Res Sci Educ (2010) 40:551–571
DOI 10.1007/s11165-009-9133-1

A Cross-National Study of Secondary Science Classroom Environments in Australia and Indonesia

Barry J. Fraser · Jill M. Aldridge · F. S. Gerard Adolphe

Published online: 13 August 2009

Abstract This article reports a cross-national study of classroom environments in Australia and Indonesia. A modified version of the What Is Happening In this Class? (WIHIC) questionnaire was used simultaneously in these two countries to: 1) crossvalidate the modified WIHIC; 2) investigate differences between countries and sexes in perceptions of classroom environment; and 3) investigate associations between students' attitudes to science and their perceptions of classroom environment. The sample consisted of 1,161 students (594 students from 18 classes in Indonesia and 567 students from 18 classes in Australia). Principal components factor analysis with varimax rotation supported the validity of a revised structure for the WIHIC. Two-way MANOVA revealed some differences between countries and between sexes in students' perceptions of their classroom environments. Simple correlation and multiple regression analyses revealed generally positive associations between the classroom environment and student attitudes to science in both countries.

Keywords Attitudes · Classroom environments · Cross-national research · Science education · What Is Happening In this Class? (WIHIC)

Introduction

Educational research that crosses national boundaries offers promise for generating new insights for two main reasons (Brislin 1983; Fraser 1996). First, there is greater variation in variables of interest (e.g. teaching methods and student attitudes) in a sample drawn from

B. J. Fraser · J. M. Aldridge (✉) · F. S. G. Adolphe
Curtin University of Technology, Bentley, WA, Australia
e-mail: J.Aldridge@curtin.edu.au

B. J. Fraser
Science and Mathematics Education Centre (SMEC), Curtin University of Technology, Bentley, WA 6102, Australia
e-mail: b.fraser@curtin.edu.au

multiple countries than from a one-country sample. Second, familiar educational practices, beliefs and attitudes in one country can be exposed and questioned when research involves teaching and learning crosses two countries. Such research not only provides researchers with an understanding of science education in another country, but also sharpens insights into science education in their own country (OECD Programme for International Student Assessment, PISA 2006). Despite this potential value, there appear to be very few past classroom environment studies that were conducted simultaneously in Australia and a neighbouring country in Southeast Asia (Aldridge and Fraser 2000). Therefore, the present study is unique because of its focus on both Australia and Indonesia.

Aims of the Study

1. To crossvalidate modified Indonesian and English versions of the What Is Happening In this Class? (WIHIC) questionnaire among lower-secondary students in Indonesia and Australia.
2. To investigate whether students' perceptions of classroom environment vary with:
   (a) country (Indonesia and Australia)
   (b) sex of the student.
3. To examine the strength of associations between students' attitudes to science and their perceptions of their classroom environment in Indonesia and in Australia.

Background

Field of Learning Environments

This study draws on and extends the field of learning environments. The notion that a distinct classroom environment exists began as early as the 1930s, when Kurt Lewin (1936) recognised that the environment and its interactions with personal characteristics of the individual are determinants of human behaviour. Following Lewin's work, Murray (1938) proposed a needs-press model in which situational variables in the environment account for a degree of behavioural 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 behaviours, including students' outcomes. Walberg (1981) 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 of instruction), and four psychological environments (the home, classroom, peer group and mass media environments).

A milestone in the historical development of the field of learning environments occurred about 40 years ago when Herbert Walberg and Rudolf Moos began their seminal independent programs of research. Walberg developed the Learning Environment Inventory (LEI) as part of the research and evaluation activities of Harvard Physics Project (Walberg 1979; Walberg and Anderson 1968), whereas Moos developed social climate scales for various human environments including the Classroom Environment Scale (Moos 1974; Moos and Trickett 1974).

The field of the learning environment is now well established in science education. One of the 10 sections of the 72-chapter *International Handbook of Science Education* (Fraser and Tobin 1998) is devoted to this topic, as is one of the 39 chapters in Abell and Lederman's (2007) *Handbook of Research on Science Education* (see Fraser 2007). The topic of learning environments also constitutes a section in Anderson's (1995) *International Encyclopaedia of Teaching and Teacher Education* and is a basis for numerous entries in Husen and Postlethwaite's (1994) *International Encyclopaedia of Education.* The subject index of the 2008 Annual Meeting Program of the American Educational Research Association (AERA) includes 122 papers under the topic heading of 'learning environments'. Also *Learning Environments Research: An International Journal* is devoted exclusively to this topic (Fraser 1998c) and a new book series entitled *Advances in Learning Environments Research* has recently been initiated (Aldridge and Fraser 2008).

Although the use of questionnaires has led to important insights into science learning environments through the students' eyes, the field also includes many studies that have used qualitative as well as quantitative data-collection methods. Considerable progress has been made in combining qualitative and quantitative methods in learning environment research (Fraser and Tobin 1991; Tobin and 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 and Tobin 1989); a study of higher-level learning (Tobin et al. 1990); an interpretative study of a teacher-researcher teaching science in a challenging school setting (Fraser 1999); and a cross-cultural study of science classrooms in Taiwan and Australia (Aldridge and Fraser 2000).

Literature reviews trace the considerable progress in the conceptualisation, assessment and investigation of the subtle but important concept of the learning environment over the previous quarter of a century (Fisher and Khine 2006; Fraser 1998a, 2002, 2007; Fraser and Walberg 1991; Khine and Fisher 2003). For example, the varied types of past research on the learning environment in science education include: (1) investigations of associations between student outcomes and the classroom environment (den Brok et al. 2004; Haertel et al. 1981; Wong et al. 1997); (2) evaluation of educational innovations and systemic reform (Martin-Dunlop and Fraser 2008; Scantlebury et al. 2001; Wolf and Fraser 2008); (3) investigation of differences between students' and teachers' perceptions of experienced and perceived learning environments (Fisher and Fraser 1983); (4) studies of changes in learning environments during the transition from primary to high school (Ferguson and Fraser 1999); (5) teachers' practical attempts to improve their own classroom environments (Aldridge et al. 2004; Yarrow and Millwater 1995); (6) incorporation of educational environment ideas into the work of school psychologists (Burden and Fraser 1993; Sink and Spencer 2005) and (7) developing typologies of classroom learning environments (den Brok et al. 2008; Dorman et al. 2006; Telli et al. 2006).

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 1998b, 2007). Of these various questionnaires, the What Is Happening In this Class? (WIHIC) questionnaire is the most widely used instrument around the world today. The WIHIC has exhibited impressive validation characteristics (Dorman in press) and has achieved 'almost bandwagon status' according to Dorman (2003). We selected the WIHIC for our study.

Associations Between Students' Attitudes and the Learning Environment

A strong theme in past classroom learning environment research has involved investigations into associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classroom environments (den Brok et al. 2004; Fraser and Fisher 1982; McRobbie and Fraser 1993). Numerous studies have shown that students' classroom environment perceptions, relative to students' background characteristics, are more closely associated with learning outcomes. For example, the WIHIC has been utilised in investigating associations between the learning environment and students' affective and cognitive outcomes with large samples of students from around the world (Telli et al. 2006; Wong et al. 1997; Zandvliet and Fraser 2004, 2005).

Given that one of the aims of our study was to investigate associations between the learning environment and students' attitudes for both Indonesian and Australian students, literature on students' attitudes to science and their assessment is briefly reviewed here. The concept of attitude, its definition and its measurement have been widely explored in books such as Eiser (1984) and Mueller (1986). According to Mueller (1986), because attitudes cannot be observed or measured directly, their existence must be inferred from their consequences. Given that an attitude is a non-observable psychological construct that can only be deduced from the behaviour manifested, it is not surprising that there is no unanimous agreement amongst social scientists on any given definition for the term attitude. Furthermore, the definition of the term could undergo modification with the passage of time as new light is thrown by attitudes-related research. Reid's (2006) definition of attitudes involves three components, namely, cognitive (knowledge of the object, belief or ideas), affective (feelings regarding the object, such as like or dislike) and behavioural (the tendency towards an action or objective). Other researchers have tended to view these three components more independently and as the basis of 'evaluative judgements', such as when we judge something emotively such as good or bad, like or dislike (Crano and Prislin 2006). Such a definition enables researchers to distinguish attitudes from emotions or behaviours. Kind et al. (2007, p. 873) provide a definition based on these components of attitudes as "the feelings that a person has about an object [evaluative attitudes are always towards something often called an attitude object] based on their beliefs about that object". This definition of attitudes is very similar to what was used in our study.

Over the years, many instruments have been developed to measure attitudes, such as Likert scaling, Thurstone scaling, Guttman scaling and the semantic differential technique. In measuring the attitude of a respondent using the Likert scaling technique, the researcher locates the respondent's position on a continuum ranging from the extreme end of positive to that of negative. Responses to given statements about an attitudinal object on a five-point continuum (e.g., strongly agree, agree, uncertain, disagree and strongly disagree) are tallied.

Kind et al. (2007) drew on the widely-cited work of Munby (1983, 1997) and Osborne et al. (2003) in identifying numerous important, well-known and long-standing problems related to many of the attitude scales developed in the past. Some of these include: the lack of clarity in the descriptions for the constructs to be measured; the combining of conceptually-different constructs to form one unidimensional scale; low reliability of the measurement; and failure to address construct validity.

The widely-used Test of Science-Related Attitudes (TOSRA, Fraser 1981) was selected for use in this study because it overcomes most of the problems addressed by Kind et al. (2007) and Munby (1997). First, the TOSRA clearly defines each of the constructs to be measured by providing distinct subscales based on Klopfer's (1971) classification of

students' attitudinal aims: attitude to science and scientists, attitude to inquiry, adoption of scientific attitudes, enjoyment of science learning experiences, interest in science, and interest in a career in science. These six constructs are clearly defined and each represents a different 'object' about which students are likely to form opinions. Second, the TOSRA does not combine conceptually-different constructs to form one scale. Third, past studies that have used the TOSRA provide strong evidence of psychometric quality in terms of scale reliability. Fourth, each scale of the TOSRA has demonstrated unidimensionality and independence in past studies through factor analysis. When Munby investigated the adequacy of 56 attitude instruments using criteria similar to those described by Kind et al. (2007), he summed up the TOSRA as "an exceptionally well developed scale" (Munby 1983, p. 314). Further, the present study demonstrated the unidemensionality and independence of the three scales selected for use in our research using factor analysis (see Table 1) as recommended by Kind et al. (2007).

Table 1 Factor loadings for the modified TOSRA in Indonesia and Australia

Item No		Factor loadings					
		Normality of scientists		Attitude to scientific inquiry		Career interest in science	
		Indonesia	Australia	Indonesia	Australia	Indonesia	Australia
9		0.45	0.31				
16		0.40	0.50				
23		0.47	0.30				
30		0.57	0.58				
37		0.59	0.38				
44		0.46	0.54				
3				0.55	0.48		
17				0.54	0.51		
31				0.57	0.48		
38				0.54	0.41		
45				0.60	0.61		
52				0.50	0.51		
66				0.45	0.53		
14						0.65	0.51
21						0.46	0.56
28						0.55	0.54
35						0.60	0.42
42						0.51	0.36
56						0.60	0.59
70						0.61	0.70
% Variance		8.44	7.58	10.66	9.61	11.75	11.09
Eigenvalue		1.90	1.84	2.46	2.09	3.85	3.80
Alpha	Indiv.	0.66	0.59	0.75	0.71	0.77	0.74
Reliability	Class	0.64	0.83	0.79	0.85	0.91	0.89

Factor loadings smaller than 0.30 have been omitted.

The sample consisted of 594 students in Indonesia and 567 students in Australia.

The above literature review of the field of learning environments leads to several tentative conclusions. First, because measures of learning outcomes alone cannot provide a complete picture of the educational process, assessments of learning environment should also be used to provide information about subtle but important aspects of classroom life. Second, science educators should strive to create 'productive' learning environments as identified by research. Third, the evaluation of innovations and new curricula should include classroom environment variables to provide economical, valid and reliable process measures of effectiveness. Fourth, teachers should use assessments of their students' perceptions actual and preferred classroom environment to monitor and guide attempts to improve classrooms. Additionally, the above review of literature on the assessment of attitudes to science has not only identified various common shortcomings that need to be avoided when developing or choosing an appropriate questionnaire, but also has established the need to provide evidence for the reliability and empirical independence of each conceptually-distinct scale in a multi-scale attitude instrument.

Methods

The What Is Happening In this Class (WIHIC) questionnaire (Aldridge et al. 1999) was used to measure students' perceptions of their classroom environment. The WIHIC brings parsimony to the field of learning environments by combining the most salient scales from existing questionnaires with new dimensions of contemporary relevance to science education (Aldridge and Fraser 2000). The version of the WIHIC questionnaire used in our study contains eight scales with 10 items in each scale. Table 2 provides a description and sample item for each scale. Each WIHIC item is responded to on a five-point frequency scale with the alternatives of Almost Never, Seldom, Sometimes, Often and Almost Always. The layout of each item is shown below.

	Almost Never	Seldom	Some-times	Often	Almost Always
14. The teacher helps me when I have trouble with the work.	1	2	3	4	5

The choice of the WIHIC for use in our study can be justified partly in terms of its established validity and usefulness in many past studies involving large samples in numerous countries. These include studies in the USA (Ogbuehi and Fraser 2007; Wolf and Fraser 2008), Singapore (Chionh and Fraser 2009; Khoo and Fraser 2008), Turkey (Telli et al. 2006), Korea (Kim et al. 2000) and India (Koul and Fisher 2005). In addition, the WIHIC has exhibited impressive validity characteristics in other cross-national studies in Australia and Canada (Zandvliet and Fraser 2004, 2005) and Australia and Taiwan (Aldridge et al. 1999).

Although the assessment of students' attitudes was not a major focus of the present study, the Test of Science-Related Attitudes (TOSRA) was included to permit investigation of relationships between the learning environment and students' attitudes in the two countries. TOSRA measures seven distinct science-related attitudes among secondary school students: Social Implications of Science; Normality of Scientists; Attitude to Scientific Inquiry; Adoption of Scientific Attitudes; Enjoyment of Science Lessons; Leisure Interest in Science; and Career Interest in Science (Fraser 1978, 1981). Each scale contains

Table 2 Description and sample item for each WIHIC scale

Scale	Scale description The extent to which ...	Sample item
Student Cohesiveness	... students know, help and are supportive of one another	I help other class members who are having trouble with their work.
Teacher Support	... the teacher helps, befriends, trusts and is interested in students	The teacher helps me when I have trouble with the work.
Involvement	... students have attentive interest, participate in discussions, do additional work and enjoy the class	I explain my ideas to other students.
Autonomy/ Independence	... students have to make their own decisions and choose their own modes of learning	I work at my own pace.
Investigation	... mphasis on the skills and processes of inquiry and their use in problem solving and investigation	I find out answers to questions by doing investigations.
Task Orientation	... it is important to complete activities planned and to stay on the subject matter	I know the goals for this class.
Cooperation	... students cooperate rather than compete with one another on learning tasks	Students work with each other in this class.
Equity	... the teacher treats students equally.	I receive the same encouragement from the teacher as other students do.

10 items, making a total of 70 items for the whole instrument. The response scale is a five-point Likert scale and has response categories ranging from Strongly Agree to Strongly Disagree. TOSRA probably is still the most widely-used attitude instrument in science education research today.

Teachers and researchers have found TOSRA useful and easy to use for measuring and monitoring progress of science-related attitudes of individual students or whole classes of students. In particular, TOSRA also makes it possible for researchers and teachers to obtain a 'profile' of attitude scores for a particular group of students. This is a major advantage that TOSRA has over some other science attitude tests which yield only a single overall score rather than a separate score for a number of distinct attitudinal measures. In addition to studies that have examined the validity of the TOSRA (Kalili 1987; Schibeci and McGaw 1981), the TOSRA has been used to evaluate innovations (Lott 2002), to compare the attitudes of different groups of students (White and Richardson 1993; Joyce and Farenga 1999) and to explore associations between the learning environment and students' attitudes (Fraser and Butts 1982; Fraser and Fisher 1982; Wong and Fraser 1996). For the purpose of our study, three of the seven scales were selected as being the most salient: Normality of Scientists, Attitude to Scientific Inquiry and Career Interest in Science.

The WIHIC and TOSRA were translated into Bahasa Indonesian using a rigorous process of back-translation (which involved the translation of the English version into Indonesian and then the back-translation of the Indonesian version into English by an independent party) to ensure that each item retained its original meaning (Brislin 1970). As the WIHIC had been used and validated in Indonesia by Wahyudi and Treagust (2004) and Margianti et al. (2004) in previous studies, a pilot study of limited scope was considered adequate for the present study. This pilot study involved interviewing students in Indonesia

Table 3 Sample size in Australia and Indonesia

Country	City	Schools	Classes	Students		
				Males	Females	Total
Australia	Sydney, New South Wales	4	9	142	136	278
	Perth, Western Australia	4	9	156	133	289
Indonesia	Jakarta, Java	4	9	143	148	291
	Singaraja, Bali	4	9	139	164	303
Total		16	36	580	581	1,161

to establish whether the items had maintained their original meaning and intent, and then making any modifications needed.

The sample for the present study consisted of a total of 1,161 students in 36 Grade 9/10 classes in eight private coeducational schools in each of Australia (four schools in two cities) and in Indonesia (four schools in two cities). In both countries, schools were selected to be as representative as possible, but this was dependent on the willingness of the teachers to be involved. Table 3 shows the distribution of the sampled schools and classes in the two countries, namely, Australia and Indonesia.

Students in both Australia and Indonesia were either 14–15 years of age and had completed a minimum of 2 years of lower-secondary education. Being 14 and 15 years old, students were likely to be able to understand the meaning of the items in the questionnaires and hopefully make logical decisions when completing the questionnaires. At that age, relationships between student and student and between student and teacher are more meaningful and these students start to perceive their classroom environments more like young adults than like children.

In cross-validating the WIHIC in our study, factor and item analyses were conducted. Cronbach's alpha reliability and ANOVA for class membership differences were also used to provide further evidence of scale validity and reliability. A two-way MANOVA was used in exploring differences between countries (Indonesia and Australia) and sexes in terms of students' perceptions of classroom environment. For the investigation of the associations between classroom environment and attitudes, simple correlation analysis and the multiple regression analysis were used.

Findings

Validity and Reliability of WIHIC

Statistical analyses were conducted to examine the internal structure of the 80 items in the version of the WIHIC used in the present study. When principal components factor analysis with varimax rotation was used to generate orthogonal factors for each of the two data sets (Indonesia and Australia), the two scales of Autonomy/Independence and Cooperation were eliminated. The factor analysis finally resulted in the acceptance of a revised version of the instrument comprising 55 items in six scales (see Table 4). After omission of two scales, 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 0.30 on their own scale

Table 4 Factor loadings for the modified WIHIC in Indonesia and Australia

Item No	Factor loadings											
	Student cohesiveness		Teacher support		Involvement		Investigation		Task orientation		Equity	
	Indon	Aust	Indon	Aust	Indon	Aust	Indon	Aust	Indon	Aust	Indon	Aust
1	0.62	0.51										
2	0.45	0.48										
3	0.51	0.55										
4	0.64	0.39										
5	0.51	0.51										
6	0.61	0.70										
7	0.64	0.67										
8	0.48	0.52										
9	0.49	0.49										
10	0.64	0.46										
12			0.46	0.54								
13			0.73	0.62								
14			0.68	0.64								
15			0.61	0.52							0.33	
16			0.70	0.57								
17			0.73	0.64								
18			0.65	0.50								
19			0.39	–								
21					0.71	0.59						
22					0.75	0.68						
24					0.64	0.54						
26				0.31	0.51	0.37						
27		0.32			0.53	0.68						
28	0.39				0.38	0.50						
29					0.44	0.53						
30					0.52	0.49						
41							0.48	0.48				
42							0.65	0.69				
43							0.62	0.55				
44							0.69	0.73				
45							0.60	0.57				
46							0.69	0.74				
47							0.56	0.76				
48							0.42	0.50				
49							0.62	0.78				
50							0.57	0.72				
51									0.46	0.53		
52									0.49	0.43		
53									0.44	0.46	0.32	0.33
54									0.56	0.50		

Table 4 (continued)

Item No	Factor loadings											
	Student cohesiveness		Teacher support		Involvement		Investigation		Task orientation		Equity	
	Indon	Aust	Indon	Aust	Indon	Aust	Indon	Aust	Indon	Aust	Indon	Aust
55									0.54	–		
56									0.63	0.53		
57									0.69	0.58		
58									0.58	0.58		
59									0.61	0.65		
60									0.64	0.60		
71											0.69	0.68
72											0.66	0.58
73											0.70	0.75
74											0.68	0.58
75											0.67	0.73
76											0.75	0.66
77											0.72	0.67
79											0.53	0.36
80											0.63	0.64
% Variance	7.27	6.31	7.38	5.50	5.92	5.73	8.43	8.88	7.76	6.33	9.49	7.94
Eigenvalue	2.22	2.47	2.82	1.88	1.75	1.95	3.98	10.44	3.29	4.21	14.44	4.83

Factor loadings smaller than 0.30 have been omitted.

The sample consisted of 594 students in Indonesia and 567 students in Australia.

and on no other scale (Table 4). The conventionally-accepted minimum value of 0.30 for factor loading to be meaningful was used (Stevens 1992).

The only two cases for which an item's factor loading with its a priori scale was less than 0.30 were Items 19 and 56, both for the Australian sample. Also, there were six cases for which an item had a factor loading of greater than 0.30 on a scale other than its own scale: Item 15 loaded on Equity as well as in its own scale (Teacher Support) for the Indonesian sample; Item 26 loaded on Teacher Support for the Australian sample; Item 27 loaded on Student Cohesiveness for the Australian sample; Item 28 loaded on Student Cohesiveness for the Indonesian sample; and Item 53 loaded on Equity for both the Indonesian and Australian students.

Table 4 shows the factor loadings for the WIHIC questionnaire (six scales) for Indonesia and Australia, using the individual student as the unit of analysis, along with the percentage of variance and eigenvalue for each scale. The percentage of variance for different scales ranged from 5.73% to 9.49% for Indonesian students and from 5.50% to 8.88% for Australian students. The total proportion of variance explained was 46.25% for the Indonesian sample and 40.69% for the Australian sample. The value of the eigenvalue for different scales varied from 1.75 to 14.44 for Indonesian students and from 1.88 to 10.44 for Australian students. Overall Table 4 provides relatively strong support for the factorial validity of both the English-language version of the WIHIC when used in Australia and the Indonesian-language version of the WIHIC when used in Indonesia.

For the revised 55-item version of the WIHIC, three further indices of scale reliability and validity were generated, namely, the Cronbach alpha reliability coefficient (as an index of scale internal consistency), the mean correlation of a scale with the other scales (as a convenient index of discriminant validity), and the ability to differentiate between classrooms. Table 5 shows that the Cronbach alpha reliability coefficients for the six scales, using the individual student as the unit of analysis, were high and ranged from 0.82 to 0.92 for Indonesian students and from 0.78 to 0.89 for Australian students. With the class mean as the unit of analysis, the alpha reliability coefficients were generally higher, ranging from 0.75 to 0.95 for Indonesian students and from 0.88 to 0.97 for Australian students.

Table 5 also shows that the discriminant validity (mean correlation of a scale with other scale), using the individual student as the unit of analysis, ranged from 0.32 to 0.44 for Indonesian students and from 0.23 to 0.36 for Australian students. When using the class mean as the unit of analysis, the discriminant validity ranged from 0.30 to 0.61 for Indonesian students and from 0.46 to 0.70 for Australian students. These results suggest that raw scores on the WIHIC measure distinct, but somewhat overlapping, aspects of classroom environment (although the factor analysis results attest to the independence of factor scores).

The ability for the actual form of each WIHIC scale to differentiate between the perceptions in different classes of students was investigated using a series of analyses of variance (ANOVAs) with class membership as the independent variable. This provides information about the extent to which students within the same class perceive it relatively similarly, while mean class perceptions vary from class to class. Table 5 shows that each WIHIC scale differentiated significantly ($p<0.05$) between classrooms for both Indonesian

Table 5 Internal consistency reliability (Cronbach Alpha Coefficient), discriminant validity (Mean Correlation With Other Scales) and ability to differentiate between classrooms (ANOVA Results) for two units of analysis for the modified WIHIC

Scale	Unit of analysis	Alpha reliability		Mean correlation with other scales		ANOVA Eta^2	
		Indonesia	Australia	Indonesia	Australia	Indonesia	Australia
Student Cohesiveness	Individual	0.82	0.81	0.32	0.23	0.07**	0.11**
	Class Mean	0.88	0.88	0.30	0.46		
Teacher Support	Individual	0.88	0.82	0.44	0.36	0.10**	0.08**
	Class Mean	0.91	0.92	0.56	0.56		
Involvement	Individual	0.85	0.78	0.40	0.32	0.05*	0.05*
	Class Mean	0.75	0.88	0.32	0.57		
Investigation	Individual	0.87	0.89	0.42	0.24	0.14**	0.12**
	Class Mean	0.95	0.94	0.61	0.70		
Task Orientation	Individual	0.87	0.78	0.43	0.31	0.11**	0.08**
	Class Mean	0.83	0.95	0.47	0.65		
Equity	Individual	0.92	0.87	0.44	0.29	0.11**	0.08**
	Class Mean	0.93	0.97	0.49	0.56		

* $p<0.05$

** $p<0.01$

The sample consisted of 594 students in 18 classes in Indonesia and 567 students in 18 classes in Australia. The eta^2 statistic (which is the ratio of 'between' to 'total sums of squares') represents the proportion of variance explained by class membership.

and Australian students. The eta^2 statistic, which represents the proportion of the variance in environment scores accounted for by class membership, ranged from 0.05 to 0.14 for Indonesian students and from 0.05 to 0.12 for Australian students.

The results in Tables 3 and 4 support the contention that the WIHIC questionnaire is valid and reliable for the assessment of students' perceptions of their psychosocial classroom environments in both Indonesia and Australia. Therefore, the present study replicates considerable research which has supported the validity and reliability of the WIHIC in Australia and Taiwan (Aldridge et al. 1999), Singapore (Chionh and Fraser 2009; Khoo and Fraser 2008), Brunei (Riah and Fraser 1998), Turkey (Telli et al. 2006), Canada (Raaflaub and Fraser 2002; Zandvliet and Fraser 2004, 2005), Korea (Kim et al. 2000), India (Koul and Fisher 2005), Indonesia (Margianti et al. 2004; Wahyudi and Treagust 2004) and the USA (Allen and Fraser 2007; Ogbuehi and Fraser 2007; Martin-Dunlop and Fraser 2008; Wolf and Fraser 2008), as well as in a three-country study (Dorman in press).

Validity and Reliability of TOSRA

In this cross-national study of learning environments, the assessment of attitudes to science was only a minor component (included to permit the investigation of associations between learning environment and student attitudes). Nevertheless, given the common problems and past criticisms of attitude questionnaires reviewed above, it was still important, before using TOSRA scores in investigating attitude-environment relationships, to demonstrate the sound validity and reliability of both its Indonesian and English versions. In particular, it was necessary to establish not only that each separate TOSRA scale was individually reliable, but also that conceptually-distinct scales were empirically distinct (through factor analysis) for both the Indonesian and Australian samples. Factor analysis (principal components with varimax rotation) and internal consistency reliability analysis (Cronbach's alpha coefficient) were conducted using the same methods as for the WIHIC. These results are reported briefly in Table 1, which shows that a 20-item three-scale version of the TOSRA accounted for a total of 30.85% of the variance for the Indonesian sample and 28.28% for the Australian sample. Also Table 1 shows that each of the 20 TOSRA items had a factor loading of at least 0.30 on its own scale and less than 0.30 on each of the other two scales.

The bottom of Table 1 shows that alpha reliability for the different TOSRA scales with the student as the unit of analysis ranged from 0.66 to 0.77 for the Indonesian sample and from 0.59 to 0.74 for the Australian sample. With the class as the unit of analysis, the alpha coefficient for different attitude scales ranged from 0.64 to 0.91 for the Indonesian sample and from 0.83 to 0.89 for the Australian sample. Overall, the results reported in Table 1 attest to internal consistency reliability and empirical independence of TOSRA scales for both the Indonesian and Australian versions.

Differences Between Countries and Sexes in Learning Environment

Country and sex differences in classroom environment were explored using a two-way MANOVA with repeated measures for one of the independent variables. The two independent variables were country and sex, with sex forming a repeated-measures factor (as explained below). The set of WIHIC scales formed the dependent variables.

The unit of analysis chosen was the within-class sex subgroup mean. As males and females could have been represented in disproportionate numbers in the different coeducational classes in our sample, a separate mean for males and a separate mean for females were calculated for each class. Therefore, each class furnished a matched pair of

means (repeated measures), consisting of the males' mean and the females' mean, for each scale.

Given that MANOVA yielded statistically significant results overall for the set of dependent variables using Wilks' lambda criterion, univariate two-way ANOVAs were examined and interpreted for each individual WIHIC scale. Table 6 shows the *F* ratio obtained for each dependent variable for country, sex and the country-by-sex interaction.

Differences between Australian and Indonesian Learning Environments

Given that the number of items in each WIHIC scale differs, the average item mean, or scale total divided by the number of items in that scale, was used to provide a meaningful comparison between scales. Table 7 reports the average item and average item standard deviation for each classroom environment scale for Australia and Indonesia. In order to estimate the magnitude of the differences between countries (in addition to their statistical significance), effect sizes (the difference between two means divided by the pooled standard deviation) were calculated as recommended by Thompson (1998a, b). The effect sizes in Table 7 show the magnitudes of the differences between countries expressed in standard deviation units. Table 7 also repeats the ANOVA results from Table 6 to show the statistical significance of differences between countries for each scale.

Table 7 reveals that, for some scales (Involvement and Investigation), Indonesian students perceived their learning environments significantly more positively than did Australian students. However, for some other scales (Task Orientation and Equity), Australian students had significantly more positive perceptions of their classroom environment than their Indonesian counterparts. Table 7 also shows that the effect size for six scales of the WIHIC questionnaire ranged between 0.12 and 0.69. According to criteria recommended by Cohen (1988), these effect sizes are modest for all WIHIC scales, except for Investigation and Task Orientation for which effect sizes suggest a fairly substantial difference between countries of around two-thirds of a standard deviation.

Table 6 Two-way ANOVA results (*F* Ratio and Eta^2 Statistic) for country and sex differences for WIHIC scales

Scale	ANOVA Results					
	Country		Sex		Country x Sex	
	F	Eta^2	F	Eta^2	F	Eta^2
Student Cohesiveness	0.58	0.03	20.00**	0.54	15.35**	0.48
Teacher Support	0.15	0.01	1.08	0.06	0.99	0.06
Involvement	5.95*	0.26	0.22	0.01	0.89	0.05
Investigation	64.39**	0.79	0.23	0.01	1.19	0.07
Task Orientation	62.50**	0.79	0.38	0.02	0.39	0.02
Equity	7.65*	0.31	8.67**	0.34	0.06	0.00

*$p < 0.05$

**$p < 0.01$

The sample consisted of 18 matched pairs of within-class sex means in Indonesia and another 18 matched pairs of within-class sex means in Australia.

Table 7 Average item mean, average item standard deviation, and difference between Indonesian and Australian students (Effect Size and ANOVA Results) for WIHIC scales

Scale	Average item mean		Average standard deviation		Difference	
	Indonesia	Australia	Indonesia	Australia	Effect size	*F*
Student Cohesiveness	3.74	3.81	0.64	0.52	0.12	0.58
Teacher Support	3.05	2.93	0.87	0.61	0.16	0.15
Involvement	2.95	2.85	0.76	0.66	0.14	5.95*
Investigation	3.01	2.51	0.72	0.72	0.69	64.39**
Task Orientation	3.33	3.74	0.72	0.57	0.64	62.50**
Equity	3.51	3.61	0.88	0.72	0.13	7.65*

* $p<0.05$

** $p<0.01$

The sample consisted of 594 students in 18 classes in Indonesia and 567 students in 18 classes in Australia.

Differences between Males and Females in Learning Environment Perceptions

Table 8 reports sex differences in the average item mean for scores on each environment scale. *F* ratios from Table 6 are repeated in Table 8 to show the statistical significance of sex differences. Effect sizes are also shown in Table 8. This table shows that female students perceived significantly more Cohesiveness and Equity than did male students. The effect sizes for these two scales were 0.46–0.78, suggesting a fairly substantial difference between the sexes (using Cohen's criteria) for the learning environment scales of Student Cohesiveness and Equity.

Country-by-Sex Interaction Effects

The results in Table 6 also show that a statistically significant country-by-sex interaction emerged for only one learning environment scale, namely, Student Cohesiveness. Therefore, the independent interpretations of country differences and sex differences are

Table 8 Average item mean, average item standard deviation and difference between male and female students (Effect Size and *F* Ratio) for WIHIC scales

Scale	Average item mean		Average standard deviation		Difference	
	Male	Female	Male	Female	Effect size	*F*
Student Cohesiveness	3.69	3.88	0.24	0.25	0.78	20.00**
Teacher Support	2.98	2.92	0.24	0.36	0.20	1.08
Involvement	2.88	2.93	0.20	0.30	0.20	0.22
Investigation	2.73	2.74	0.35	0.39	0.03	0.23
Task Orientation	3.50	3.52	0.32	0.36	0.06	0.38
Equity	3.42	3.57	0.31	0.34	0.46	8.67**

* $p<0.05$

** $p<0.01$

The sample consisted of 594 students in 18 classes in Indonesia and 567 students in 18 classes in Australia.

valid for all scales except this scale. When the eta^2 statistic was calculated to provide an estimate of the strength of association between each effect (country membership, sex and the interaction) for each WIHIC scale, the amount of variance accounted for was found to be 0.48 for the interaction for Student Cohesiveness. Australian females had higher Student Cohesiveness scores than Australian males, but sex differences in Student Cohesiveness were negligible for Indonesian students.

Associations between Learning Environment and Student Attitudes to Science

Associations between students' perceptions of the classroom environment (as assessed by the WIHIC questionnaire) and their attitudes to science (as assessed by the TOSRA) are reported in Table 9. These associations were investigated using the sample of 1,161 students (594 from Indonesia and 567 from Australia), in 18 classes for each of Indonesia and Australia. All analyses were performed separately for the Indonesian sample and the Australian sample. The individual was used as the unit analysis. Simple correlation analyses were used to provide information about the bivariate relationship between each attitude measure and each individual environment scale, whereas multiple regression analyses were used to describe the joint relationship between each attitude measure and the whole set of six environment scales. The multiple regression analyses provide a more parsimonious picture of the joint influence of correlated environment scales on an attitude outcome and they reduce the Type I Error rate associated with the simple correlation analysis. The standardised regression coefficients were used to identify which specific environment scales make a significant contribution to explaining the variance in an attitudinal outcome when the other environment scales are mutually controlled.

With the individual student as the unit of analysis, Table 9 shows that the simple correlation between an environment scale and an attitude scale was statistically significant ($p<0.05$) in 33 out of 36 cases. The only nonsignificant correlations occurred between Attitude to Scientific Inquiry and Equity for the Australian sample and between Career Interest in Science and Student Cohesiveness for both the Indonesian and Australian samples. An inspection of the signs for the significant correlations shows that the attitude-environment relationship was positive in all cases.

Furthermore, Table 9 demonstrates that the multiple correlation (R) between each attitude scale and the set of the environment scales was statistically significant ($p<0.01$) both for Indonesian students and for Australian students. In order to interpret the significant multiple correlations, the standardised regression coefficients were examined. Table 9 shows that the number of significant standardised regression coefficients (β) was six for Indonesian students and four for Australian students ($p<0.05$). Inspection of the signs for the significant standardised regression coefficients in Table 9 shows that the relationship between an attitude scale and an environment scale was positive in each of the ten cases.

In Table 9, the regression coefficients indicate the following 10 statistically significant, positive and independent associations: between Normality of Scientists and Student Cohesiveness, Teacher Support and Equity for the Indonesian sample; between Normality of Scientists and Task Orientation for the Australian sample; between Career Interest in Science and Teacher Support, Involvement, Equity for the Indonesian Sample; and between Career Interest in Science and Teacher Support, Involvement and Investigation for the Australian sample. Overall, the simple correlation and multiple regression analyses reported in Table 9 replicate considerable prior research (Fraser 2002, 2007) that has established links between a positive classroom environment and positive student attitudes. Furthermore,

Table 9 Simple correlation and multiple regression analyses for associations between attitudes and classroom environment using the individual as the unit of analysis

Scale	Normality of scientists				Attitude to scientific inquiry				Career interest in science			
	r		β		*r*		β		*r*		β	
	Indo	Aust	Indo	Aust	Indo	Aust	Indo	Aust	Indo	Aust	Indo	Aust
Student Cohesiveness	0.19**	0.17**	0.09*	0.06	0.10*	0.10*	0.02	0.04	0.01	0.00	0.09	0.07
Teacher Support	0.27**	0.18**	0.15**	0.03	0.16**	0.13**	0.09	0.01	0.27**	0.29**	0.18**	0.20**
Involvement	0.13**	0.19**	−0.01	0.09	0.14**	0.20**	0.06	0.15	0.24**	0.23**	0.15**	0.11*
Investigation	0.09*	0.10*	0.08	−0.02	0.11**	0.12**	0.00	0.06	0.23**	0.28**	0.09	0.16**
Task Orientation	0.32**	0.28**	0.03	0.22**	0.14**	0.11**	0.03	0.07	0.18**	0.20**	−0.03	0.09
Equity	0.19**	0.22**	0.25**	0.04	0.14**	0.06	0.06	−0.04	0.25**	0.15**	0.14**	0.01
Multiple Correlation (*R*)			0.36**	0.33**			0.20**	0.22**			0.37**	0.38**

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

it is noteworthy that the magnitudes of the associations between classroom environment and students attitudes to science are comparable for the Indonesian and Australian samples.

Summary and Conclusions

The present two-country research in Indonesia and Australia is one of the first learning environment studies in Indonesia, as well as one of the first cross-national studies of learning environments involving Australia and an Asian country. Given that our cross-national comparison focused not on relationships between people and their culture, but on relationships between people of different nations (Escotet 1973; Mead 1964), careful interpretation is required given that Indonesia and Australia have very different cultures.

A significant contribution made by the present study was through translating and validating a widely-applicable questionnaire to assess students' perceptions of the learning environments for future use by researchers and teachers in Indonesia. Careful translation (and back translation) into Bahasa Indonesian was undertaken prior to piloting the questionnaire with a range of students to ensure that individual questionnaire items retained their original intent. Modifications were made in light of a pilot study before the administration of the Indonesian version of the questionnaire in the main study. The data were collected from 1,161 students in a total of 36 classes (18 Indonesian classes and 18 Australian classes). All classes were coeducational and the number of boys (584) was slightly higher than the number of girls (577). At the same time, the Test of Science-Related Attitudes (TOSRA) was translated, administered and validated to enable investigation of attitude-environment relationships.

A major aim of the study was to investigate the validity and reliability of the WIHIC for both the Indonesian and Australian samples. First, in order to check the empirical independence of each WIHIC scale, principal components factor analysis with varimax rotation was used in conjunction with discriminant validity analysis. Second, to check whether each item in a scale assesses the same construct, we estimated internal consistency reliability. Finally, to check whether each WIHIC scale was sufficiently sensitive to distinguish between the perceptions of students in different classes, a one-way ANOVA for class membership differences was used. Overall, the results suggest that the WIHIC questionnaire is a valid and reliable instrument that can be used with confidence for the assessment of students' perceptions of their psychosocial classroom environments in both Indonesia and Australia. Although investigating students' attitudes was not a primary goal of the present study, it still was considered important to check the reliability and validity of the TOSRA for both the Indonesian and Australian sample before using it to explore attitude-environment associations. Factor analysis and reliability estimates both supported the internal consistency reliability and independence of each scale of the TOSRA for both Indonesian and Australian samples.

Given the cultural differences between the two countries, one would expect country and sex differences in learning environment perceptions, which we explored using a two-way MANOVA with WIHIC scales as dependent variables. Because the MANOVA yielded statistically significant results overall for the set of dependent variables using Wilks' lambda criterion, the univariate two-way ANOVA was examined and interpreted for each individual WIHIC scale. For some scales (Involvement and Investigation), Indonesian students perceived their learning environment significantly more positively than did Australian students. However, for some other scales (Task Orientation and Equity), Australian students had significantly more positive perceptions of their classroom

environment than their Indonesian counterparts. The effect sizes for these scales for which between-country differences were statistically significant ranged from 0.13 to 0.69 standard deviations. Also, MANOVA revealed that male students perceived significantly more Teacher Support and Equity than did females. Effect sizes, ranging from 0.46 to 0.78 for scales exhibiting significant differences, suggest a fairly substantial difference between sexes according to criteria for effect sizes proposed by Cohen (1988). An interesting interaction between country and sex occurred for the WIHIC scale of Student Cohesiveness.

Simple correlation and multiple regression analyses with the student as the unit of analysis were conducted to determine the strength and direction of associations between the six scales of the WIHIC questionnaire (Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation and Equity) and the three scales of the TOSRA (Normality of Scientists, Attitude to Scientific Inquiry and Career Interest in Science). Overall, the present findings of associations between students' attitudes and their perceptions of their classroom learning environment on most WIHIC scales replicate considerable prior research in a range of countries (Fraser 1998a, 2002).

Cross-national studies provide increased variation in variables of interest as the sample is drawn from more than one country. Such variation can help to expose and make strange familiar educational practices, beliefs and attitudes. Therefore, cross-national research provides researchers not only with an understanding of science education in another country but also with insights into science education in their own country that hitherto may have gone unrecognised.

The research reported in this article has implications for improving science education. Given that measures of learning outcomes alone do not provide a complete picture of the educational process, assessments of learning environment can be usefully employed to provide information about important aspects of classroom life. We assume in this article that having a positive classroom environment is an educationally desirable end in its own right. Moreover, there is comprehensive evidence in this article and elsewhere (Fraser 2007) to suggest that the classroom environment influences how well students achieve a range of desirable outcomes.

It is acknowledged that the assessment of classroom environment should include both qualitative and quantitative research methods. Although studies such as ours generate useful data for comparisons, the contextual information associated with social, cultural and educational aspects is often limited. It is recommended, therefore, that future studies include qualitative research methods that can tap into these aspects, as recommended by Tobin and Fraser (1998) and Aldridge and Fraser (2000).

References

Abell, S. K., & Lederman, N. G. (eds). (2007). *Handbook of research on science education*. Mahwah: Lawrence Erlbaum.

Aldridge, J. M., & Fraser, B. J. (2000). A cross-national study of classroom environments in Taiwan and Australia. *Learning Environments Research: An International Journal, 3*, 101–134.

Aldridge, J. M., & Fraser, B. J. (2008). *Outcomes-focused learning environments: Determinants and effects (Advances in Learning Environments Research series)*. Rotterdam: Sense.

Aldridge, J. M., Fraser, B. J., & Huang, I. T. C. (1999). Investigating classroom environment in Taiwan and Australia with multiple research methods. *Journal of Educational Research, 93*, 48–62.

Aldridge, J. M., Fraser, B. J., & Sebela, M. P. (2004). Using teacher action research to promote constructivist learning environments in South Africa. *South African Journal of Education, 24*, 245–253.

Allen, D. V., & Fraser, B. J. (2007). Parent and student perceptions of classroom learning environment and its association with student outcomes. *Learning Environments Research: An International Journal, 10*, 67–82.

Anderson, L. W. (1995). *International encyclopaedia of teaching and teacher education* (2nd ed.). Cambridge: Cambridge University Press.

Brislin, R. W. (1970). Back translation for cross-cultural research. *Journal of Cross-Cultural Psychology, 1*, 185–216.

Brislin, R. W. (1983). Cross-cultural research in psychology. *Annual Review of Psychology, 34*, 363–400.

Burden, R., & Fraser, B. J. (1993). Use of classroom environment assessments in school psychology: A British perspective. *Psychology in the Schools, 30*, 232–240.

Chionh, Y. H., & Fraser, B. J. (2009). Classroom environment, achievement, attitudes and self esteem in geography and mathematics in Singapore. *International Research in Geographical and Environmental Education, 18*, 29–44

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. New York: Academic.

Crano, W. D., & Prislin, R. (2006). Attitudes and persuation. *Annual Review of Psychology, 57*, 345–374.

den Brok, P., Brekelmans, M., & Wubbels, T. (2004). Interpersonal teacher behavior and student outcomes. *School Effectiveness and School Improvement, 15*, 407–442.

den Brok, P., Telli, S., Cakiroglu, J., & Tekkaya, C. (2008). *Students' perceptions of their biology classroom learning environments: A study on typology of learning environments.* Paper presented at the annual meeting of the American Educational Research Association, New York, NY.

Dorman, J. P. (2003). Cross-national validation of the What Is Happening In this Class? (WIHIC) questionnaire using confirmatory factor analysis. *Learning Environments Research: An International Journal, 6*, 231–245.

Dorman, J. P. (in press). Use of multitrait-multimethod modeling to validate actual and preferred forms of the What is Happening In this Class (WIHIC) questionnaire. *Learning Environment Research: An International Journal.*

Dorman, J. P., Aldridge, J. M., & Fraser, B. J. (2006). Using students' assessment of classroom environment to develop a typology of secondary school classrooms. *International Education Journal, 7*, 906–915.

Eiser, J. R. (ed). (1984). *Attitudinal judgment*. New York: Springer-Verlag.

Escotet, M. A. (1973). *Cross-cultural research methodology in education.* Paper presented at the National Convention of the Comparative and International Education Society, San Antonio, TX.

Ferguson, P. D., & Fraser, B. J. (1999). Changes in learning environment during the transition from primary to secondary school. *Learning Environments Research: An International Journal, 1*, 369–383.

Fisher, D. L., & Fraser, B. J. (1983). A comparison of actual and preferred classroom environment as perceived by science teachers and students. *Journal of Research in Science Teaching, 20*, 55–61.

Fisher, D. L., & Khine, M. S. (eds). (2006). *Contemporary approaches to research on learning environments: Worldviews*. Singapore: World Scientific.

Fraser, B. J. (1978). Development of a test of science related attitudes. *Science Education, 62*, 509–515.

Fraser, B. J. (1981). *Test of Science-Related Attitudes (TOSRA)*. Melbourne: Australian Council for Educational Research.

Fraser, B. J. (1996). *NARST's expansion, internationalization, and cross nationalization: History in the making.* Presidential address at the annual meeting of the National Association for Research in Science Teaching, St Louis, MO.

Fraser, B. J. (1998a). Science leaning environments: Assessment, effects and determinants. In B. J. Fraser & K. G. Tobin (Eds.), *The international handbook of science education* (pp. 527–564). Dordrecht: Kluwer Academic.

Fraser, B. J. (1998b). Classroom environment instruments: Development, validity and applications. *Learning Environments Research: An International Journal, 1*, 7–33.

Fraser, B. J. (1998c). The birth of a new journal: Editor's introduction. *Learning Environments Research: An International Journal, 1*, 1–5.

Fraser, B. J. (1999). "Grain sizes" in learning environment research: Combining qualitative and quantitative methods. In H. C. Waxman & H. J. Walberg (Eds.), *New directions for teaching practice and research* (pp. 285–296). Berkeley: McCutchan.

Fraser, B. J. (2002). Learning environments research: Yesterday, today and tomorrow. In S. C. Goh & M. S. Khine (Eds.), *Studies in educational environments: An international perspective* (pp. 1–25). Singapore: World Scientific.

Fraser, B. J. (2007). Classroom learning environments. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 103–124). Mahwah: Lawrence Erlbaum.

Fraser, B. J., & Butts, W. L. (1982). Relationship between perceived levels of classroom individualization and science-related attitudes. *Journal of Research in Science Teaching, 19*, 143–154.

Fraser, B. J., & Fisher, D. L. (1982). Predicting student outcomes from their perceptions of classroom psychosocial environment. *American Educational Research Journal, 19*, 498–518.
Fraser, B. J., & Tobin, K. (1989). Student perceptions of psychosocial environments in classrooms of exemplary science teachers. *International Journal of Science Education, 11*, 14–34.
Fraser, B. J., & Tobin, K. (1991). Combining qualitative and quantitative methods in classroom environment research. In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 271–292). London: Pergamon.
Fraser, B. J., & Walberg, H. J. (eds). (1991). *Educational environments: Evaluation, antecedents, and consequences*. London: Pergamon.
Fraser, B. J., & Tobin, K. (eds). (1998). *The international handbook of science education*. Dordrecht: Kluwer Academic.
Getzels, J. W., & Thelen, H. A. (1960). The classroom as a unique social system. In N. B. Henry (Ed.), *The dynamics of instructional groups: Sociopsychological aspects of teaching and learning (Fifty-ninth Yearbook of the National Society for the Study of Education, Part 2* (pp. 53–82). Chicago: University of Chicago Press.
Haertel, G. D., Walberg, H. J., & Haertel, E. H. (1981). Socio-psychological environments and learning: A quantitative synthesis. *British Educational Research Journal, 7*, 27–36.
Husen, T., & Postlethwaite, T. N. (eds). (1994). *The international encyclopedia of education* (2nd ed.). Oxford: Pergamon.
Joyce, B. A., & Farenga, S. J. (1999). Informal science experience, attitudes, future interest in science and gender of high ability students: An exploratory study. *School Science and Mathematics, 99*, 431–437.
Kalili, K. Y. (1987). A crosscultural validation of a test of science related attitudes. *Journal of Research in Science Teaching, 24*, 127–136.
Khine, M. S., & Fisher, D. L. (eds). (2003). *Technology-rich learning environments: A future perspective*. Singapore: World Scientific.
Khoo, H. S., & Fraser, B. J. (2008). Using classroom psychosocial environment in the evaluation of adult computer application courses in Singapore. *Technology, Pedagogy and Education, 17*, 53–67.
Kim, H. B., Fisher, D. L., & Fraser, B. J. (2000). Classroom environment and teacher interpersonal behaviour in secondary science classes in Korea. *Evaluation and Research in Education, 14*, 3–22.
Kind, P. K., Jones, K., & Barmby, P. (2007). Developing attitudes towards science measures. *International Journal of Science Education, 29*, 871–893.
Klopfer, L. E. (1971). Evaluation of learning in science. In B. S. Bloom, J. T. Hastings & G. F. Madaus (Eds.), *Handbook on formative and summative evaluation of student learning* (pp. 559–642). New York: McGraw Hill.
Koul, R. B., & Fisher, D. L. (2005). Cultural background and students' perceptions of science classroom learning environment and teacher interpersonal behaviour in Jammu, India. *Learning Environments Research: An International Journal, 8*, 195–211.
Lewin, K. (1936). *Principals of topological psychology*. New York: McGraw.
Lott, K. (2002). The evaluation of a statewide in-service and outreach program: Preliminary findings. ERIC Document # ED465509.
Margianti, E. S., Aldridge, J. M.., & Fraser, B. J. (2004). Learning environment perceptions, attitudes and achievement among private Indonesian university students. *International Journal of Private Higher Education* [online]. Retrieved from: www.xaiu.com/xaiujournal
Martin-Dunlop, C., & Fraser, B. J. (2008). Learning environment attitudes associated with an innovative science course designed for prospective elementary teachers. *International Journal of Science and Mathematics Education, 6*, 163–190.
McRobbie, C. J., & Fraser, B. J. (1993). Associations between student outcomes and psychosocial science environment. *Journal of Education Research, 87*, 78–85.
Mead, M. (1964). *Anthropology: A human science*. Princeton: Van Nostrand.
Moos, R. H. (1974). *The social climate scales: An overview*. Palo Alto: Consulting Psychologists.
Moos, R. H., & Trickett, E. J. (1974). *Classroom environment scale manual*. Palo Alto: Consulting Psychologists.
Murray, H. A. (1938). *Explorations in personality*. New York: Oxford University Press.
Mueller, D. J. (1986). *Measuring social attitudes*. New York: Teacher College Press, Columbia University.
Munby, H. (1983). An investigation into the measurement of attitudes in science education. Columbus, OH: Ohio State University. *ERIC Document # ED237347*.
Munby, H. (1997). Issues of validity in science attitude measurement. *Journal of Research in Science Teaching, 34*, 337–341.
OECD Programme for International Student Assessment (PISA). (2006). *Assessing scientific, reading and mathematical literacy*. Paris: Organisation for Economic Co-Operation and Development (OECD).

Ogbuehi, P. I., & Fraser, B. J. (2007). Learning environment, attitudes and conceptual development associated with innovative strategies in middle-school mathematics. *Learning Environments Research: An International Journal, 10*, 101–114.

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

Raaflaub, C. A., & Fraser, B. J. (2002). *Investigating the learning environment in Canadian mathematics and science classrooms in which laptop computers are used.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Reid, N. (2006). Thoughts on attitude measurement. *Research in Science and Technological Education, 24*, 3–27.

Riah, H., & Fraser, B. J. (1998). *Chemistry learning environment and its association with students' achievement in chemistry.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Scantlebury, K., Boone, W., Kahle, J. B., & Fraser, B. J. (2001). Design, validation, and use of an evaluation instrument for monitoring systemic reform. *Journal of Research in Science Teaching, 38*, 646–662.

Schibeci, R. A., & McGaw, B. (1981). Empirical validation of the conceptual structure of the Test of Science Related Attitudes. *Educational and Psychological Measurement, 41*, 1195–1201.

Sink, C. A., & Spencer, L. R. (2005). My class inventory-short form as an accountability tool for elementary school counselors to measure classroom climate. *Professional School Counseling, 9*, 37–48.

Stern, G. G. (1970). *People in context: Measuring person-environment congruence in education and industry.* New York: Wiley.

Stevens, J. P. (1992). *Applied multivariate statistics for the social sciences* (2nd ed.). Hillsdale: Lawrence Erlbaum.

Telli, S., Cakiroglu, J., & den Brok, P. (2006). Turkish secondary education students' perceptions of their classroom learning environment and their attitude towards Biology. In D. L. Fisher & M. S. Khine (Eds.), *Contemporary approaches to research on learning environments: World views* (pp. 517–542). Singapore: World Scientific.

Thompson, B. (1998a). Review of 'What if there were no significance tests?'. *Educational and Psychological Measurement, 58*, 334–346.

Thompson, B. (1998b). *Five methodology errors in educational research: The pantheon of statistical significance and other faux pas.* Invited address presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Tobin, K., & Fraser, B. J. (1998). Qualitative and quantitative landscapes of classroom learning environments. In B. J. Fraser & K. G. Tobin (Eds.), *The international handbook of science education* (pp. 633–640). Dordrecht: Kluwer Academic.

Tobin, K., Kahle, J. B., & Fraser, B. J. (eds). (1990). *Windows into science classes: Problems associated with-higher level cognitive learning*. London: Falmer.

Wahyudi, W., & Treagust, D. F. (2004). The status of science classroom learning environments in Indonesian lower secondary schools. *Learning Environments Research: An International Journal, 7*, 43–63.

Walberg, H. J. (ed). (1979). *Educational environments and effects: Evaluation, policy, and productivity.* Berkeley: McCutchan.

Walberg, H. J. (1981). A psychological theory of educational productivity. In F. Farley & N. J. Gordon (Eds.), *Psychology and education: The state of the union* (pp. 81–108). Berkeley: McCutchan.

Walberg, H. J., & Anderson, G. J. (1968). Classroom climate and individual learning. *Journal of Educational Psychology, 59*, 414–419.

White, J. A. R., & Richardson, G. D. (1993). *Comparison of science attitudes among middle and junior high school students*. ERIC Document # ED368559.

Wolf, S. J., & Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle-school science students using inquiry-based laboratory activities. *Research in Science Education, 38*, 321–341.

Wong, A. F. L., & Fraser, B. J. (1996). Environment-attitude associations in the chemistry laboratory classroom. *Research in Science and Technological Education, 14*, 91–102.

Wong, A. F. L., Young, D. J., & Fraser, B. J. (1997). A multilevel analysis of learning environments and student attitudes. *Educational Psychology, 17*, 449–468.

Yarrow, A., & Millwater, J. (1995). SMILE: Student Modification In Learning Environments - Establishing congruence between actual and preferred classroom learning environment. *Journal of Classroom Interaction, 30*(1), 11–15.

Zandvliet, D. B., & Fraser, B. J. (2004). Learning environments in information and communications technology classrooms. *Technology, Pedagogy and Education, 13*, 97–123.

Zandvliet, D. B., & Fraser, B. J. (2005). Physical and psychosocial environments associated with networked classrooms. *Learning Environments Research: An International Journal, 8*, 1–17.