

## Using Student Perception Data for Teacher Reflection and Classroom Improvement

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### ABSTRACT

This paper reports the development, validation and use of two instruments designed to provide teachers with feedback information about students' perceptions of their learning environment and their attitudes.

Data collected using these instruments are analysed to provide teachers with student feedback data as a basis for reflecting on their teaching practices which, in turn, can be used to guide the development and implementation of strategies to improve the learning environment and target attitudinal issues. Data collected over a three year period from a sample of 10 345 secondary students (2042 students in 2008, 4467 in 2009 and 3836 in 2010) in 684 classes (147 classes in 2008, 298 in 2009 and 239 in 2010) across 29 Western Australian schools were analysed to determine the validity and reliability of the two instruments. The results suggest that both of the instruments have strong construct validity when used with high school students.

To investigate the processes undertaken by teachers as they used the data as part of an action research process, qualitative data (including entries in reflective journals, written reports, discussions and interviews) were collected from 43 teachers. This qualitative data was used to evaluate the usefulness of the two instruments as tools for teacher reflection and professional development. The practical application of the two instruments indicate that the student feedback data was a useful way for teachers to reflect on their practices and implement changes which resulted in improvements in the classroom learning environment.

### INTRODUCTION

Action research begins with teachers deliberately and consciously reflecting on their teaching practices and feedback based on students' perceptions of the learning environment can provide a useful means of doing just that. The results of studies conducted over the past 40 years have shown that the quality of the learning environment has a significant influence on student learning (Fraser, 1998a, 2007). That is, students learn better when they perceive the classroom environment more positively. By evaluating students' perceptions of actual and preferred classroom learning environments, teachers can utilise an action research process in which they reflect on student feedback, plan for improvement, implement strategies and re-assess the learning environment to gauge the impact of their efforts and plan for future improvement. The purpose of this paper is to report the development, validation and use of a new classroom learning environment instrument. The preceding sections outline the specific objectives of the study, provide a background to the study, describe the design and procedures used for the study and report the results of the study. Finally, the paper provides a discussion of the results and a conclusion.

## OBJECTIVES

The aims of the research reported in this paper were to:

1. Develop and validate an instrument to assess students' perceptions of the classroom learning environment in terms of relationships, assessment and instructional delivery.
2. Examine the extent to which teacher action research, based on student perception data, can guide teachers' improvement of their classroom learning environments.
3. Investigate whether improvements in the learning environment differed for teachers who used the student feedback for reflection and those who used it as part of a more formalised action research process.
4. Investigate the processes used by teachers during the action research process.

## BACKGROUND

### **Using the Field of Learning Environments to Provide Teachers with Students' Perspectives**

The study reported in this paper drew on and extended research carried out in the field of learning environments (Aldridge & Fraser, 2008; Fraser, 1998a, 2007; Goh & Khine, 2002; Fisher & Khine, 2006). Contemporary research on school environments partly owes inspiration to Lewin's (1936) seminal work in non-educational settings, which recognised that both the environment and its interaction with characteristics of the individual are potent determinants of human behaviour. Since then, the notion of person-environment fit has been elucidated in education by Stern (1970) and Walberg (1981) has proposed a model of educational productivity in which the educational environment is one of nine determinants of student outcomes. Research specifically on classroom learning environments took off about 40 years ago with the work of Anderson and Walberg (1968) and Moos (1974) which spawned many, diverse research programs around the world (Fisher & Khine, 2006; Fraser, 1998a) and the creation of *Learning Environments Research: An International Journal*. Past research on learning environments provides numerous research traditions, conceptual models and research methods that are relevant to our study.

This study draws on the rich resource of diverse, valid, economical and widely-applicable assessment instruments available in the field of learning environments (Fraser, 1998b) as a starting point for developing the questionnaire described in this paper. Typically, studies involving the use of feedback from a learning environment survey to guide improvements have used a five-step procedure (Fraser, 2007):

1. assessing the actual and preferred learning environment
2. providing feedback to teachers based on students' responses
3. reflection and discussion based on feedback from the survey in order to identify which aspects of the learning environment might be chosen for change and to consider teaching strategies that might be used
4. implementing an intervention over a period of time in an attempt to change the learning environment; and
5. re-administration of the survey to students at the end of the intervention period to determine whether students perceive their learning environment differently from before.

As this five-step procedure has been used successfully at a range of educational levels, the teachers involved in this study made use of the same procedure as a basis for reflection, discussion and attempts to improve the classroom learning environment.

### **Reflection and Teacher Action Research**

Reflection has been described as a way of thinking about a problematic situation that needs to be resolved. According to Fullan (1999), it is only through reflection that teachers begin to question and think differently about their teaching practices. In this respect, reflection provides the opportunity for teachers to be aware that a problem exists.

Schön (1987) claims that an understanding of alternative perspectives about one's teaching lies at the heart of professional development, so it is possible that the perspectives of students can provide a teacher with valuable source of data for personal reflection. Seeking students' perspectives can help a teacher to question assumptions and to view his or her own practice through the eyes of others (Bustingorry, 2008; Hoban & Hastings, 2006; Rhine, 1998). The present study examined the use of students' perceptions, assessed with a learning environment survey, as a tool for reflection in teacher action research.

### **DESIGN AND PROCEDURES**

Our research was based on three main assumptions. First, teachers generally are interested in improving their practice and want to create an environment that suits the needs of their students. Second, conscious and purposeful reflection on one's teaching can provide a catalyst for change and guide improvements in the way in which one teaches. Finally, students, as the major stakeholders in the education process, are worth listening to.

Our study utilised different 'grain sizes' (Fraser, 1999) for collecting and analysing data which was collected over a three year period. At the largest grain size, a sample of 10 345 student

responses (2042 student responses in 2008, 4467 in 2009 and 3836 in 2010) in 684 classes (147 classes in 2008, 298 in 2009 and 239 in 2010) in 29 coeducational high schools was used. An overview of the sample is provided in Table 1. To provide a more representative sample of students, four regional schools and 25 schools from the metropolitan area were involved in the study. The teachers involved in the study ranged in both age and teaching experience. As no learning area was specifically targeted, the sample included the full range of learning areas (English, science, mathematics, society and environment, technology and enterprise, the arts and LOTE). This large sample was used in investigating the validity and reliability of the new instrument (Research Objective 1).

**Table 1:** Overview of the data sample showing the number of teachers, classes, student responses and school over the three year period.

Year	Number of Teachers		Number of Classes			Number of Student Responses		Number of Schools
	Pre	Post	Pre	Post	Focus Classes	Pre	Post	
2008	107	91	147	122	15	2042	1182	9
2009	247	210	298	248	15	4467	2749	25
2010	194	158	239	190	22	3836	2176	21
TOTAL	548	459	684	560	52	10345	6107	29

The classes of 459 teachers (some of who selected more than one class) were used to examine pre-post changes (Research Objective 2). Only data for those students that were present for both the pretest and posttest were involved and was comprised of 6107 student responses (1182 student responses in 2008, 2749 in 2009 and 2176 in 2010) in 560 classes (122 classes in 2008, 248 in 2009 and 190 classes in 2010).

To address Research Objective 3, 45 of the 459 teachers volunteered to be 'focus teachers'. Unlike the other teachers (who were provided with data for reflection), these 45 focus teachers (12 teachers in 2008, 13 in 2009 and 20 in 2010) used the student feedback data as part of a more formal action research process. To address Research Objective 4, the 45 teachers described above documented their action research activities using a reflective journal and a written report that outlined the processes undertaken, the types of strategies implemented and the effect these strategies had on their classroom and their teaching practices. At the end of the year, these focus teachers were invited to present their findings at a forum. This group of teachers were considered to be representative of the larger population as they ranged in age, level of experience and included teachers from all learning areas, with the exception of Languages Other Than English (LOTE).

## ANALYSES AND RESULTS

### Development of the Constructivist-Oriented Learning Environment Survey (COLES)

The first objective of the study focused on the development of an instrument to assess students' perceptions of the classroom learning environment. During this process, we endeavoured to include scales with a constructivist orientation. With this in mind, we identified principles relevant to student-centred classrooms and which are consistent with a more constructivist pedagogy. These principles were used to identify dimensions that could be used as a basis for developing specific scales that would give an indication of whether these principles were present. As a result of these efforts, a widely-applicable and distinctive instrument for assessing students' perceptions of their learning environment has been developed.

Six of the 11 scales are based on the widely-used What Is Happening In this Class? (WIHIC, Fraser, McRobbie & Fisher, 1996) questionnaire that has been cross-validated across many subject areas and in numerous countries (Aldridge, Fraser & Sebela, 1999; Khoo & Fraser, 2008). In addition to these six scales, the new instrument incorporated the Young Adult Ethos and Differentiation scales (adapted from the Technology-Rich Outcomes-Focused Learning Environment Instrument, Aldridge & Fraser, 2008) and the Personal Relevance scale (from the widely-used Constructivist Learning Environment Survey, Taylor, Fraser & Fisher, 1997). Two other scales, Formative Assessment and Clarity of Assessment, were developed for the purpose of the present study. A brief description of what each scale assesses and the reason for its inclusion in the instrument are provided below.

It was considered highly desirable for teachers to provide students with learning experiences that cater for student diversity. The *Differentiation* scale (modified from the Individualised Classroom Environment Questionnaire, developed by Rentoul and Fraser (1979), was included to assess the extent to which students perceive that teachers cater for students differently based on their need, capabilities and interests. This scale was included as it was considered important to acknowledge that students differ in terms of their abilities, rates of learning and interests (Griffin & Smith, 1997; Spady, 1993).

To assess the extent to which students perceive that it is important to complete activities and understand the goals of the subject, the *Task Orientation* scale was selected. Students need to have goals, both short-term and long-term, to provide them with motivation and purpose (Killen, 2001; Spady, 1994). If goals are clear and relevant, students are more likely to be

engaged in their learning. Coupled with the need to have meaningful goals is the need to have clear expectations and frequent feedback and reinforcement to ensure that students' time-on-task is optimised.

Research has established that, if students are actively involved in learning activities, then it is likely that learning will be more meaningful to students. According to the Curriculum Council (1998, p. 34), "Students should be encouraged to think of learning as an active process on their part, involving a conscious intention to make sense of new ideas or experiences and improve their own knowledge and capabilities, rather than simply to reproduce or remember." In addition, research evidence suggests that language plays an important part in helping students to understand what they are learning (Taylor & Campbell-Williams, 1993) and by participating in classroom discussions and negotiating understandings with peers are important aspects of the learning process. The *Involvement* scale was selected to assess the extent to which students feel that they have opportunities to participate in discussions and have attentive interest in what is happening in the classroom.

The *Personal Relevance* scale was introduced to examine the connectedness of a subject with students' out-of-school experiences. To ensure that students engage in their learning, it is necessary for teachers to make the content relevant to the students' lives outside school (Taylor et al., 1997). In this way, teachers are able to provide a meaningful context in which they can introduce new knowledge.

In developing this questionnaire, an environment in which teachers encourage a collaborative setting was considered more desirable than a competitive one (Johnson, Johnson & Smith, 2007; Tan, Sharan & Lee, 2007). Whilst it is acknowledged that students should be given opportunities to work as individuals, it was considered to be equally important that they work together collaboratively. It was with this in mind that the *Cooperation* scale was selected to assess the extent to which students cooperate with one another in a collaborative atmosphere.

Two scales were selected for assessing the extent to which students feel that their learning environment is conducive to learning, namely, *Student Cohesiveness* and *Teacher Support*. The first of these scales, *Student Cohesiveness* was included to assess the extent to which students know, help and are supportive of one another. To make sure that the environment is supportive of student learning, teachers need to employ practices that help students to feel

that they are accepted and supported by their peers (Curriculum Council, 1998). In a supportive environment, students are able to make mistakes without the risk of being ridiculed. Social acceptance by peers and the need to have friends are important aspects that can affect students' learning.

The second scale, *Teacher Support*, assesses the extent to which the teacher helps, relates to, trusts and is interested in students. The teacher's relationship with his or her students is a pivotal aspect of any learning environment, which can lead the student to love or hate a subject, and to be inspired or turned away from learning. The supportiveness of a teacher may give students the confidence they need to tackle new problems, take risks in their learning, and to work on and complete challenging tasks. The teacher's relationship with their students, in many ways, is integral to a student's success and to creating a cooperative learning environment (Hijzen, Boekaerts & Vedder, 2007). It was with this in mind that the *Teacher Support* scale was selected.

It was considered important that the learning environment created by the teacher provides opportunities for all of the students in the class (Rennie, 2004; 2005). The *Equity* scale assesses the extent to which students' perceive that the teacher treats them in a way that encourages and includes them as much as their peers. This scale gives teachers an indication of whether students perceive that they are being treated fairly by the teacher.

It was also considered important that a high school environment encourages students to be responsible for their own learning (Aldridge & Fraser, 2008). This led to a scale called *Young Adult Ethos* being selected to assess whether students feel that teachers give them responsibility and treat them as young adults.

Two additional scales were developed to gauge students' perceptions of the assessment practices used by the teacher, namely, Formative Assessment and Clarity of Assessment Criteria. Assessment, particularly formative assessment, is critical for knowing how a student is performing academically and how best to support that student in the classroom (Allen, Ort & Schmidt, 2009). By making clear the goals to which students are striving and providing useful feedback on their progress provides a powerful means of improving student learning by encouraging them to reflect on their current understandings, and to plan for success in their future learning (O'Donovan, Price & Rust, 2004).



Formative assessment relates to assessment practices that are part of the learning process rather than a separate (summative) process conducted at the end of the learning journey (Bell & Cowie, 2001). Formative assessment practices can provide opportunities for students to discuss their progress with their teachers as well as to engage in peer and self assessment as ways of monitoring and reflecting on their learning. More importantly, if students are able to recognise the link between their learning and assessment, then assessment becomes educative, improves student learning, enables students to plan for future learning and may foster self-directed learning practices (Bell & Cowie, 2001; Black & Wiliam, 1998). The *Formative Assessment* scale assesses the extent to which students feel that assessment tasks make a positive contribution to their learning.

The *Clarity of Assessment Criteria* scale assesses the extent to which the assessment criteria are explicit so that the basis for judgements is clear and public. While clear and public criteria can support and enhance a teachers' ability to make professional judgements about student learning, as a matter of fairness, students should also know the criteria by which they are being assessed.

The initial version of the Constructivist-Oriented Learning Environment Survey (COLES) was comprised of 11 scales, each with 8 items (a total of 88 items). The COLES was refined in 2008 when, after consideration of a number of issues (related to survey fatigue and low reading levels) the instrument was refined. In consultation with classroom practitioners who had used the survey, individual items were refined and the number of items in each scale were reduced. The final version of the COLES has 11 scales with six (and in one case seven) items in each (providing a total of 67 items). Although it is acknowledged that an instrument comprising 11 scales cannot assess every aspect of the learning environment, the selected scales were all considered to be relevant to teachers aiming to create more constructivist-oriented learning environments in a range of contexts. Importantly, many of these scales have also been shown to be good predictors of student outcomes (Aldridge & Fraser, 2008).

Students respond to the items using a five-point frequency scale of Almost Always, Often, Sometimes, Seldom and Almost Never. Importantly, this instrument enables students to provide information about the learning environment that is currently present in the classroom (the *actual* environment) as well as information about the learning environment that they would like (their *preferred* environment). To achieve this, the instrument makes use of a side-



by-side response format in which students are able to respond to each item with respect to both their actual and preferred responses (see Figure 1).

<i>Formative Assessment</i>	ACTUAL					PREFERRED				
	Almost Never	Seldom	Some times	Often	Almost Always	Almost Never	Seldom	Some times	Often	Almost Always
14. Assessment tasks help me to monitor my learning.	1	2	3	4	5	1	2	3	4	5

**Figure 1:** Illustration of Side-by-Side Response Format for Actual and Preferred Responses

The 11 dimensions of the COLES can be grouped into three broad categories: Relationships (Student Cohesiveness, Teacher Support, Equity and Young Adult Ethos), Assessment (Clarity of Assessment Criteria and Formative Assessment), and Delivery (Task Orientation, Differentiation, Personal Relevance, Involvement, and Cooperation). A description of each scale and example of an item for each scale has been included in Table 2.

### Validity and Reliability of the COLES

Data collected from the 10,345 students in 684 secondary high school classes, over three years (described earlier), were analysed in various ways to support the validity and reliability of the actual and preferred versions of the new instrument at the secondary high school level. To ensure test-retest reliability (Pallant, 2011), data were analysed separately for each year.

When the researcher’s goal is to construct a multiscale questionnaire, factor analysis provides a means of determining whether items within the same scale are tapping into the same construct and whether each scale is assessing a distinct construct. Principal axis factor analysis with oblique rotation (used because it can be assumed that dimensions of a learning environment overlap) and Kaiser normalisation was used to examine the factor structure for actual and preferred data for each of the three years. The two criteria for retaining any item was that it must have a factor loading of at least 0.40 on its own scale and less than 0.40 on any of the other scales (Field, 2005; Stevens, 1992; Thompson, 2004). The factor loadings and percentage of variance for each year for the actual versions are reported in Appendix 1 and for the preferred versions in Appendix 2. For all three years, all items (with the exceptions of 3 items) had a loading of at least 0.40 on their *a priori* scale and no other scale. These three exceptions include Item 32 from the Clarity of Assessment scale (2010 only), Item 49 from Task Orientation (2008 only) and Item 62 from the Differentiation scale (all three years). In each case the items did not load on their own or any other scale.

**Table 2:** Description of Each Scale in the COLES and an example of an item in each scale

	Scale	Description	Example	Adapted from:
<b>RELATIONSHIPS</b>		<i>The extent to which ...</i>		
	Student Cohesiveness	...students know, help and are supportive of one another.	<i>Members of this class are my friends.</i>	What Is Happening In this Class? (WIHIC)
	Teacher Support	...the teacher helps, befriends, trusts and is interested in students.	<i>The teacher moves around the class to talk with me.</i>	What Is Happening In this Class? (WIHIC)
	Equity	...students are treated equally by the teacher.	<i>I get the same amount of help from the teacher as do other students.</i>	What Is Happening In this Class? (WIHIC)
	Young Adult Ethos	...teachers give students responsibility and treat them as young adults.	<i>I am given the opportunity to be independent.</i>	Technology-Rich Outcomes-Focused Learning Environment Instrument (TROFLEI)
<b>ASSESSMENT</b>	Formative Assessment	...students feel that the assessment tasks given to them make a positive contribution to their learning.	<i>Assessment tasks help me to monitor my learning.</i>	Developed for the COLES
	Assessment Criteria	... the assessment criteria are explicit so that the basis for judgments is clear and public	<i>I understand how the teacher judges my work.</i>	
<b>DELIVERY</b>	Involvement	...students have attentive interest, participate in discussions, ask questions and share ideas.	<i>I explain my ideas to other students.</i>	What Is Happening In this Class? (WIHIC)
	Task Orientation	...it is important to complete activities planned and to stay on the subject matter.	<i>I pay attention during this class.</i>	What Is Happening In this Class? (WIHIC)
	Personal Relevance	...subject is relevant to students' everyday out-of-school experiences.	<i>I relate what I learn in this class to my life outside of school.</i>	Constructivist Learning Environment Survey (CLES)
	Cooperation	...students cooperate with one another on learning tasks.	<i>When I work in groups in this class, there is teamwork.</i>	What Is Happening In this Class? (WIHIC)
	Differentiation	...teachers cater for students differently on the basis of ability, rates of learning and interests.	<i>I am able to work at the speed which suits my ability.</i>	Technology-Rich Outcomes-Focused Learning Environment Instrument (TROFLEI)

For the preferred version, all items with the exception of Item 13 from the Equity scale (2010 only) and Item 62 from the Differentiation scale (all three years), had a loading of at least 0.40 on their *a priori* scales and no other scale. These two items both had a loading of less than 0.40 on their own scale and all other scales.

For the actual version, the percentage of variance ranged from 1.17% to 26.02% for different scales, with the total variance accounted for being 70.19% in 2008, 68.63% in 2009 and

64.32% in 2010 (see Appendix 1). For the preferred version, the percentage of variance ranged from 1.19% to 22.64% for different scales, with the total variance accounted for being 66.80% in 2008, 65.20% in 2009 and 62.87% in 2010 (see Appendix 2).

Two further indices of scale reliability and validity were generated separately for each year for the actual and preferred versions of the COLES, these being, the internal consistency reliability and analysis of variance (ANOVA) to examine whether the scales of the COLES can differentiate between the perceptions of students in different classrooms.

Table 3 reports the internal consistency of each COLES scale, using Cronbach's alpha coefficient for two units of analysis (the individual student and the class mean). The results are reported separately for each year for the actual and preferred versions. Using the individual as the unit of analysis, scale reliability estimates for the actual form ranged from 0.74 to 0.92 in 2008, 0.70 to 0.93 in 2009 and 0.80 to 0.92 in 2010. For the preferred form, scale reliabilities ranged from 0.75 to 0.92 in 2008, 0.73 to 0.92 in 2009 and 0.80 to 0.92 in 2010. Generally reliability figures were higher with the class mean as the unit of analysis. For the actual form, scale reliabilities ranged from 0.83 to 0.97 in 2008, 0.79 to 0.97 in 2009 and 0.84 to 0.97 in 2010. For the preferred form, scale reliabilities ranged from 0.76 to 0.96 in 2008, 0.75 to 0.96 in 2009 and 0.74 to 0.96 in 2010. This alpha reliability estimate supports the internal consistency of all scales of the COLES for each year of administration.

**Table 3:** Internal consistency reliability (Cronbach alpha coefficient) for actual and preferred responses and ability to differentiate between classrooms (ANOVA) for actual version of the COLES

Scale	Unit of Analysis	Alpha Reliability ACTUAL			Alpha Reliability PREFERRED			ANOVA Eta <sup>2</sup> ACTUAL only		
		2008	2009	2010	2008	2009	2010	2008	2009	2010
Student Cohesiveness	Individual	0.85	0.85	0.82	0.88	0.88	0.85	0.14**	0.17**	0.19**
	Class	0.89	0.90	0.88	0.92	0.92	0.90			
	Mean									
Teacher Support	Individual	0.91	0.90	0.90	0.88	0.88	0.87	0.31**	0.30**	0.27**
	Class	0.96	0.96	0.96	0.93	0.92	0.91			
	Mean									
Equity	Individual	0.92	0.93	0.92	0.92	0.91	0.90	0.23**	0.24**	0.28**
	Class	0.97	0.97	0.97	0.95	0.96	0.94			
	Mean									
Young Adult Ethos	Individual	0.92	0.90	0.89	0.92	0.90	0.89	0.20**	0.19**	0.30**
	Class	0.96	0.95	0.94	0.96	0.94	0.91			
	Mean									
Formative Assessment	Individual	0.90	0.88	0.86	0.90	0.89	0.88	0.17**	0.17**	0.18**
	Class	0.94	0.94	0.92	0.95	0.94	0.92			
	Mean									
Clarity of Assessment	Individual	0.90	0.90	0.87	0.92	0.92	0.89	0.18**	0.19**	0.23**
	Class	0.95	0.95	0.92	0.96	0.97	0.95			
	Mean									
Involvement	Individual	0.87	0.86	0.90	0.90	0.90	0.92	0.17**	0.15**	0.20**
	Class	0.91	0.90	0.94	0.93	0.93	0.96			
	Mean									
Task Orientation	Individual	0.84	0.82	0.83	0.88	0.88	0.87	0.15**	0.13**	0.13**
	Class	0.88	0.88	0.84	0.93	0.94	0.91			
	Mean									
Personal Relevance	Individual	0.91	0.90	0.90	0.92	0.92	0.92	0.22**	0.20**	0.23**
	Class	0.95	0.95	0.93	0.96	0.95	0.94			
	Mean									
Cooperation	Individual	0.88	0.87	0.83	0.89	0.89	0.87	0.18**	0.16**	0.19**
	Class	0.94	0.93	0.86	0.94	0.93	0.92			
	Mean									
Differentiation	Individual	0.74	0.70	0.80	0.75	0.73	0.80	0.20**	0.17**	0.19**
	Class	0.83	0.79	0.84	0.76	0.75	0.74			
	Mean									

\*\*  $p < 0.01$

The sample consisted of 2042 students in 147 classes in 2008, 4467 students in 298 classes in 2009 and 3836 students in 239 classes in 2010.

The eta<sup>2</sup> statistic (which is the ratio of 'between' to 'total' sums of squares) represents the proportion of variance explained by class membership.

A one-way analysis of variance (ANOVA), with class membership as the independent variable, was computed to determine the degree to whether each COLES scale was able to differentiate between the perceptions of students in different classes. The proportion of variance accounted for by class membership was calculated using the eta<sup>2</sup> statistic (the ratio of 'between' to 'total' sums of squares). The results, reported in Table 3, show that all 11 COLES scales differentiated significantly between classes ( $p < 0.01$ ), that is, students within

the same class perceived the environment in a relatively similar manner, while the within-class mean perceptions of the students varied between classes. The  $\eta^2$  statistic (an estimate of the strength of association between class membership and the dependent variable) for different COLES scales ranged from 0.14 to 0.31 in 2008, 0.13 to 0.30 in 2009 and 0.13 to 0.30 in 2010. These results indicate that the COLES scales all are sufficiently sensitive to distinguish between the learning environments of different classrooms.

In summary, for our sample of 10 345 students ( $N=147$  classes for 2008, 298 classes in 2009 and 239 classes in 2010), the results indicated satisfactory factorial validity, internal consistency (Cronbach alpha coefficient) and ability of each scale to differentiate between the perceptions of the students in different classrooms. The results, reported in Table 3, in conjunction with the factor analysis results and mean correlations, reported in Appendices 1 and 2, support the COLES as a valid and reliable instrument for assessing students' perceptions of their classroom psychosocial environments at the secondary high school level.

### **Pre-Post Changes in Students' Perceptions of the Learning Environment**

The second research aim was to investigate the extent to which the teachers' reflections on the feedback data of students initiated improvements to the classroom learning environments. Over a three year period, a total of 459 teachers (working with 560 classes) were involved in a pre-post design. All of these teachers selected at least one class with which they would like to work with. The learning environment survey, described above, was administered to the students in the selected classes and teachers were provided with the data. After six to eight weeks, the COLES was readministered to the same classes. Only students present for both the pretest and posttest were included in the analyses.

Multivariate Analysis of Variance (MANOVA) with repeated measures (using the class mean as the unit of analysis) was used to investigate whether differences between pretest and posttest scores were statistically significant. When the multivariate test (Wilks' lambda) revealed significant pre-post differences overall, the ANOVA with repeated measures was interpreted for each individual COLES scale (see Table 4). The pre-post differences were statistically significant ( $p<0.01$ ) for eight of the eleven COLES scales, namely, Student Cohesiveness, Teacher Support, Young Adult Ethos, Clarity of Assessment, Involvement, Personal Relevance, Cooperation and Differentiation. The results indicate that, for those

scales with a statistically significant difference, students perceived the learning environment more favourably.

To examine the magnitudes of these pre-post differences, as recommended by Thompson (2001), effect sizes were calculated in terms of the differences in means divided by the pooled standard deviation. The effect sizes for those scales with statistically significant differences, reported in Table 4, ranged between 0.06 and 0.13 of a standard deviation. These results suggest moderately important educational differences between learners' perceptions of the classroom learning environment before and after the teachers' reflection on the feedback data.

**Table 4:** Average Item Mean, Average Item Standard Deviation, Effect Size and MANOVA Results for Differences between Pre and Posttest Scores Using the Class Mean as the Unit of Analysis

Scale	Average Item Mean <sup>a</sup>		Average Item Standard Deviation		Difference	
	Pretest	Posttest	Pretest	Posttest	Effect Size	F
Student Cohesiveness	4.18	4.25	0.29	0.30	0.12	2.70**
Teacher Support	3.88	3.95	0.49	0.50	0.07	2.33**
Equity	4.10	4.09	0.46	0.48	-0.01	0.89
Young Adult Ethos	4.16	4.21	0.38	0.38	0.07	2.03**
Formative Assessment	3.96	3.97	0.36	0.41	0.01	0.94
Clarity of Assessment	3.86	3.96	0.40	0.38	0.13	2.74**
Involvement	3.29	3.49	0.40	0.42	0.24	3.65**
Task Orientation	4.03	4.02	0.29	0.35	-0.02	0.68
Personal Relevance	3.22	3.41	0.52	0.49	0.18	3.28**
Cooperation	3.78	3.83	0.38	0.41	0.06	1.99**
Differentiation	3.38	3.48	0.39	0.44	0.12	2.74**

\*\* $p < 0.01$

N= 560 classes.

<sup>a</sup> Average item mean=Scale mean divided by the number of items in that scale.

### **Posttest Changes for Reflection and Action Research Teachers**

Of the 459 teachers, 45 teachers volunteered to be 'focus teachers' and to be involved in the action research component on a more formal basis. These teachers all agreed to keep a reflective journal, in which they recorded the strategies that they intended to use and the outcomes of using these strategies as they implemented them in the classroom. To investigate whether improvements in the learning environment differed for teachers who used student feedback for reflection and those who used feedback as part of a more formalised action research process (Research Objective 3), MANOVA were utilised. As there was no significant differences, on any of the scales, between the pretest scores for those teachers using the data for reflection and those using the data as part of the action research process, it was acceptable to examine the differences between posttest scores only for each of the groups.

As for research question 2, MANOVA with repeated measures (using the class mean as the unit of analysis) was used to investigate whether differences between the posttest scores for the two groups of teachers were statistically significant. When the multivariate test (Wilks' lambda) revealed significant posttest differences overall, the ANOVA with repeated measures was interpreted for each individual COLES scale (see Table 5). The posttest differences for these two groups of teachers were statistically significant ( $p < 0.05$ ) for six of the eleven COLES scales, namely, Teacher Support, Equity, Young Adult Ethos, Formative Assessment, Task Orientation, and Differentiation. In all cases with a statistically significant difference, the results indicate that students perceived the learning environment more favourably.



**Table 5:** Average Item Mean, Average Item Standard Deviation, Effect Size and MANOVA Results (Using the Class Mean as the Unit of Analysis) for Differences between Posttest Scores for Teachers using the Results for Reflection Only and those Using the Results as Part of an Action Research Process

Scale	Average Item Mean <sup>a</sup>		Average Item Standard Deviation		Difference	
	Reflection Only	Action Research	Reflection Only	Action Research	Effect Size	F
Student Cohesiveness	4.25	4.27	0.30	0.26	0.04	0.80
Teacher Support	3.94	4.09	0.50	0.48	0.15	1.45*
Equity	4.07	4.25	0.48	0.39	0.20	1.77**
Young Adult Ethos	4.20	4.35	0.38	0.35	0.20	1.73**
Formative Assessment	3.96	4.07	0.42	0.32	0.15	1.49*
Clarity of Assessment	3.96	4.02	0.40	0.37	0.08	1.03
Involvement	3.48	3.53	0.43	0.32	0.07	1.01
Task Orientation	4.02	4.12	0.35	0.26	0.16	1.56*
Personal Relevance	3.41	3.43	0.53	0.50	0.02	0.59
Cooperation	3.83	3.87	0.41	0.35	0.05	0.89
Differentiation	3.48	3.59	0.44	0.48	0.12	1.36*

\*\* $p < 0.01$

N= 560 classes. Teachers used the data for reflection only in 508 classes and teachers used the data as part of an action research process in 52 classes.

<sup>a</sup> Average item mean=Scale mean divided by the number of items in that scale.

The effect sizes for those scales with statistically significant differences, calculated to examine the magnitudes of the posttest differences (as recommended by Thompson, 2001), ranged between 0.15 and quarter (0.20) of a standard deviation. These results suggest moderately important educationally differences between learners' perceptions of the classroom learning environment.

### Using Student Feedback Data as the Basis for Teacher Action Research

This next section outlines how the focus teachers used the data and the types of activities that were undertaken as part of the action research process (Research Objective 4). The

final section illustrates how the data was presented to teachers and how one of the teachers, Michael, utilised the data to reflect, plan and implement improvement strategies.

In all cases, the COLES was administered to those classes selected by the teachers by an external party. This data were used to generate a teacher feedback package with two profiles and a series of complimentary data for each scale. The first profile involved a simple comparison of the average item means for actual and preferred responses for each scale (see Figure 2). The second profile was a box plot, including the mean, median and range of responses for each scale. Finally, the package provided teachers with the means for each item for actual and preferred responses.

Teachers were shown how to interpret the results for their class either through a workshop, small group or a one-on-one session. Teachers were then asked to reflect on their results and use actual-preferred discrepancies to help them to identify an area or areas on which they felt that they would like to focus. In some cases, teachers discussed the results with their students to help to explain anomalies. One teacher explained,

After some reflection and discussion with students in the class, I decided that I needed to structure my questions better in order to check for understanding; address issues with Equity; increase student involvement and focus on clarifying with students my expectations of them as individual students and as part of the whole class. (Teacher, Mathematics)

In other cases, teachers discussed the results with colleagues:

I worked with a colleague in society and environment and two colleagues in science; we discussed our current teaching strategies that were focused on fostering cooperative learning. We decided to video record each other's lessons and to meet later for further discussion about what parts of our selected strategies made the most impact on increasing student centred learning. (Teacher, Physics)

Some of the teachers reflected on their data individually and planned strategies with which they were already aware. A human biology teacher stated:

I had found that I had become too comfortable using only a few different strategies, and there were numerous effective strategies that could be implemented. It was just a matter of remembering them and finding ways and activities in which to implement them. I decided to modify a couple of assessments so as they became more student directed. This was easy and just a matter of letting the students pick a research topic that they personally found interesting or perhaps was relevant in their lives at that time. (Teacher, Human Biology)

Once teachers had decided the scale or scales that they would like to focus on, they worked either individually or collaboratively to devise strategies that they felt would help to reduce the actual-preferred gap. For example, one teacher identified two aspects of her teaching that she wanted to do differently. To this end she commented:

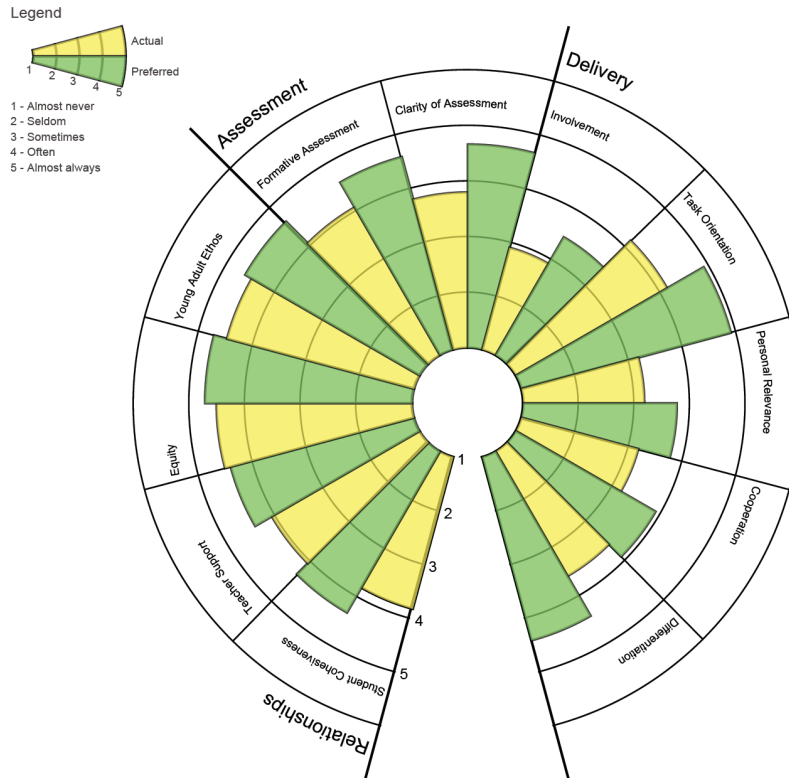
I identified two aspects of my teaching that I wanted to do differently. Firstly, I needed to make my instructions much clearer for assessment tasks. It was apparent that students were not sure what their assessment tasks should include or what the final product should look like. Secondly, I needed to make my marking keys more transparent as the students were not sure how to achieve the highest possible marks. (Teacher, Career and Enterprise)

After the teachers had implemented their selected strategies over a six to eight week period, the COLES was then re-administered to allow teachers to examine whether the strategies had led to changes in students' perceptions of the learning environment. All of the focus teachers reported that while the pretest data helped them to reflect and identify areas to target for improvement, the posttest results provided meaningful information about the success of the strategies that they had implemented. Analysis of data collected using reflective journals and reports (written by focus teachers) indicated that the teachers used a range of strategies and that in most cases, these strategies were specific to the context of the class from which the student responses were drawn. To illustrate how the student feedback data was used, a description of how one teacher, Michael, utilised the student feedback data is provided below.

Michael, a teacher with over 22 years of classroom experience, was one of the 45 focus teachers who volunteered to record their action research activities and to be monitored throughout the study. Michael selected a Grade 11 Photography class with 21 students. Although it was a fairly cooperative class with what he considered to be 'nice' kids, he felt that his rapport with these students differed to other classes he taught and that the students were not generally achieving the results that he expected.

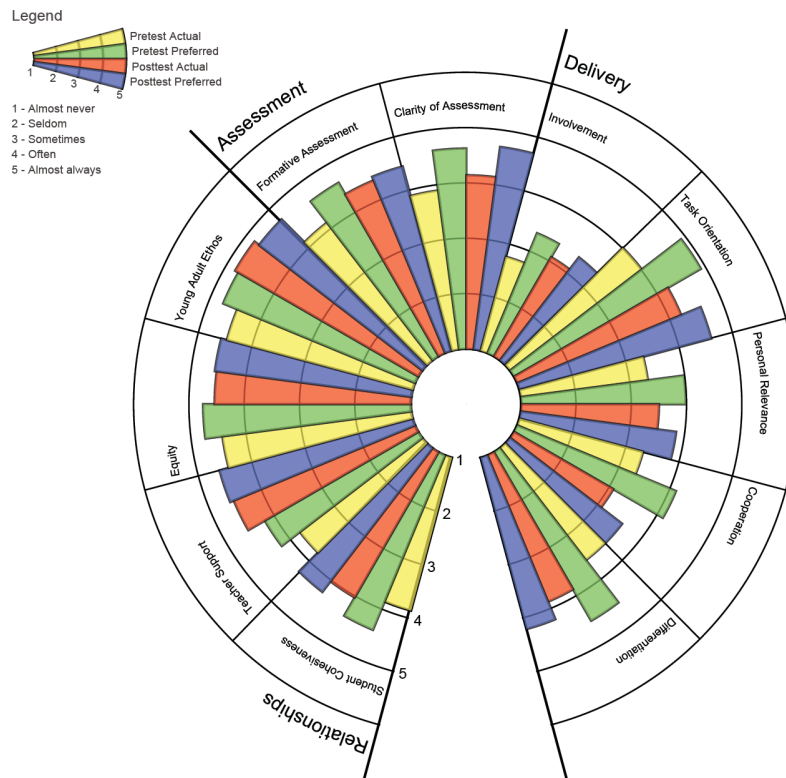
After examining his feedback data (see Figure 3), Michael decided to focus on the assessment category because of the large actual-preferred difference. His key strategy involved changing the way that he delivered his feedback to the students. To do this, he supplemented his usual written feedback with audio comments. The comments were saved as an audio file on the school network and when he handed assignments back (with his written comments); students were able to spend the first part of the lesson listening to his audio feedback. Michael believed that, by addressing issues with assessment in his class, he

might also target issues with Teacher Support. Michael implemented his strategy over a six-week intervention period during which time he provided audio feedback to one major assessment submitted by his students.



**Figure 3:** Mean Actual and Preferred Scores for Students' Perceptions of the Learning Environment for Michael's Class for the Pretest.

When the class was re-surveyed at the end of the intervention period, Michael noted that there were positive shifts in student scores on the *Formative Assessment* and *Clarity of Assessment* scales (which he had targeted) as well the *Teacher Support* scale (see Figure 4). Michael felt that an improved rapport with his students reflected the improvement in this scale. In addition to an improved relationship with his students he also noticed an increase in the number of students asking questions related to their work and requesting clarification of what was required for assessment tasks. Importantly, it became evident in subsequent assessments that students made a concerted effort to improve areas of their work that he had highlighted in the audio feedback. Michael also reported that students had responded positively to his new method of feedback, three students commented that they felt the feedback was personalised and that they believed the teacher was really trying to help them improve.



**Figure 4:** Mean Actual and Preferred Scores for Students' Perceptions of the Learning Environment for Michael's Class for the Posttest.

The 45 focus teachers involved in this study over the three year period provided valuable feedback about the COLES and the activities that they undertook as part of their action research. Through their written reports and their participation at an end of year forum, the teachers provided valuable criticism that was used to fine tune the instrument. In the main, these teachers felt that the data gathered using the COLES provided them with valuable insights into their students' views of the classroom learning environment that provided a good vehicle for reflection. According to these teachers, they were able to effectively use the data to devise strategies to target areas or issues particular to a specific class. Finally, the teachers reported that the posttest data allowed them to, not only gauge the success of the strategies implemented, but also to provide further opportunities for reflection of their practice within their own classrooms.

## DISCUSSION AND CONCLUSION

Much literature suggests that action research has the capacity to bring about meaningful changes or improvements at the classroom level (Kemmis & McTaggart, 1998). As part of

the action research cycle, reflection is perceived to be an integral component that alerts teachers that a problem exists (Bustingorry, 2008). The present study considered the viability of using student feedback as a basis for reflection and was based on the assumptions that: 1) teachers are genuinely interested in improving their teaching; 2) purposeful reflection provides a medium through which worthwhile change can be brought about; and 3) students, as major stakeholders in the education process, are worth listening to. To this end, the Constructivist-Oriented Learning Environment Survey (COLES) was developed to tap into students' perceptions of important aspects of the learning environment. Student feedback data were used by teachers to help them to reflect on what was happening in their classroom through the eyes of their students.

The refined version of the COLES has 67 items that assess 11 dimensions of the classroom environment, namely, Student Cohesiveness, Teacher Support, Involvement, Personal Relevance, Task Orientation, Cooperation, Equity, Differentiation, Young Adult Ethos, Formative Assessment and Clarity of Assessment Criteria. Incorporated into the questionnaire is a side-by-side response format which enables students to record their views of their actual and preferred learning environment.

As a first step, we established the validity and reliability of the instrument, so that teachers could be confident in the feedback that was provided to them. A sample of 10 345 student responses (2042 student responses in 2008, 4467 in 2009 and 3836 in 2010) in 684 classes (147 classes in 2008, 298 in 2009 and 239 in 2010) in 29 schools were involved over the three year period. For the actual and preferred versions of the COLES, the internal consistency reliability was found to be satisfactory both at the class mean and individual levels of analysis and further analyses supported the ability of the actual form of each of the 11 COLES scales to differentiate between classrooms. These results support the strong validity and reliability of the COLES and can be used in confidence in the future.

For the pre-post data collected in 560 classes, MANOVA was used to examine changes in students' perceptions of the classroom learning environment. The results indicate that, for eight of the eleven COLES scales, there were statistically significant improvements. The study went further to examine whether differences exist between the changes made by those teachers who used the student feedback as a basis for reflection (414 teachers and 508 classes) and the 45 focus teachers (52 classes) who used the feedback as part of a formal

action research process. The results indicated that the posttest differences for the two groups of students was statistically significantly larger for those teachers using a more formal approach than for their counterparts who used the student feedback as a basis for reflection only.

The reflective nature of this study, which involves encouraging teachers to examine their teaching practices through the eyes of their students, offers promise. The results indicate that when teachers reflect on the student feedback, then it is likely that they will make changes to the learning environment that students perceive as more favourable. This component of our study replicates past teacher action research which has been successful in stimulating improvements in classroom environments (Aldridge et al. 2004; Aldridge & Fraser 2008; Aldridge, Fraser & Ntuli, 2009; Fraser & Fisher, 1986; Sinclair & Fraser, 2002; Thorp, Burden & Fraser, 1994; Yarrow, Millwater & Fraser, 1997).

Qualitative data, gathered from the 45 focus teachers, indicated that teachers interpreted the data in ways that were meaningful to the context of their classes. In cases where teachers were unable to explain actual-preferred differences, teachers were likely to discuss the results with their students. Based on the interpretation of the results, teachers generally reported that these helped them to decide upon and implement strategies with the aim of closing the actual-preferred gap. Although our qualitative findings indicated that teachers used a range of strategies, it is recommended that further research involve examining the types of strategies that were most likely to successfully improve the learning environment and whether these differed for different learning environments.

The results indicate that the COLES provides a reliable tool that can be used to generate student feedback data. The teachers were able to use the COLES for the purposes of reflecting on their teaching, providing them with an opportunity to step back from their teaching and reflect on what they do in an objective and analytical manner. An initial examination of the reports, summaries, and reflective journals collected from the 45 focus teachers who agreed to record their activities and be monitored while undertaking a formal action research process using the student feedback data, indicate that the COLES provides valuable data that can be used to prompt reflections to guide teachers to implement classroom changes to improve the classroom learning environment. Further analysis of the qualitative data will provide a greater depth of understanding the ways student feedback data



can be used by teachers to improve classroom learning environments and its potential as a tool for teacher professional development.

## REFERENCES

- Aldridge, J.M., & Fraser, B.J. (2008). Outcomes-focused learning environments: Determinants and effects (*Advances in Learning Environments Research* series). Rotterdam, The Netherlands: Sense Publishers.
- Aldridge, J.M., Fraser, B.J., & Huang, I.T.C. (1999). Investigating classroom environments in Taiwan and Australia with multiple research methods. *Journal of Educational Research*, 93, 48–62.
- Aldridge, J.M., Fraser, B.J., & Ntuli, S. (2009). Utilising learning environment assessments to improve teaching practices among in-service teachers undertaking a distance-education programme. *South African Journal of Education*, 29, 147–170.
- 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., Ort, S.W., & Schmidt, J. (2009). Supporting classroom assessment practice: Lessons from a small high school. *Theory into Practice*, 48, 72–80.
- Anderson, G. L., & Walberg, H. J. (1968). Classroom climate group learning. *International Journal of Educational Sciences*, 2, 175–180.
- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84, 191–215.
- Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, 37, 122–147.
- Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist*, 44, 1175–1184.
- Bell, B., & Cowie, B. (2001). *Formative assessment and science education*. Dordrecht: Kluwer Academic Publishers.
- Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education*, 5, 7–11.
- Bustingorry, S.O. (2008). Towards teachers' professional autonomy through action research. *Educational Action Research*, 16, 407–420.
- Curriculum Council. (1998). *Curriculum framework*. Perth: Curriculum Council of Western Australia.
- Field, A. (2005). *Discovering statistics using SPSS* (2<sup>nd</sup> ed.). London: Sage Publications.
- 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 handbook (TOSRA)*. Melbourne, Australia: Australian Council for Educational Research.
- Fraser, B.J. (1998a). Science learning environments: Assessment, effects and determinants. In B. J. Fraser and K.G. Tobin (Eds.), *International handbook of science education* (pp. 527–564). Dordrecht, The Netherlands: Kluwer.
- Fraser, B.J. (1998b). Classroom environment instruments: Development, validity and applications. *Learning Environments Research: An International Journal*, 1, 7–33.
- 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, CA: McCutchan.

- Fraser, B.J. (2007). Classroom learning environments. In S.K. Abell and N.G. Lederman (Eds.), *Handbook of research on science education* (pp. 103–124). Mahwah, NJ: Lawrence Erlbaum.
- Fraser, B.J., & Fisher, D.L. (1986). Using short forms of classroom climate instruments to assess and improve classroom psychosocial environment. *Journal of Research in Science Teaching*, 23, 387–413.
- Fullan, M. (1999). *Change forces: The sequel*. London: Falmer Press.
- Goh, S.C., & Khine, M.S. (Eds.). (2002). *Studies in educational learning environments: An international perspective*. Singapore: World Scientific.
- Griffin, P., & Smith, P. (1997). *Hindering and facilitating factors in OBE*. Canberra: Australian Curriculum Studies Association.
- Hijzen, D., Boekaerts, M., & Vedder, P. (2007). Exploring the links between students' engagement in cooperative learning, their goal preferences and appraisals of instructional conditions in the classroom. *Learning and Instruction*, 17, 673–687.
- Hoban, G., & Hastings, G. (2006). Developing different forms of student feedback to promote teacher reflection: A 10-year collaboration. *Teaching and Teacher Education*, 22, 1006–1019.
- Jinks, J.L., & Morgan, V. (1999). Children's perceived academic self-efficacy: An inventory scale. *Clearing House*, 72, 224–230.
- Johnson, D.W., & Johnson, R.T., & Smith, K. (2007). The state of cooperative learning in postsecondary and professional settings. *Educational Psychology Review*, 19, 15–29.
- Killen, R. (2002). Outcomes-based education: Principles and possibilities. *Interpretations*, 35(1), 1–18.
- Kemmis, S., & McTaggart, R. (Eds.). (1998). *The action research planner*. Geelong, Australia: Deakin University.
- 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.
- Lewin, K. (1936). *Principles of topological psychology*. New York: McGraw.
- Moos, R.H. (1974). *The Social Climate Scales: An overview*. Palo Alto, CA: Consulting Psychologists Press.
- O'Donovan, B., Price, M., & Rust, C. (2004). Know what I mean?: Enhancing student understanding of assessment standards and criteria. *Teaching in Higher Education*, 9, 325–335.
- Pajares, F. (1996) Self-efficacy beliefs in academic settings. *Review of Educational Research*, 66, 543–578.
- Pallant, J. (2011). *SPSS: Survival manual* (4<sup>th</sup> ed.). Crowsnest, NSW: Allen & Unwin.
- Rennie, L.J. (2004). Equity and the inclusive science curriculum. In G. Venville & V. Dawson (Eds.), *The art of teaching science* (pp. 178–193). Sydney, Australia: Allen & Unwin.
- Rennie, L.J. (2005). Equity in science teaching and learning: The inclusive science curriculum. In S. Alsop, L. Benze & E. Pedretti (Eds.), *Analysing exemplary science teaching* (pp. 183–192). Columbus, OH: Open University Press.
- Rentoul, A. & Fraser, B., (1979). Conceptualisation of Enquiry-Based or Open Classroom Learning Environments, *Journal of Curriculum Studies*, 11(3), 233–245.
- Rhine, S. (1998). The role of research and teachers' knowledge base in professional development. *Educational Researcher*, 27(5), 27–31.
- Schön, D. (1987). *Educating the reflective practitioner*. San Francisco, CA: Jossey-Bass.
- Schunk, D. H. (1989). Self-efficacy and achievement behaviours. *Educational Psychology Review*, 1, 173–208.

- Schunk, D. H., & Pajares, F. (2005). Competence beliefs in academic functioning. In A. J. Elliot & C. Dweck (Eds.), *Handbook of competence and motivation* (pp. 85–104). New York: Guilford Press.
- Sinclair, B.B., & Fraser, B.J. (2002). Changing classroom environments in urban middle schools. *Learning Environments Research*, 5, 301–328.
- Spady, W. (1993). *Outcomes-based education*. Canberra: Australian Curriculum Studies Association.
- Spady, W. (1994). *Outcome-based education: Critical issues and answers*. Arlington, VA: American Association of School Administrators.
- 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* (2<sup>nd</sup> ed.). Hillsdale, NJ: Erlbaum.
- Tan, I.G.C., Sharan, S., & Lee, C.K.E. (2007). Group investigation effects on achievement, motivation, and perceptions of students in Singapore. *Journal of Educational Research*, 100, 142–154.
- Taylor, P.C., & Campbell-Williams, M. (1993). Discourse toward balanced rationality in the high school mathematics classroom: Ideas from Habermas's critical theory. In J.A. Malone & P.C.S. Taylor (Eds.), *Constructivist interpretations of teaching and learning mathematics* (Proceeding of Topic Group 10 at the Seventh International Congress on Mathematical Education; pp. 135–148). Perth, Western Australia: Curtin University of Technology.
- Taylor, P.C., Fraser, B.J., & Fisher, D.L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research*, 27, 293–302.
- Thompson, B. (2004). *Exploratory and confirmatory factor analysis: Understanding concepts and applications*. Washington, DC: American Psychological Association.
- Thorp, H., Burden, R.L., & Fraser, B.J. (1994). Assessing and improving classroom environment. *School Science Review*, 75, 107–113.
- Walberg, H.J. (Ed.). (1979). *Educational environments and effects: Evaluation, policy and productivity*. Berkeley, CA: 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, CA: McCutchan.
- Walker, S. L. (2006). Development and validation of the Test of Geography-Related Attitudes (ToGRA). *Journal of Geography*, 105, 175–181.
- Yarrow, A., Millwater, J., & Fraser, B.J. (1997). Improving university and primary school classroom environments through preservice teachers' action research. *International Journal of Practical Experiences in Professional Education*, 1(1), 68–93.
- Zimmerman, B.J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, 29, 663–676.

