sample of 1,175 students in 50 high school agricultural science classes in eight States of Nigeria.

Influenced partly by the CES, Wong (1993) developed a questionnaire to assess the actual and preferred environment of classes in Hong Kong along the dimensions of Enjoyable, Order, Involvement, Achievement Orientation, Teacher Led, Teacher Involvement, Teacher Support and Collaborativeness.

Whereas most classroom environment instruments focus on general psychosocial characteristics, Woods and Fraser (1995) developed a questionnaire to assess student perceptions of specific teacher behaviours. The *Classroom Interaction Patterns Questionnaire* (CIPQ) assesses teaching style with the scales of Praise and Encouragement, Open Questioning, Lecture and Direction, Individual Work, Discipline and Management, and Group Work. Successive versions were field tested with a total of 1,470 grade 8-10 students in 62 classes in Western Australia.

Based partly on existing instruments, Fisher and Waldrup (1997) developed a questionnaire to assess culturally sensitive factors of learning environments. The 40-item *Cultural Learning Environment Questionnaire* (CLEQ) assesses students' perceptions of Equity, Collaboration, Risk Involvement, Competition, Teacher Authority, Modeling, Congruence and Communication. Administration of the new questionnaire to 3,031 secondary science students in 135 classes in Australia provided support for the internal consistency reliability and factorial validity of the CLEQ.

Jegede, Fraser and Fisher (1995) developed the *Distance and Open Learning Environment Scale* (DOLES) for use among university students studying by distance education. The DOLES has the five core scales of Student Cohesiveness,

Teacher Support, Personal Involvement and Flexibility, Task Orientation and Material Environment, and Home Environment, as well as the two optional scales of Study Centre Environment and Information Technology Resources. Administration of the DOLES to 660 university students provided support for its internal consistency reliability and factor structure.

IMPORTANT DEVELOPMENTS WITH LEARNING ENVIRONMENT INSTRUMENTS

Preferred Forms of Scales

A distinctive feature of most of the instruments in Table 1 is that they have, not only a form to measure perceptions of 'actual' or experienced classroom environment, but also another form to measure perceptions of 'preferred' or ideal classroom environment. The preferred forms are concerned with goals and value orientations and measure perceptions of the classroom environment ideally liked or preferred. Although item wording is similar for actual and preferred forms, slightly different instructions for answering each are used. For example, an item in the actual form such as 'There is a clear set of rules for students to follow' would be changed in the preferred form to 'There would be a clear set of rules for students to follow'.

Short Forms of ICEQ, MCI and CES

Although the long forms of classroom environment instruments have been used successfully for a variety of purposes, some researchers and teachers have reported that they would like instruments to take less time to administer and score. Consequently, short forms of the ICEQ, MCI and CES were developed (Fraser 1982a; Fraser & Fisher 1983a) to satisfy three main criteria. First, the total number of items in each instrument was reduced to approximately 25 to provide greater economy in testing and scoring time. Second, the short forms were designed to be amenable to easy hand scoring. Third, although long forms of instruments might be needed to provide adequate reliability for the assessment of the perceptions of individual students, short forms are likely to have adequate reliability for the many applications which involve averaging the perceptions of students within a class to obtain class means. The development of the short form was based largely on the results of several item analyses performed on data obtained by administering the long forms of each instrument to a large sample. The short form of the ICEQ and the MCI each consist of 25 items divided equally among the five scales comprising the long form. Because the long form of the CES consisted of 90 items, this was reduced to a short version with 24 items divided equally among six of the original nine scales.

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Combining quantitative and qualitative approaches in studying classroom
climate in Taiwan and Australia

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A Cross-National Study of Classroom Environments
in Taiwan and Australia



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Science Teaching (NARST), Boston, March, 1999.*

Abstract

This research is distinctive in that it not only provides an example of one of the few cross-national studies in science education, but also it used multiple methodologies from different paradigms in exploring the nature of classroom learning environments in Taiwan and Australia. When English and Mandarin versions of a questionnaire assessing student perceptions of seven dimensions of the classroom learning environment were administered to 50 classes in each country, data analysis supported the reliability and factorial validity of the questionnaire, and revealed differences between Taiwanese and Australian classroom environments. These data provided a starting point from which other methods (such as observations, interviews and narrative stories) were used to gain a more in-depth understanding of the classroom environments in each country. Among the findings, the study suggested the danger of 'imposed etic' when using a questionnaire developed in a Western country to measure classroom environments in an Eastern country, and exposed the role of a researcher's bias and assumptions during a cross-cultural study.

1.0 Introduction and Significance

As the 21st century approaches, there is a need not only for a larger pool of talented, well-educated leaders to fill science-related positions in government and industry, but also for all citizens to be scientifically literate in order to lead rewarding and successful lives. At a time when so much is expected of science education, however, it has been found to be wanting. Judging by the hundreds of reports on the state of science education during the 1880s and 1990s (Hurd, 1994), there is a great need for reform. Enrolment numbers in physical science courses at the high school level have remained low or dropped and show marked gender imbalances. There is a serious worldwide shortage of secondary physical science teachers, and many current teachers are disenchanted and would like to leave the profession (Lokan, Ford & Greenwood, 1996). International comparisons reveal that the relative science achievement of Western school students has fallen behind that of many Asian countries (TIMSS International Study Centre, 1996). Given the persistence and pervasiveness of the current problems with science education, it is essential that attempts at lasting and widespread reform be built upon a foundation of high-quality, relevant research.

However, while much continues to be achieved in science education research, there is a need for fresh research approaches that might yield greater dividends in terms of understandings that can guide the needed improvements in science education. This paper describes one such research approach which goes beyond the vast majority of past studies in science education that are confined to the researcher's own country and culture and transcends national boundaries in search of new insights.

In a recent presidential address at a NARST annual meeting, Fraser (1966) claimed that educational research which crosses national boundaries offers much promise for generating new insights for at least two reasons. First, there usually is greater variation in variables of interest (e.g. teaching methods, student attitudes) in a sample drawn from multiple countries than from a one-country sample. Second, the taken-for-granted familiar educational practices, beliefs and attitudes in one country can be exposed, made 'strange' and questioned when researchers from two countries collaborate on research involving teaching and learning in two countries. Such research not only provides a researcher with understanding of science education in another country, but also sharpens insights into science education in his or her own country.

Comparative studies of science classroom learning environments in different countries have been limited. For example, to date, there are no studies that compare the classroom learning environments found in Australia with those found in neighboring countries of South East Asia. The present research involved six Australian and seven Taiwanese researchers in working together on a cross-national study of learning environments involving a comparison of classroom learning environments in the two countries, as well as an investigation of factors that influence the learning environment in each country.

However, the present study went beyond most past cross-national research which has been confined to the use of common evaluation instruments across different countries. Our investigation included such a questionnaire survey component, but it also generated richer insights and explanations through the use of qualitative methods which permitted the researchers to 'cross the border' into the culture of another country.

Our study combined multiple research methods as recommended by Denzin and Lincoln (1994) and Tobin and Fraser (1998). Although important initial aims were to validate a learning environment questionnaire for use in two countries and to identify differences between Taiwanese and Australian classroom environments, the interpretive nature of the study led the researchers to explore additional factors which influenced the learning environments in each culture using more culturally sensitive research methods. This paper is organized under the following headings:

- theoretical framework (section 2.0);
- background: field of learning environments (section 3.0);
- research methods (section 4.0);
- analysis of the questionnaire data (section 5.0);
- information gathered using observations and interviews (section 6.0);
- findings related to recognizing and minimizing cultural bias (section 7.0); and
- discussion (section 8.0).

2.0 Theoretical Framework

The present study employed an interpretive framework, drawing on elements of the constructivist (Taylor, 1994; von Glasersfeld, 1987, 1993) and critical theory (Giroux, 1983, 1988) paradigms. The constructivist perspective assumes that there are multiple realities in which the researcher and their subjects create their own understandings (von Glasersfeld, 1987, 1993). From this perspective, our study was emergent in both its design and nature. The critical theory perspective implies that reality is shaped over time by social, political, cultural, ethnic and gender factors (Guba & Lincoln, 1994). Epistemologically, this paradigm assumes that the values of the researcher will influence the inquiry. The present study drew on elements of feminism, which is related to critical theory, that assumes a materialist-realist ontology from which the "real world makes a material difference in terms of race, class and gender" (Denzin & Lincoln, 1994, p. 14).

Each of the views mentioned above challenge the traditional objectivist view that inquiry is a reflection of knowledge of the world. In the case of constructivism, the voice of the inquirer is that of passionate participant (whereby the researcher voices his or her own construction as well as the constructions of other participants) and, in the case of critical theory, is that of 'transformative intellectual' (Giroux, 1988) (whereby the researcher confronts ignorance and develops greater insights into the inquiry).

During a process that involved dialectical tensions and critical reflexivity, the researcher formed new standpoints and assertions, whilst new research questions (some of which subsumed the original ones) were framed and generated. As a truly interpretive study, a sense of the problematic emerged when data presented anomalies and conflicting ideas. Critical events, such as discussions and interviews, led to emergent aims, which reshaped the original research questions.

Research methods evolved as questions emerged as a result of findings (Denzin & Lincoln, 1994) and were guided by the research question, context and the researchers' appreciation of the interplay between hermeneutic and phenomenological understanding. The selection of methodology was drawn from a number of interpretive perspectives, including survey research, hermeneutics, phenomenology, and feminism (Erickson, 1998; Taylor & Dawson, 1998).

The present study examined and explored the learning environments in science classes in Taiwan and Australia. The notion that a distinct classroom environment exists began as early as the 1930s, when Kurt Lewin (1936) recognized that the environment and its interactions with personal characteristics of the individual are determinants of behavior. Following Lewin's work, Murray (1938) proposed a Needs-Press Model in which situational variables in the environment account for a degree of behavioral variance. Stern's (1970) Person-Environment Congruence Theory, based on Murray's Needs-Press Model, proposes that more congruence between personal needs and environmental press leads to enhanced outcomes. Also, following Murray's Needs-Press Model, Getzels and Thelen (1960) put forward a model for the class as a social system that suggests that the interaction of personality needs, expectations and the environment predicts behavior, including student outcomes. Walberg (1981) has proposed a multi-factor psychological theory of educational productivity which holds that students learning is a function of three student aptitude variables (age, ability and motivation), two instructional

variables (quantity and quality) and four psychosocial environments (home, classroom, peer group and mass media).

The work of Lewin and Murray has provided a strong theoretical base which has influenced research into classroom environments. The assessment of perceptions has reflected the work of these pioneers and, more recently, Murray's Needs-Press Model of interaction has been used to identify the situational variables recognized in his model (Anderson & Walberg, 1974; Moos, 1974; Rentoul & Fraser, 1979). In the late 1960s, two instruments were developed which pioneered the use of perceptions to measure the classroom environment. The *Learning Environment Instrument*, developed by Herbert Walberg (Anderson & Walberg, 1968), and the *Classroom Environment Scale*, developed by Rudolf Moos (Moos & Houts, 1968), paved the way for the development of the subsequent instruments described in section 3.1.

During the progress of the present study, the researchers became aware of the importance of examining social and cultural factors that influence the learning environments in each county. Culturally sensitive methods of collecting data, that would take into account that social action is "locally distinct and situationally contingent" (Erickson, 1998, p. 1155), were used to help to develop a clearer picture of such factors.

A critical constructivist perspective (Dawson & Taylor, 1998) brought the researcher to the forefront of the present study. Awareness that there is no such things as objective observations, as they're filtered through lenses clouded by "language, gender, social class, race and ethnicity" (Denzin & Lincoln, 1994, p. 12), led us to examine the influences of cultural hegemony during the course of the study. Through *critical reflection and reflexivity*, a practice advocated by critical theory and feminist theory (Fonow & Cook, 1991), we were involved in a critical awareness of our assumptions, beliefs and actions (or the researchers' voice) during the course of the inquiry.

Interpretation of the data and findings for the present study were drawn from a combination of grounded theory (Strauss & Corbin, 1994) and Denzin's (1994) interpretive interactionism. Guba and Lincoln's (1989) criteria of *trustworthiness* (credibility, transferability, dependability and confirmability), which represent issues concerned with constructivism, and *authenticity* (fairness, ontological authenticity, educative authenticity, catalytic authenticity and tactical authenticity), which overlaps with critical theory, were of concern throughout the study.

3.0 Background: Field of Learning Environments

This section places the present study of science learning environments in Taiwan and Australia into context by providing (1) a historical perspective on past developments in the burgeoning field of learning environments (section 3.1) and (2) a review of the limited number of previous learning environment studies that have been conducted in Eastern countries (section 3.2).

3.1 Historical Perspectives

A milestone in the historical development of the field of learning environments occurred approximately 30 years ago when Herbert Walberg and Rudolf Moos began seminal independent programs of research. Walberg developed the *Learning Environment Inventory* as part of the researcher and evaluation activities of the Harvard Physics Project (Walberg, 1979; Walberg & Anderson, 1968), whereas Moos developed social climate scales for various human environments including the *Classroom Environment Scale* (Moos, 1979; Moos & Tickett, 1987). As noted in the previous section, Walberg's and Moos' pioneering work built on earlier foundations of Lewin (1936) and Murray (1938).

A historical look at the field of learning environments over the past few decades shows that a striking feature is the availability of a variety of economical, valid and widely applicable questionnaires for assessing student perceptions of classroom environments (Fraser, 1998a, 1998b). Few fields in education can boast of the existence of such a rich array of validated and robust instruments which have been used in so many research applications. These instruments include the *Individualised Classroom Environment Questionnaire* for open or individualized settings (Fraser, 1990), the *Science Laboratory Environment Inventory* for laboratory settings (Fraser, Giddings & McRobbie, 1995), the *College and University Classroom Environment Inventory* for higher education classrooms (Fraser &

Treagust, 1986), the *Questionnaire on Teacher Interaction* for assessing the interpersonal relationship between teachers and students (Wubbels & Levy, 1993), and the *Constructivist Learning Environment Survey* for assessing the degree to which a particular classroom environment is consistent with constructivist epistemology (Taylor, Fraser & Fisher, 1997).

Whilst the instruments described above have been used and validated in a number of countries, many of the questionnaires overlap in what they measure and some contain items that might not be pertinent in today's classroom settings. Therefore, in the present study, the new *What is Happening in this Class?* (WIHIC) questionnaire was used to collect data (Fraser, McRobbie & Fisher, 1996) because it combines scales from past questionnaires with contemporary dimensions to bring parsimony to the field of learning environments.

The field of learning environments is now very well established in science education. One of 10 sections of the 72-chapter *International Handbook of Science Education* (Fraser & Tobin, 1998) is devoted to this topic, as is one of 19 chapters in Gabel's (1994) *Handbook of Research on Science Teaching and Learning*. Learning environments also constitutes a section in Anderson's (1996) *International Encyclopedia of Teaching and Teacher Education* and a basis for numerous entries in Husén and Posthelwaite's (1994) *International Encyclopedia of Education*. Also the recently-initiated *Learning Environments Research: An International Journal* is devoted exclusively to this topic (Fraser, 1998c).

Although the use of questionnaire's has led to many insights in science learning environments through the students' eyes, the field also includes many fine studies that have used qualitative or interpretive methods (Fraser, 1998a), and considerable progress has been made in combining qualitative and quantitative methods in learning environment research (Fraser & Tobin, 1991; Tobin & Fraser, 1998). Examples of studies that highlight the benefits of combining qualitative and quantitative methods in learning environment research include research on exemplary science teachers (Fraser & Tobin, 1989), as study of higher-level learning (Tobin, Kahle & Fraser, 1990), and an interpretive study of a teacher-researcher teaching science in a challenging school setting (Fraser, 1999).

Literature reviews trace the considerable progress in the conceptualization, assessment and investigation of the subtle but important concept of learning environments over the previous quarter of a century (Fraser, 1994, 1998a; Fraser & Walberg, 1991). For example, the varied types of past research on learning environments in science education include (1) investigations of associations between student outcomes and classroom environment (McRobbie & Fraser, 1993; Wong, Young & Fraser, 1997), (2) evaluation of educational innovations and systemic reform (Fraser, Kahle, Scantlebury, 1999; Maor & Fraser, 1996); (3) investigation of differences between student and teacher perceptions of experienced and perceived learning environments (Fisher & Fraser, 1983), (5) studies of changes in learning environments during the transition from elementary to high school (Ferguson & Fraser, 1999), (6) teachers' practical attempts to improve their own classroom environments (Thorp, Burden & Fraser, 1994), and (7) incorporation of educational environment ideas into the work of school psychologists (Burden & Fraser, 1993).

3.2 Past Research in Eastern Countries

Although a recent literature review (Fraser, 1998a) shows that the majority of the classroom environment studies ever undertaken involved Western students, a number of important studies have been carried out in non-Western countries. Early studies established the validity of classroom environment instruments that had been translated into the Indian (Walberg, Singh & Rasher, 1977) and Indonesian (Schibeci, Rideng & Fraser, 1987) languages and replicated associations between student outcomes and classroom environment perceptions. Recently, Asian researchers working in Singapore (Chionh & Fraser, 1998; Goh, Young & Fraser, 1995; Teh & Fraser, 1994; Wong & Fraser, 1996) and Brunei (Riah & Fraser, 1998) have made important contributions to the field of learning environments.

In Singapore, the growing pool of literature related to classroom learning environments across different subjects includes computing (Khoo & Fraser, 1998; Teh & Fraser, 1994), geography (Chionh & Fraser, 1998), mathematics (Goh, Young & Fraser, 1995) and science (Wong & Fraser, 1996; Wong, Young & Fraser, 1997). Also a study from Brunei investigated how the introduction of new curricula has influenced learning environments in high school chemistry classes (Riah & Fraser, 1998). The questionnaires used in these studies were written in English and validated for use in Singapore. Studies

in Singapore (Chionh & Fraser, 1998), Brunei (Riah & Fraser, 1998) and Korea (Kim, Fisher & Fraser, in press) were conducted simultaneously with the present study and, like the present study, used the *What is Happening in this Class* (WIHIC) questionnaire to collect data pertaining to the classroom learning environment. The studies in Singapore and Brunei validated an English version of the WIHIC questionnaire, whilst the study in Korea validated a Korean version of the questionnaire. The findings in each study replicate those of past research, reporting strong associations between the learning environment and student outcomes for almost all scales. Whilst these studies provide useful suggestions to educators regarding classroom environment dimensions that could be changed in order to improve students' outcomes, they do not identify causal factors associated with the classroom environments.

In Hong Kong, qualitative methods involving open-ended questions were used to explore students' perceptions of the learning environment in grade nine classrooms (Wong, 1993, 1996). This study found that many students identified the teacher as the most crucial element in a positive classroom learning environment. These teachers were found to keep order and discipline whilst creating an atmosphere that was not boring or solemn. They also interacted with students in ways that could be considered friendly and showed concern for the students. Also, in Hong Kong, Cheung (1993) used multilevel analysis to determine the effects of the learning environment on students' learning. The findings of this study provide insights that could help to explain why Hong Kong was found to rank highly in physics, chemistry and biology in international comparisons (Keeves, 1992).

The present interpretive study went beyond past research in non-Western countries to involve a multimethod approach that emerged in light of new findings. The study was used not only to replicate previous research, but also to explore causal factors associated with students' perceptions of their learning environment. Furthermore, by drawing on a range of paradigms, past research on learning environments was extended by piecing together a more in-depth understanding of social and cultural influences on the classroom environments created in each country.

4.0 Research Methods

It is widely accepted that the paradigm used will shape the way in which the researcher perceives the world (Feyerabend, 1978; Kuhn, 1962; Lakatos, 1970). In cross-cultural studies, cultural representations are constructed in terms of the researcher's own culture, thus making method and methodology inseparable (van Maanen, 1988).

Comparative studies in education have the luxury of being able to draw their methodology from a range of disciplines, including psychology, sociology, philosophy and anthropology. There is no single scientific method which applies to comparative studies and the choice will invariably depend on the research questions posed (Denzin & Lincoln, 1994). The issue of which paradigm is most appropriate depends largely on the situation and the appropriateness of the measure, although it is widely agreed that multiple methods in comparative research are useful in achieving greater understanding (Keeves & Adams, 1994; Tobin & Fraser, 1998).

4.1 Multiple Research Methods

The present interpretive study drew on multiple methodologies that were combined to help examine and compare science classroom learning environments in Taiwan and Australia from different perspectives. Triangulation was used to secure an in-depth understanding of the learning environment and to provide richness to the whole. The idea of 'grain sizes' (the use of different sized samples for different research questions varying in extensiveness and intensiveness) in learning environment research (Fraser, 1999) has been used effectively in studies that combine different methodologies (Fraser & Tobin, 1991; Tobin & Fraser, 1998), and was used to guide the collection of data for this study.

Initially, a large-scale quantitative probe (involving samples of students in Australia and Taiwan responding to the WIHIC questionnaire and an attitude scale) provided an overview of the learning environments in each country. In the spirit of this interpretive inquiry, the data posed more questions than it answered. A sense of the problematic was developed during observations which reshaped the inquiry towards an examination of socio-cultural influences that might affect what was considered 'a desirable learning environment' in each country. The data collected using the questionnaires were then

used as a springboard for further data collection using different research methods, including interviews with participants, observations and narrative stories.

4.2 Instruments Used to Assess Classroom Environment and Attitudes

The recently-developed *What Is Happening In This Class?* (WIHIC) questionnaire was used to measure students' perceptions of their classroom environment. These data provided an overview of the learning environment in each country and provided as a starting point from which comparisons could be made. The WIHIC was developed by Fraser, McRobbie and Fisher (1996) to bring parsimony to the field of learning environments by combining the most salient scales from existing questionnaires with new dimensions of contemporary relevance to assess the following seven dimensions of the classroom environment:

- *Student Cohesiveness* (extent to which students know, help and are supportive of one another)
- *Teacher Support* (extent to which the teacher helps, befriends, trusts and is interested in students)
- *Involvement* (extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class)
- *Investigation* (emphasis on the skills and processes of inquiry and their use in problem solving and investigation)
- *Task Orientation* (extent to which it is important to complete activities planned and to stay on the subject matter)
- *Cooperation* (extent to which students cooperate rather than compete with one another on learning tasks)
- *Equity* (extent to which students are treated equally by the teacher).

The Appendix contains those items from the WIHIC which survived the factor and item analysis described later in this paper.

In addition, an eight-item scale was used to assess students' satisfaction in terms of enjoyment, interest and how much they look forward to science classes. This was based on a scale from the *Test of Science Related Attitudes* (TOSRA; Fraser, 1981).

The instruments were translated into Chinese by team members based in Taiwan. The next step involved an independent back translation of the Chinese version into English again by other Taiwanese team members who were not involved in the original translation (Brislin, 1970). Then, the Australian researchers checked the back translations and, for some items, this necessitated the modification of the original English version, the Chinese translation, or both. For example, one item in the original English version read "In this class, I am able to depend on other students for help" was changed to enhance the clarity to "In this class, I get help from other students". In other cases, we found that some English words had no direct translation into Mandarin. In these cases, the English version was changed. For example, because the term 'favors' in the original item "I do favors for members of this class" had no direct equivalent, the original English item was changed to "I am friendly to members of this class".

4.3 Sample

The final 70-item version of the WIHIC questionnaire, along with the attitude survey, were administered to a sample of 1081 grade 8 and 9 general science students from 50 classes in 25 schools in Western Australia and 1879 grade 7-9 students from 50 classes in 25 schools in Taiwan. Of the classes sampled in Western Australia, 38 were selected from within the metropolitan area of the capital city, Perth, and the remaining 12 classes were from rural schools. The sample in Taiwan was selected from three areas, northern Taiwan (Taipei), central Taiwan (Changhua) and southern Taiwan (Kaohsiung). In Taiwan, 25 classes were biology classes and 25 were physics classes, and in Australia all 50 classes were general science classes. The samples from both countries were drawn from government, coeducational schools that could be considered typical and representative of science classes in each country.

The data collected using the questionnaires were analyzed to provide information regarding the reliability and validity of the questionnaires in each country, and to inform researchers of the differences and similarities between students' perceptions in each country (see sections 5.1 and 5.3).

4.4 Qualitative Data Generation and Analysis

The data from the questionnaires were used not only to provide a parsimonious and economical view of learning environments in each country, but also as a starting point from which qualitative data were collected using classroom observations, interviews with teachers and students, and narrative stories written by the researchers.

Observations were carried out in the classes of four teachers in each of Australia and Taiwan. The selection of these teachers was based on their willingness to be involved in the study. Narrative stories, in keeping with Denzin and Lincoln's (1994) fifth moment, were used to portray archetypes of science classrooms in each country. Stories were used to represent a way of knowing and thinking (Carter, 1993; Casey, 1995), making use of the researchers' images, understandings and interpretations of the learning environments in each country. The stories were used with their interpretations and subsequent commentaries to provide a second layer of representation (Geelan, 1997).

At least three students from each of the eight classes were interviewed, based initially on student responses to selected questionnaire items. Analysis of these interviews invariably raised more in-depth questions related to the learning environment and cultural aspects that were unclear. Observations were also the source of many student interview questions about various actions that had taken place and students' views of the classroom environment. The analysis of each interview invariably raised more questions which were asked in proceeding interviews.

The teachers of the eight classes were also interviewed to seek their reasons for various actions and whether the classroom environments created by different teachers were influenced by socio-cultural factors. As with the students, we found ourselves returning to ask more questions in our attempt to piece together our understanding of the learning environments in each country.

The cross-cultural nature of the present study led to a multimethod approach to allow triangulation of the methods and crossvalidation of the data. The data collected using the different methodologies complemented each other and together they formed a more complete and coherent picture of the learning environments in each country (Denzin & Lincoln, 1994). The results are presented in three sections: analysis of the questionnaire data (section 5.0); information gathered using observations and interviews (section 6.0); and findings related to recognizing and minimizing cultural bias (section 7.0).

5.0 Analysis of the Questionnaire Data

The analysis of the quantitative and qualitative information related to the questionnaires is reported below in terms of statistical validation (section 5.1), differences between scale scores in the two countries (section 5.2), and the cross-cultural viability of the WIHIC questionnaire (section 5.3).

5.1 Statistical Validation of Scales

Data collected from the 50 classes in Taiwan and the 50 classes in Australia were analyzed in various ways to investigate the reliability and validity of the 70-item version of the WIHIC questionnaire in both countries. Principal components factor analysis followed by varimax rotation resulted in the acceptance of a revised version of the instrument comprising 56 items with 8 items in each of the seven scales (see Table 1). The *a priori* factor structure of the final version of the questionnaire was replicated in both countries, with nearly all items having a factor loading of at least 0.40 on their *a priori* scale and no other scale (see the factor loadings reported in Table 1).

Table 1 also reports the internal consistency reliability (Cronbach alpha coefficient) of each of the seven eight-item scales for two units of analysis (individual and class mean). Using the class mean as the unit of analysis, scale reliability estimates ranged from 0.87 to 0.97 in Australia and from 0.90 to 0.96 in Taiwan.