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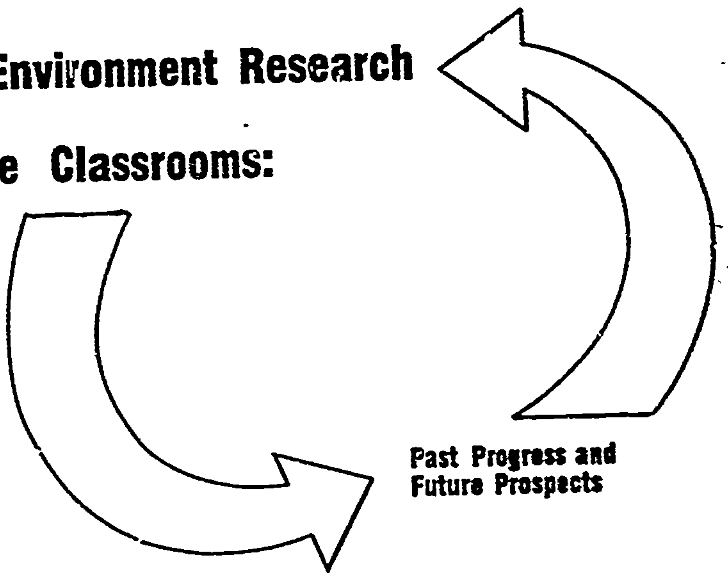
ABSTRACT

In this monograph, an overview of research on learning environments in science classrooms is provided. Various forms of classroom research are compared, including student perceptions, direct observation, case studies, and combinations of ethnographic and student perception methodologies. Included are: (1) "Background," including historical perspectives, and discussions of research approaches and perspectives; (2) "Instruments for Assessing Classroom Environment," including descriptions of six instruments and discussions of alternate forms and scoring procedures; (3) "Research Involving Classroom Environment Instruments"; (4) "Combining Quantitative and Qualitative Methods in the Study of Classroom Environments"; and (5) "Teachers' Attempts To Improve Classroom Environments." Over 200 references are listed. An appendix contains an "acutal short form" of the "My Class Inventory" instrument. (CW)

NARST MONOGRAPH, Number Two, 1989

Learning Environment Research In Science Classrooms:



Past Progress and Future Prospects

Barry J. Fraser

NARST MONOGRAPH, Number Two, 1989

LEARNING ENVIRONMENT RESEARCH IN SCIENCE CLASSROOMS: PAST PROGRESS AND FUTURE PROSPECTS

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The National Association for Research in Science Teaching (NARST) is a professional organization devoted to promoting and disseminating science education research.

FOREWORD

In this second NARST Monograph, Professor Fraser provides an excellent overview of his own extensive work on science classroom environments, as well as related research by others. Various forms of classroom environment research are compared, including student perceptions, direct observation, case studies, and combinations of ethnographic and student perception methodologies.

I find Professor Fraser's proposals for combining quantitative and qualitative methods in the study of classroom environments particularly interesting and most likely to lead to a rich, stable foundation for future science education research.

With colleagues such as Tobin and Walberg, Barry Fraser has established a very impressive literature base and conceptual foundation for the study of classroom psychosocial environments, with science classrooms providing much of the specific data base. I am confident that this NARST Monograph will be extensively used by science education researchers and by practitioners at all levels of education. Whether one's interest is in cooperative grouping, individualized instruction, learning cycle strategies, or any of the many other variations on science education, the information and many references in this monograph on classroom environments will prove valuable.

I congratulate the author on a fine piece of work that meets the high standard for research review and application set by the first NARST Monograph. Together, they form an excellent beginning of what I hope becomes a NARST tradition of producing monographs that have a noticeably positive impact on science education research.

Ron Good

LEARNING ENVIRONMENT RESEARCH IN SCIENCE CLASSROOMS: PAST PROGRESS AND FUTURE PROSPECTS

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INTRODUCTION

Science educators often speak of a classroom's climate, environment, atmosphere, tone, ethos, or ambience and consider it to be both important in its own right and influential in terms of student learning. Although classroom environment is a somewhat subtle concept, nevertheless remarkable progress has been made over the last two decades in conceptualizing it, assessing it, and researching its determinants and effects. Although important classroom climate work has been undertaken by researchers interested in a variety of school subject areas, clearly science education researchers have led the world in terms of developing, validating, and applying classroom environment assessment instruments.

Many questions of interest to teachers, educational researchers, curriculum developers, and policy makers in science education can be asked about classroom environment. Does a classroom's environment affect student learning and attitudes? What is the impact of a new curriculum or teaching method on the nature of a classroom's environment? Can teachers conveniently assess the climates of their own classrooms and can they change these environments? What are some of the determinants of classroom environment? Is there a discrepancy between actual and preferred classroom environment, as perceived by students, and does this discrepancy matter in terms of student outcomes. Do teachers and their students perceive the same classroom environments similarly? The above questions represent the thrust of the work on science classroom environments over the past 20 years and constitute the main areas considered in this monograph.

Traditionally research and evaluation in science education have tended to rely heavily and sometimes exclusively on the assessment of academic achievement and other valued learning outcomes. Although few responsible educators would dispute the worth of outcome measures, these measures cannot give a complete picture of the educational process. Moreover, because students spend up to 15,000 hours at school by the time they finish senior high school (Rutter, Maughan, Mortimore, Ouston & Smith, 1979), students certainly have a large stake in what happens to them at school, and students' reactions to and perceptions of their school experiences are significant. This monograph is devoted to one approach to conceptualizing, assessing, and investigating what happens to students during their schooling. In particular, the main focus is upon students' and teachers' perceptions of important social and psychological aspects of the learning environments of school science classrooms.

In contrast to methods which rely on outside observers, the approach described here defines classroom environment in terms of the shared perceptions of the students and teachers in that environment. This approach has the dual advantage of characterizing the class through the eyes of the actual participants and capturing data which the observer could miss or consider unimportant. Students are at a good vantage point to make judgments about classrooms because they have encountered many different learning environments and have enough time in a class to form accurate impressions. Also, even if teachers are inconsistent in their day-to-day behavior, they usually project a consistent image of the long-standing attributes of classroom environment.

This monograph falls into five main parts. First, an introductory section provides background information about the field of classroom environment (including alternative assessment approaches, a historical perspective on past work, the distinction between school and classroom environment, and the unit-of-analysis question). Second, a section is devoted to instruments for assessing perceptions of classroom psychosocial environment. Third, an overview is given of several lines of past research involving environment assessments in science classrooms (including associations between outcomes and environment, the use of environment dimensions as criterion variables, and person-environment fit studies of whether students achieve better in their preferred environment). Fourth, a description is given of recent research in which quantitative and qualitative methods were combined to advantage within the same classroom environment studies. Fifth, consideration is given to teachers' use of classroom environment instruments in practical attempts to improve their own classrooms.

BACKGROUND

This introductory section sets the scene for the remainder of the monograph by raising four important issues which recur in subsequent sections. First, the method of assessing classroom environment in terms of students' and teachers' perceptions is compared with alternative approaches, and the relative merits of perceptual measures are weighed. Second, a historical perspective is taken on past work which has influenced the ways of conceptualizing, assessing, and investigating classroom environment. Third, the distinction between school-level and classroom-level environment is considered. Fourth, the important issue of choosing an appropriate level or unit of analysis for classroom environment work is discussed.

Approaches to Studying Classroom Environments

The use of students' and teachers' perceptions has been contrasted with the method of direct observation which typically involves an external observer in systematic coding of classroom communication and events according to some category scheme (e.g., Rosenshine & Furst, 1973; Dunkin & Biddle, 1974). The distinction between the "objective" approach of directly observing the environment and the "subjective" approach based on milieu inhabitants' apprehension of the environment is widely recognized in the psychological literature (see Jessor & Jessor, 1973). In particular, Murray (1938) introduced the term alpha press to describe the environment as assessed by a detached observer and the term beta press to describe the environment as perceived by milieu inhabitants.

Rosenshine (1970) makes the distinction between low inference and high inference measures of classroom environment. Low inference measures tap specific explicit phenomena (e.g., the number of student questions), whereas high inference measures require a judgment about the meaning of classroom events (e.g., the degree of teacher friendliness). That is, compared with low inference measures, high inference measures are involved more with the psychological significance that classroom events have for students and teachers. Whereas it has been common for classroom observation schemes to focus on low inference variables, perceptual measures have tended to focus on high inference variables.

Fraser and Walberg (1981) outline some advantages which student perceptual measures can have over observational techniques. First, paper-and-pencil perceptual measures are more economical than classroom observation techniques which involve the expense of trained outside observers. Second, perceptual measures are based on students' experiences over many lessons, while observational data usually are restricted to a very small number of lessons. Third, perceptual measures involve the pooled judgments of all students in a class, whereas observation techniques typically involve only a single observer. Fourth, students' perceptions, because they are the determinants of student behavior more so than the real situation, can be more important than observed behaviors. Fifth, perceptual measures of classroom environment typically have been found to account for considerably more variance in student learning outcomes than have directly observed variables.

Another approach to studying classroom environments involves application of the techniques of naturalistic inquiry, ethnography, and case study which are well illustrated by the vivid descriptions of classroom settings found in popular books such as To Sir With Love and Thirty-Six Children. Some of the other approaches to conceptualizing and assessing human environments delineated by Moos (1973) include ecological dimensions (e.g., meteorological and geographical dimensions as well as the physical design and architectural features reviewed by Weinstein, 1979) or behavior settings which are conceptualized as naturally occurring ecological units concerned, with molar behavior and the ecological context in which it occurs (e.g., Barker & Gump, 1964). In another approach (e.g., Astin & Holland, 1961), the character of an environment is assumed to depend on the nature of its members, while the dominant features of an environment are considered to depend on its members' typical characteristics.

Historical Perspectives

By an interesting coincidence, this monograph is being published approximately two decades since Herbert Walberg and Rudolf Moos began their seminal independent programs of research which form the starting points for the work reviewed in this paper. It was approximately 20 years ago when Walberg began developing earlier versions of the widely used Learning Environment Inventory as part of the research and evaluation activities of Harvard Project Physics (see Anderson & Walberg, 1968; Walberg, 1968; Walberg & Anderson, 1968a, 1986b). Two decades ago also mark the time when Moos began developing the first of his world-renowned social climate scales, including those for use in psychiatric hospitals (Moos & Houts, 1968) and correctional institutions (Moos, 1968), which ultimately resulted in the development of the widely known Classroom Environment Scale (Moos & Trickett, 1984, 1987).

The way that the important pioneering work of Walberg and Moos on perceptions of classroom environment developed into major research programs and spawned a lot of other research is reflected in numerous comprehensive literature overviews. These include books (Moos, 1979a; Walberg, 1979; Fraser, 1986a; Fraser & Walberg, in press; van der Sijde & van de Grift, in press), monographs (Fraser, 1981b; Fraser & Fisher, 1983a), a guest-edited journal issue (Fraser, 1980b), an annotated bibliography (Moos & Spinrad, 1984), several state-of-the-art literature reviews (Randhawa & Fu, 1973; Anderson & Walberg, 1974; Walberg, 1976; Walberg & Haertel, 1980; Chavez, 1984; Fraser, 1986b, 1989b), including special purpose reviews with an emphasis on classroom environment work in science education (Fraser & Walberg, 1981), in Australia (Fraser, 1981a), and in Germany (Dreesman, 1982; Wolf, 1983). As well, the American

Educational Research Association established a very successful Special Interest Group (SIG) on the Study of Learning Environments in 1984 and this group sponsors an annual monograph (e.g., Fraser, 1986c, 1987b, 1988).

Although this paper focuses predominantly upon the classroom environment work which developed over the previous two decades, it is fully acknowledged that this research builds upon and has been influenced by two areas of earlier work. First, the influence of the momentous theoretical, conceptual, and measurement foundations laid half a century ago by pioneers like Lewin and Murray and their followers (such as Pace and Stern) is recognized. Second, Chavez (1984) observes that research involving assessments of perceptions of classroom environment epitomized in the work of Walberg and Moos also was influenced by prior work involving low inference, direct observational methods of measuring classroom climate.

One fruitful way to think about classroom life is in terms of Lewin's (1936) early but seminal work on field theory. Lewin's contribution was to recognize that both the environment and its interaction with personal characteristics of the individual are potent determinants of human behavior (see von Saldern, 1984). The familiar Lewinian formula, $B=f(P,E)$, was first enunciated largely for didactic reasons to stress the need for new research strategies in which behavior is considered to be a function of the person and the environment. Murray (1938) was the first worker to follow Lewin's approach by proposing a needs-press model which allows the analogous representation of person and environment in common terms. Personal needs refer to motivational personality characteristics representing tendencies to move in the direction of certain goals, while environmental press provides an external situational counterpart which supports or frustrates the expression of internalized personality needs. Needs-press theory has been popularized and elucidated in Pace and Stern's (1958) prize-winning and widely cited article and in Stern's (1970) comprehensive book.

Although the work described in this paper clearly has some historical antecedents in the work of Lewin, Murray, and others, earlier writings neither focus sharply on educational settings nor provide empirical evidence to support linkages between climate and educational outcomes. Moreover, the epic work of Pace and Stern (1958), although involving high inference measures of educational environments, focused on higher education institutions rather than high/elementary schools and assessed the environment of the whole college rather than the environment of specific classrooms. Consequently, this monograph's focus on the previous two decades of research on perceived classroom environment is distinctive.

School-Level vs. Classroom-Level Environment

Various writers have found it useful to distinguish classroom or classroom-level environment from school or school-level environment, which involves psychosocial aspects of the climate of whole schools (Anderson, 1982; Fraser & Rentoul, 1982; Genn, 1984). Nevertheless, despite their simultaneous development and logical linkages, the fields of classroom-level and school-level environment have remained remarkably independent. Consequently, it is common for workers in one field to have little cognizance of the other field and for different theoretical and conceptual foundations to be used to underpin the two areas. Although the focus of the present paper is primarily upon classroom-level environment, it also is acknowledged that it would be desirable to break away from the existing tradition of independence of the two fields of school and classroom environment and for there to be a confluence of the two areas.

A common way of viewing school environment is to consider it as something distinct from and more global than classroom environment. For example, whereas classroom climate might involve relationships between the teacher and his/her students or among students, school climate might involve relationships between teachers and their teaching colleagues, head of department, and school principal. Similarly, while classroom environment is usually measured in terms of either student or teacher perceptions, school environment is usually (but not exclusively) assessed in terms of teacher perceptions.

School climate research owes much in theory, instrumentation, and methodology to earlier work on organizational climate in business contexts (Anderson, 1982). This point is clearly illustrated by the fact that two widely used instruments in school environment research, namely, Halpin and Croft's (1963) Organizational Climate Description Questionnaire (OCDQ) and Stern's (1970) College Characteristic Index (CCI), relied heavily on previous work in business organizations. Consequently, one feature of school-level environment work which distinguishes it from classroom-level environment research is that the former has tended to be associated with the field of educational administration and to rest on the assumption that schools can be viewed as formal organizations (Thomas, 1976). Another distinguishing feature is that, whereas classroom-level research has been concentrated on secondary and primary schools rather than in higher education, a sizable proportion of school-level environment research has involved the climate of higher education institutions.

Level of Analysis: Private and Consensual Press

Murray's distinction between alpha press (the environment as observed by an external observer) and beta press (the environment as perceived by milieu inhabitants) has been extended by Stern, Stein, and Bloom (1956) who distinguish between the idiosyncratic view that each person has of the environment (private beta press) and the shared view that members of a group hold about the environment (consensual beta press). Private and consensual beta press could differ from each other, and both could differ from the detached view of alpha press of a trained nonparticipant observer. In designing classroom environment studies, researchers must decide whether their analyses will involve the perception scores obtained from individual students (private press) or whether these will be combined to obtain the average of the environment scores of all students within the same class (consensual press).

A growing body of literature acknowledges the importance and consequences of the choice of level or unit of statistical analysis and considers the hierarchical analysis and multilevel analysis of data (Cronbach & Webb, 1975; Cronbach, 1976; Cronbach & Snow, 1977; Burstein, 1978; Burstein, Linn & Capell, 1978; Lincoln & Zeitz, 1980; Corno, Mitman & Hedges, 1981; Larkin & Keeves, 1984; Goldstein, 1986; von Saldern, 1986). The choice of unit of analysis is of key importance for a number of reasons. First, measures having the same operational definition can different substantive interpretations with different levels of aggregation. Second, it is possible that relationships obtained using one unit of analysis could differ in magnitude and even in sign from relationships obtained using another unit (Robinson, 1950). Third, the use of certain units of analysis (e.g., individuals when classes are the primary sampling units) violates the requirement of independence of observations and calls into question the results of any statistical significance tests because an unjustifiably small estimate of the sampling error is used (Peckham, Glass & Hopkins, 1969; Ross, 1978). One solution to this dilemma followed in recent research (Ross, 1978) is to use the individual as the unit of analysis but to employ the Jack-knife technique (Mosteller & Tukey, 1977) to adjust significance levels to allow for nonindependence of observations. Fourth, the use of different units of analysis involves the testing of conceptually different hypotheses (Cronbach, 1976; Burstein, Linn & Capell, 1978).

For example, in a study of the effects of classroom environment on some student outcome measure, use of the individual as the unit of analysis (i.e., a between-student analysis) involves substantive questions about the relationship between individuals' outcomes and their environment scores when class membership is disregarded. Use of the deviation of a student's score from the class mean as the unit of analysis (i.e., a pooled within-class analysis) involves substantive questions about whether the amount by which a student's classroom environment score differs from that of his or her classmates is related to how much his/her outcome performance differs from the class mean. Use of the class mean as the unit of analysis (i.e., a between-class analysis) asks whether the relationship between class means on the outcome measure varies with the average environment perceptions of the students within a class.

Although the unit of analysis problem has received considerable attention in the context of testing hypotheses using already developed classroom environment instruments, Sirotnik (1980) considers it ironic that concerns about analytic units have been virtually nonexistent at the stage of developing and empirically investigating the dimensionality of new instruments. Because of the central importance of the unit of analysis problem in classroom environment research, subsequent sections of this paper provide recurrent attention to this problem. For example, separate validation information for the individual and the class as the unit of analysis is reported, and the research reviews consider the level of statistical analysis used in different studies.

INSTRUMENTS FOR ASSESSING CLASSROOM ENVIRONMENT

This section clarifies the background and nature of several instruments commonly used in prior research in science education to assess perceptions of classroom learning environment. The instruments considered are the Learning Environment Inventory (LEI), Classroom Environment Scale (CES), Individualized Classroom Environment Questionnaire (ICEQ), My Class Inventory (MCI), College and University Classroom Environment Inventory (CUCEI), and Science Laboratory Environment Inventory (SLEI). Each instrument is suitable for convenient group administration, can be scored either by hand or computer, and has been shown to be reliable in extensive field trials. Each of these instruments is considered in a separate subsection below. In addition, separate subsections are devoted to preferred forms of scales, some economical short forms of the ICEQ, CES, and MCI, hand scoring procedures, and scale validation.

Table 1 shows the name of each scale contained in the LEI, CES, ICEQ, MCI, CUCEI, and SLEI. The table summarizes the level (elementary, secondary, higher education) for which each instrument is suited, the number of items contained in each scale, and the classification of each scale according to Moos's (1974) scheme for classifying human environments. Moos's three basic types of dimension are Relationship Dimensions (which identify the nature and intensity of personal relationships within the environment and assess the extent to which people are involved in the environment and support and help each other), Personal Development Dimensions (which assess basic directions along which personal growth and self-enhancement tend to occur), and System Maintenance and System Change Dimensions (which involve the extent to which the environment is orderly, clear in expectations, maintains control, and is responsive to change).

Learning Environment Inventory (LEI)

The initial development and validation of a preliminary version of the LEI began in the late 1960s in conjunction with the evaluation and research related to Harvard Project Physics (Anderson & Walberg, 1974; Fraser, Anderson & Walberg, 1982). The LEI is a 15-scale expansion and improvement of the Classroom Climate Questionnaire. In selecting the 15 climate dimensions, an attempt was made to include as scales only concepts previously identified as good predictors of learning, concepts considered relevant to social psychological theory and research, concepts similar to those found useful in theory and research in education, or

TABLE 1

Overview of Scales Contained in Five Classroom Environment Instruments (LEI, CES, ICEQ, MCI, and CUCEI)

Instrument	Level	Items Per Scale	Relationship dimensions	Personal development dimensions	System maintenance & change dimensions
			Scales Classified According to Moos's Scheme		
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Friction Favoritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal Direction Disorganization Democracy
Classroom Environment Scale (CES)	Secondary	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order & Organization Rule Clarity Teacher Control Innovation
Individualized Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalization Participation	Independence Investigation	Differentiation
My Class Inventory (MCI)	Elementary	6-9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
College and University Classroom Environment Inventory (CUCEI)	Higher Education	7	Personalization Involvement Student Cohesiveness Satisfaction	Task Orientation	Innovation Individualization
Science Laboratory Environment Inventory (SLEI)	Senior Secondary, Higher Education		Teacher Supportiveness Involvement Student Cohesiveness	Open-Endedness Integration	Organization Rule Clarity Material Environment

concepts intuitively judged relevant to the social psychology of the classroom.

The name of each of the 15 LEI scales is listed in Table 1 and each has a common-sense meaning. The final version of the LEI contains a total of 105 statements (or seven per scale) descriptive of typical school classes. The respondent expresses degree of agreement or disagreement with each statement on a four-point scale with response alternatives of Strongly Disagree, Disagree, Agree, and Strongly Agree. The scoring direction (or polarity) is reversed for some items. A typical item contained in the Cohesiveness scale is: "All students know each other very well." An item from the Speed scale is: "The pace of the class is rushed."

Classroom Environment Scale (CES)

The CES was developed by Rudolf Moos at Stanford University (Trickett & Moos, 1973; Fisher & Fraser, 1983c; Moos & Trickett, 1984, 1987) and grew out of a comprehensive program of research involving perceptual measures of a variety of human environments including psychiatric hospitals, prisons, university residences, and work milieus (Moos, 1974). The original version of the CES consisted of 242 items representing 13 conceptual dimensions. Following trials of the items in 22 classrooms and subsequent items analysis, the number of items was reduced to 208. This item pool was administered in 45 classrooms and modified to form the final 90-item version of the CES. These items were evaluated statistically according to whether they discriminated significantly between the perceptions of students in different classrooms and whether they correlated highly with their scale scores.

Moos and Trickett's (1974, 1987) final published version of the CES contains nine scales with 10 items of True-False response format in each scale. Published materials include a test manual, a questionnaire, an answer sheet, and a transparent hand scoring key. Typical items in the CES are: "The teacher takes a personal interest in the students" (Teacher Support) and "There is a clear set of rules for students to follow" (Rule Clarity).

Individualized Classroom Environment Questionnaire (ICEQ)

The ICEQ differs from other classroom environment scales in that it assesses those dimensions (e.g., Personalization, Participation) which distinguish individualized classrooms from conventional ones. The initial development of the long form ICEQ (Rentoul & Fraser, 1979) was guided by several criteria. First, dimensions chosen characterized the classroom learning environment described in individualized curriculum materials and in the literature of individualized education, including open and inquiry-based classrooms. Second, extensive interviewing of teachers and secondary school students ensured that the ICEQ's dimensions and individual items were considered salient by teachers and students. Third, items were written and subsequently modified after receiving reactions sought from selected experts, teachers, and junior high school students. Fourth, data collected during field testing were subjected to item analyses in order to identify items whose removal would enhance scale statistics.

The final published version of the ICEQ (Fraser, 1989a) contains 50 items altogether, with an equal number of items belonging to each of the five scales. Each item is responded to on a five-point scale with the alternatives of Almost Never, Seldom, Sometimes, Often, and Very Often. The scoring direction is reversed for many of the items. Typical items are: "The teacher considers students' feelings" (Personalization) and "Different students use different books, equipment, and materials" (Differentiation). The published form of the ICEQ consists of a handbook and test master sets from which unlimited number of copies of the questionnaires and response sheets can be made.

<u>My Class Inventory (MCI)</u>

The LEI has been simplified to form the MCI which is suitable for children in the 8-to-12 years age range (Fisher & Fraser, 1981; Fraser, Anderson & Walberg, 1982; Fraser & O'Brien, 1985). Although the MCI was developed originally for use at the elementary school level, it also has been found to be very useful with students in the junior high school, especially those who might experience reading difficulties with the LEI. The MCI differs from the LEI in four important ways. First, in order to minimize fatigue among younger children, the MCI contains only five of the LEI's original 15 scales. Second, item wording has been simplified to enhance readability. Third, the LEI's four-point response format has been reduced to a two-point (Yes-No) response format in the MCI. Fourth, students answer on the questionnaire itself instead of on a separate response sheet to avoid errors in transferring responses from one place to another.

The final form of the MCI contains 38 items altogether (six for Cohesiveness, eight for Friction, eight for Difficulty, nine for Satisfaction, and seven for Competitiveness). Typical items contained in the MCI are: "Children are always fighting with each other" (Friction) and "Children seem to like the class" (Satisfaction). It can be seen that the reading level of these MCI items is well suited to students at the elementary school level.

College and University Classroom Environment Inventory (CUCEI)

Although some notable prior work has focused on the institutional-level or school-level environment in colleges and universities (e.g., Pace & Stern, 1958; Halpin & Croft, 1963; Stern, 1970), surprisingly little work has been done in higher education classrooms which is parallel to the traditions of classroom environment research at the secondary and elementary school levels. As one likely explanation for this shortage is simply the unavailability of a suitable instrument, the CUCEI was developed to fill this void. The CUCEI is intended for use in small classes (say up to 30 students) sometimes referred to as seminars; it is not suited to lectures or laboratory classes (Fraser & Treagust, 1986; Fraser, Treagust & Dennis, 1986).

The initial development of the CUCEI involved examining the scales and items in the LEI, CES, and ICEQ to identify concepts and ideas relevant to higher education settings. An initial pool of items was developed and then modified, first after subjecting items to the scrutiny of colleagues and then after performing item analyses on data collected during field trials. The final form of the CUCEI contains seven seven-item scales. Each item has four responses (Strongly Agree, Agree, Disagree, Strongly Disagree) and polarity is reversed for approximately half of the items. Typical items are: "Activities in this class are clearly and carefully planned" (Task Orientation) and "Teaching approaches allow students to proceed at their own pace" (Individualization).

Science Laboratory Environment Inventory (SLEI)

Because of the critical importance and uniqueness of laboratory settings in science education, a new instrument specifically suited to assessing the environment of science laboratory classes at the senior high school or higher education levels recently was developed in collaboration with colleagues from various countries. This new questionnaire, the SLEI, has the eight seven-item scales listed in Table 1 and the five response alternatives are Almost Never, Seldom, Sometimes, Often, and Very Often. A noteworthy feature of the validation procedures employed is that the SLEI is being field tested simultaneously in six countries (the USA, Canada, England, Israel, Australia, and Nigeria) in order to furnish comprehensive information about the instrument's cross-national validity and usefulness.

Preferred Forms of Scales

A distinctive feature of most of the instruments in Table 1 is that they have, not only a form to measure perceptions of actual classroom environment, but also another form to measure perceptions of preferred classroom environment. The preferred (or ideal) forms are concerned with goals and value orientations and measure perceptions of the classroom environment ideally liked or preferred. Although item wording is identical or similar for actual and preferred forms, different instructions for answering each are used. Having different actual and preferred forms has enabled these instruments to be used for the range of new research applications which are discussed later in this publication. Although the LEI and MCI originally were designed only to measure actual environment, Fraser and Deer (1983) and Fraser and O'Brien (1985) have used a preferred form of the MCI successfully with elementary school classes.

Short Forms of ICEQ, MCI, and CES

Despite the fact that the long forms of classroom environment instruments have been used successfully for a variety of purposes, some researchers have expressed a preference for a more rapid and economical instrument. Similarly some teachers using these scales for local, school-based applications have reported that they would like instruments to take less time to administer and score. Consequently, short forms of the ICEQ, MCI, and CES were developed (Fraser, 1982a; Fraser & Fisher, 1983b) to satisfy three main criteria. First, the total number of items in each instrument was reduced to approximately 25 to provide greater economy in testing and scoring time. Second, the short forms were designed to be amenable to easy hand scoring. Third, although most existing classroom environment instruments were developed to provide adequate reliability for the assessment of the perceptions of individual students, the majority of applications involve averaging the perceptions of students within a class to obtain class means. Consequently, it was decided that the short forms would be developed to have adequate reliability for uses involving the assessment of class means. The use of the long form of these instruments, however, is still recommended for applications involving the individual student as the unit of analysis.

The development of the short forms was based largely on the results of several item analyses performed on data obtained by administering the long form of each instrument to a large sample of science students. In particular, the internal consistency of each scale was maximized by selecting items with large item-remainder correlations (i.e., correlations between item score and total score on the rest of the scale), and discriminant validity was enhanced by including an item only if the correlation with its a priori assigned scale was smaller than the correlation with any other items in the battery. In addition to these statistical criteria, the development of the short forms was based on logical considerations including face validity and an attempt to achieve a balance of items with positive and negative scoring directions (both within each scale and within each instrument as a whole). Nevertheless, because the long forms of some scales have an imbalance in the number of items with positive and negative polarity, this imbalance tended to be maintained in the short forms of these scales.

The application of the above criteria led to the development of short forms of the ICEQ and the MCI each consisting of 25 items divided equally among the five scales comprising the long form of each instrument. Because the long form of the CES consisted of 90 items, this was reduced considerably to form a short version with 24 items divided equally among six of the original nine scales. Furthermore, the development of this short form was guided by the fact that Trickett and Moos (1973) previously had recommended a short four-item version of each of the CES's nine scales. In fact, the present short form consists of five scales which are identical to those recommended by Trickett and Moos (namely, Involvement, Affiliation, Teacher Support, Order and Organization, and Rule Clarity) and a sixth scale (namely, Task Orientation) which contains two out of the four items recommended.

In order to clarify the nature of the short forms, a copy of the actual short form of the MCI is shown in Appendix A. Unlike the long form, the short form of the MCI does not need to make use of a separate answer sheet because all items and space for responding fit on a single page.

Hand Scoring Procedures

Appendix A illustrates typical hand scoring procedures for one classroom environment instrument, namely, the short form of the MCI. First, inclusion of the letter R in the Teacher Use Only column identifies those items which need to be scored in the reverse direction. Second, items are arranged in blocks and in cyclic order so that all items from the same scale are found in the same position in each block. For example, the first item in each block of five items in the MCI belongs to the Satisfaction scale (see Appendix A). Items in Appendix A without the letter R are scored by allocating a score of 3 for the response Yes and 1 for the response No. Underlined items with the letter R are scored in the reverse manner. Omitted or invalidly answered items are scored 2.

To obtain scale totals, the five item scores for each scale are added. The first, second, third, fourth, and fifth items in each block of five, respectively, measures Satisfaction, Friction, Competitiveness, Difficulty, and Cohesiveness. For example, the total Satisfaction score is obtained by adding scores for items 1, 6, 11, 16, and 21. Scale totals can be written in the spaces provided at the bottom of the questionnaire Appendix A illustrates how these scoring procedures were used to obtain a total of 10 for the Satisfaction scale and a total of 12 for the Cohesiveness scale.

Validation of Scales

This subsection reports typical validation data for some classroom environment scales. Table 2 provides a summary of a limited amount of statistical information for the five instruments (the LEI, CES, ICEQ, MCI, and CUCEI) considered previously. (Comprehensive validation information was not yet available for the recently-developed SLEI at the time of writing this monograph.) Attention is restricted to the student actual form and to the use of the individual student as the unit of analysis. Table 2 provides information about each scale's internal consistency reliability (alpha coefficient) and discriminant validity (using the mean correlation of a scale with the other scales in the same instrument as a convenient index), and the ability to differentiate between the perceptions of students in different classrooms (significance level and eta^2 statistic from ANOVAs). Statistics are based on 1,048 students for the LEI, except for discriminant validity data which are based on 149 class means (Fraser, Anderson & Walberg, 1982), 1,083 students for the CES (Fisher & Fraser, 1983c), 1,849 students for the ICEQ (Fraser, 1989a), 2,035 students for the MCI (Fisher & Fraser, 1981), and 372 students for the CUCEI (Fraser & Treagust, 1986). Generally the data reported in Table 2 suggest that the actual form of each scale of each instrument has adequate internal consistency reliability and discriminant validity (although each instrument appears to assess somewhat overlapping aspects) and has the ability to differentiate between classrooms (although no data are available for the LEI for this characteristic).

TABLE 2. Internal Consistency (Alpha Reliability), Discriminant Validity (Mean Correlation of a Scale with Other Scales), and ANOVA Results for Class Membership Differences (Eta^2 Statistic and Significance Level) for Student Actual Form of Five Instruments Using Individual as Unit of Analysis

Learning Environment Inventory

Scale	Alpha Rel. (N = 1048 Students)	Mean Correl. with Other Scales (N = 149 classes)	ANOVA Results Eta^2
Cohesiveness	0.69	0.14	-
Diversity	0.54	0.16	-
Formality	0.76	0.18	-
Speed	0.70	0.17	-
Material Environment	0.56	0.24	-
Friction	0.72	0.36	-
Goal Direction	0.85	0.37	-
Favoritism	0.78	0.32	-
Difficulty	0.64	0.16	-
Apathy	0.82	0.39	-
Democracy	0.67	0.34	-
Cliqueness	0.65	0.33	-
Satisfaction	0.79	0.39	-
Disorganization	0.82	0.40	-
Competitiveness	0.78	0.08	-

Classroom Environment Scale (N = 1,083 students)

Scale	Alpha Rel.	Mean Correl. with Other Scales	ANOVA Results Eta^2
Involvement	0.70	0.40	0.29*
Affiliation	0.60	0.24	0.21*
Teacher Support	0.72	0.29	0.34*
Task Orientation	0.58	0.23	0.25*
Competition	0.51	0.09	0.18*
Order & Organization	0.75	0.29	0.43*
Rule Clarity	0.63	0.29	0.21*
Teacher Control	0.60	0.16	0.27*
Innovation	0.52	0.19	0.26*

Individualized Classroom Environment Questionnaire (N = 1,849 students)

Scale	Alpha Rel.	Mean Correl. with Other	ANOVA Results Eta^2
Personalization	0.79	0.28	0.31*
Participation	0.70	0.27	0.21*
Independence	0.68	0.07	0.30*
Investigation	0.71	0.21	0.20*
Differentiation	0.76	0.10	0.43*

My Class Inventory (N = 2,305 students)

Scale	Alpha Rel.	Mean Correl. with Other	ANOVA Results Eta^2
Cohesiveness	0.67	0.20	0.21*
Friction	0.67	0.26	0.31*
Difficulty	0.62	0.14	0.18*
Satisfaction	0.78	0.23	0.30*
Competitiveness	0.71	0.10	0.19*

College and University Classroom Environment Inventory (N = 372 students)

Scale	Alpha Rel.	Mean Correl. with Other	ANOVA Results Eta^2
Personalization	0.75	0.46	0.35*
Involvement	0.70	0.47	0.40*
Student Cohesiveness	0.90	0.45	0.47*
Satisfaction	0.88	0.45	0.32*
Task Orientation	0.75	0.38	0.43*
Innovation	0.81	0.46	0.41*
Individualization	0.78	0.34	0.46*

* $p<0.01$

Table 3 illustrates the reporting of more comprehensive validation information for one instrument, namely, the ICEQ. This table incorporates reliability and discriminant validity data separately for students and teachers, separately for actual and preferred forms, and separately using the individual and class mean as the unit of analysis for the student statistics. The sample consists of 1,849 students in 150 junior high school classes in Australia for the student actual form, 1,858 students in the same 150 classes for the preferred form, 90 teachers of some of the same classes for the teacher actual form, and 34 teachers of some of the same classes for the student preforred form. Overall Table 3 suggests that the ICEQ displays adequate internal consistency reliability and discriminant validity for use with students or teachers, in its actual or preferred form, and using either the individual student or the class mean as the unit of analysis.

RESEARCH INVOLVING CLASSROOM ENVIRONMENT INSTRUMENTS

In order to illustrate the range of possible uses of classroom environment scales, past studies which have employed various instruments are briefly reviewed in this section. The three types of research considered involved (a) associations between student outcomes and classroom environment, (b) use of classroom environment dimensions as criterion variables (including curriculum evaluation studies and investigations of differences between students' and teachers' perceptions of the same classrooms), and (c) investigations of whether students achieve better when in their preferred environments.

TABLE 3. Internal Consistency (Alpha Reliability) and Discriminant Validity (Mean Correlation of a Scale with Other Four Scales) for Two Units of Analysis for ICEQ

Scale	Unit of Analysis	Alpha Reliability				Mean Correlation with Other Scales			
		Student actual (N=1849 & 150)[a]	Student pref. (N=1858 & 150)[a]	Teacher actual (N=90)	Teacher pref. (N=34)	Student actual (N=1849 & 150)[a]	Student pref. (N=1858 & 150)[a]	Teacher actual (N=90)	Teacher pref. (N=34)
Personalization	Individual	0.79	0.74	0.79	0.74	0.28	0.31	0.32	0.29
	Class	0.90	0.86			0.31	0.35		
Participation	Individual	0.70	0.67	0.79	0.82	0.27	0.29	0.39	0.34
	Class	0.80	0.75			0.32	0.32		
Independence	Individual	0.68	0.70	0.83	0.86	0.07	0.12	0.23	0.25
	Class	0.78	0.79			0.16	0.17		
Investigation	Individual	0.71	0.75	0.80	0.90	0.21	0.27	0.34	0.33
	Class	0.77	0.83			0.29	0.31		
Differentiation	Individual	0.76	0.75	0.85	0.81	0.10	0.16	0.29	0.16
	Class	0.91	0.92			0.19	0.20		

[a] The sample sizes shown are the number of individual students and classes, respectively.

Associations Between Student Outcomes and Classroom Environment

The strongest tradition in past classroom environment research has involved investigation of associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Haertel, Walberg & Haertel, 1981). Numerous research programs have shown that student perceptions account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics. The practical implication from this research is that student outcomes might be improved by creating classroom environments found empirically to be conducive to learning.

Table 4 provides a broad overview of the comprehensive set of past studies in which the effects of classroom environment on science student outcomes were investigated. The only studies included in this table are ones whose sample consisted wholly or partly of science classes at the secondary or higher education levels, or of elementary school classes in which students take all their subjects including science with the same teacher and in the same room. Table 4 excludes studies which involved non-science subject areas such as mathematics (O'Reilly, 1975) and social studies (Cort, 1979; Fraser, Pearse & Azmi, 1982). Studies are grouped according to whether they involved use of the LEI, CES, ICEQ, MCI, or other instruments. Also research in developing countries is grouped together. This table shows that studies of associations between outcome measures and classroom environment perceptions have involved a variety of cognitive and affective outcome measures, a variety of classroom environment instruments, and a variety of samples (ranging across numerous countries and grade levels).

The findings from prior research are highlighted in the results of an ambitious meta-analysis involving 734 correlations from a collection of 12 studies of 10 data sets from 823 classes in eight subject areas containing 17,805 students in four nations (Haertel, Walberg & Haertel, 1981). Learning posttest scores and regression-adjusted gains were found to be consistently and strongly associated with cognitive and affective learning outcomes, although correlations were generally higher in samples of older students and in studies employing collectivities such as classes and schools (in contrast to individual students) as the units of statistical analysis. In particular, better achievement on a variety of outcome measures was consistently found in classes perceived as having greater Cohesiveness, Satisfaction, and Goal Direction, and less Disorganization and Friction.

Fisher and Fraser's (1983b) study reported in Table 5 illustrates some of the methodological complexity involved in rigorous studies of the effects of classroom environment on student outcomes. This study used the data base from the sample of science classes in Tasmania. It consisted of a representative group of 116 Grade 8 and 9 classes, each with a different teacher, in 33 different schools. Approximately equal numbers of schools were in country and suburban areas, and approximately equal numbers of boys and girls made up the sample. Although the sample was not randomly chosen, it was carefully selected to be as representative as possible of the population of schools.

Three cognitive and six affective measures were administered both at the beginning and end of the same school year, while classroom environment was assessed by administering the CES at mid-year. The three cognitive outcomes were measured by the Test of Enquiry Skills (Fraser,

TABLE 4. Studies of Associations Between Student Outcomes and Classroom Environment

Study	Outcome Measures	Sample
Studies Involving LEI		
Anderson & Walberg (1968); Walberg & Anderson (1968a); Anderson (1970); Walberg (1969b, c, 1972)	Selected from: achievement; understanding of nature of science; science processes; participation in physics activities; science interest; attitudes	Various samples (maximum of 144 classes) of senior high school physics students mainly in USA, but with some in Canada
Walberg & Anderson (1972)	Examination results	1,600 Grade 10 and 11 students in various subject areas in 64 classes in Montreal, Canada
Lawrenz (1976)	Science attitudes	238 senior high school science classes in midwest USA
Fraser (1978, 1979a)	Inquiry skills; attitudes; understanding of nature of science	531 students in 20 Grade 7 science classes in Melbourne, Australia
Power & Tisher (1975, 1979)	Achievement; attitudes; satisfaction	315 junior high school students in 20 science classes in Melbourne, Australia
Hofstein et al. (1979)	Attitudes	400 Grade 11 students in 12 chemistry classes in Israel
Haladyna, Olsen & Shaughnessy (1982); Haladyna, Shaughnessy & Redsun (1982a, b); Haladyna, Shaughnessy & Shaughnessy (1983)	Attitudes	5,804 science, mathematics and social studies students in 277 Grade 4, 7 and 9 classes in Oregon, USA
Studies Involving CES		
Trickett & Moos (1974)	Satisfaction and mood criteria	608 students in 18 classes in USA
Moos & Moos (1978)	Absences; grades	19 high school classes in one school in USA
Moos (1979a)	Indexes of student reactions	241 secondary school classes in various subject areas
Fisher & Fraser (1983b) (See study reported in detail in this monograph)	Inquiry skills; attitudes	116 Grade 8 and 9 science classes throughout Tasmania, Australia
Galluzi et al. (1980)	Psychological outcomes	414 Grade 9 students in USA
Humphrey (in press)	Self-control	750 Grade 4 and 5 children in 36 classes in USA
Keyser & Barling (1981)	Academic self-efficacy beliefs	504 Grade 6 children in South Africa

TABLE 4 (Continued)

Study	Outcome Measures	Sample
Studies Involving ICEQ		
Rentoul & Fraser (1980)	Inquiry skills; enjoyment	285 junior high school students in 15 science and social science classes in Sydney, Australia
Wierstra (1984)	Attitudes; achievement	398 15-16 year-old students in 9 classes in the Netherlands
Wierstra et al. (1987)	Attitudes; achievement	1,105 secondary school students in 66 classes involved in Dutch option of Second International Science Study
Fraser (1981c); Fraser & Butts (1982)	Attitudes	Maximum of 712 students in 30 junior high school science classes in Sydney, Australia
Fraser, Nash & Fisher (1983)	Anxiety	116 Grade 8 and 9 science classes throughout Tasmania, Australia
Fraser & Fisher (1982b)	Inquiry skills; attitudes	116 Grade 8 and 9 science classes throughout Tasmania, Australia
Studies Involving MCI		
Fraser & Fisher (1982a, c)	Inquiry skills; understanding of nature of science; attitudes	2,305 Grade 7 science students in 100 classes in Tasmania, Australia
Payne et al. (1974-75); Ellett et al. (1977); Ellett & Walberg (1979)	Achievement; school attendance	6,151 Grade 4 students in 89 schools in Georgia, USA
Fraser & O'Brien (1985)	Word knowledge; comprehension	758 Grade 3 students in 32 classes in Sydney, Australia
Lawrenz (1988)	Energy Knowledge; two energy attitude scales	Approximately 1,000 Grade 4 and 7 students in 34 classes in Arizona, USA
Studies Involving Other Instruments		
Kelly (1980)	Achievement	41,657 students in 1,735 schools in 14 developed countries involved in an IEA science study
Johnson et al. (1981); Johnson et al. (1984); Slavin (1983a,b)	Different studies included: achievement; cross-ethnic relationships; cross-handicap relationships	Various samples involved in studies of cooperative learning strategies in various subjects, especially in USA
Fraser & Treagust (1986)	Satisfaction; locus of control	372 higher education students in 34 classes in various subject areas
Talton (1983)	Attitude; achievement	1,456 Grade 10 biology students in 70 classes in 4 schools in North Carolina

TABLE 4 (Continued)

Study	Outcome Measures	Sample
Perkins (1978)	Basic skills	3,703 Grade 4 students in 42 elementary schools in a SE state in USA
Brookover & Schneider (1975); Brookover et al. (1978, 1979)	Achievement	8,078 Grade 4 and 5 students in Michigan, USA
Gardner (1974, 1976)	Attitudes	1,014 Grade 11 physics students in 58 classses in Melbourne, Australia
Payne et al. (1974-75); Ellett & Walberg (1979)	Achievement	3,350 elementary and 3,613 secondary students in various subject areas and 1,200 teachers in Georgia, USA
Wubbels et al. (1988)	Achievement; attitudes	1,105 secondary school students in 66 classes involved in Dutch option of Second International Science Study
<u>Studies in Developing Countries</u>		
Walberg, Singh & Kasher (1977)	Achievement	3,000 Grade 10 science and social science students in 150 classes in Rajasthan, India
Schibeci, Rideng & Fraser (1987)	Attitudes	250 Grade 11 biology students in six classes in Indonesia
Paige (1978, 1979)	Achievement; individual modernity	1,621 Grade 6 students in 60 schools in East Java, Indonesia
Holsinger (1972, 1973)	Information learning; individual modernity	2,533 Grade 3-5 students in 90 classes in Brazil
Persaud (1976)	Noncognitive outcomes including social development and aspiration levels	1,277 Grade 3 and 6 students in 18 schools in Jamaica
Chatiyanonda (1978)	Attitudes	989 Grade 12 physics students in 31 classes in or near Bangkok, Thailand

1979b) and the six attitude measures each consisted of ten items of Likert format selected from the Test of Science-Related Attitudes (Fraser, 1981d). In addition, information was gathered about the general ability of the students using a version of the Otis test. In order to permit comparison with results from methodologically diverse past studies, data were analysed in six different ways (namely, simple, multiple, and canonical correlation analyses performed separately for raw posttest scores and residual posttest scores adjusted for corresponding pretest and general ability).

It has been common in prior research to perform a conservative test of outcome-environment relationships by controlling statistically certain student characteristics, especially corresponding pretest and general ability. That is, for reasons of simplicity, learning environment dimensions have been considered useful predictors of student learning outcomes only if they accounted for different variance from that attributable to well-established predictors such as pretest and general ability (Walberg & Haertel, 1980). While conservative analyses in which student characteristics are controlled have the merit that they do not overestimate the variance component attributable to environment, they might well underestimate the importance of the environment component because any variance shared by environment and student characteristics is removed. For this reason, all analyses (simple, multiple, canonical correlation) were performed twice, once using raw posttest scores as the criterion variables and once using residual posttest scores adjusted for corresponding pretest and general ability.

Table 5 shows the results of the six types of analyses. The first pair of analyses are the least complex as they involve simple correlations between class means on the nine environment scales and class means on each of the nine outcome posttests (using either raw scores or residual scores). A major advantage of these simple correlational analyses is that they furnish data to other workers interested in associations between particular environment variables and particular outcomes. The results in Table 5 show that the number of significant outcome-environment correlations ($p<0.05$) was 27 for the analyses involving raw posttest scores (i.e., about seven times that expected by chance) and 18 for the analyses using residual posttest scores (about four times that expected by chance).

The second pair of analyses reported in Table 5 consisted of a multiple correlation analysis involving the set of nine environment scales performed separately for each outcome using either raw or residual criterion scores. The multiple correlation provides a more parsimonious picture of the joint influence of correlated environment dimensions on outcomes and reduces the Type I error rate associated with simple correlational analyses. These analyses are likely to be of particular relevance to people interested in particular outcome measures. Table 5 shows that the multiple correlation between raw outcome scores and the set of classroom environment scales ranged from 0.30 to 0.51 and was significantly greater than zero ($p<0.05$) for seven of the nine outcomes. As expected, multiple correlations were smaller for analyses involving residual scores, but their magnitudes still ranged from 0.27 to 0.47 with four of these being statistically significant.

In order to interpret which individual classroom environment scales were making the largest contribution to explaining variance in learning outcomes, an examination was made of *b* and beta weights for those

TABLE 5. Simple, Multiple, and Canonical Correlations Between Classroom Environment Dimensions and Learning Outcomes (Using Raw Outcome Scores and Residual Scores Adjusted for Corresponding Pretest and General Ability)

Learning Outcomes	Raw Scores/ Residuals[a]	Simple Correlation: Invol	Affil	Teach Supp	Task Orien	Comp	Order & Org	Rule Clar	Teach Contr	Innov	Multiple Correl- ation	Beta Weights for Significant Individual Environment Predictors[b]
Social Implicat- ions of Science	Raw Scores	.22*	.16	.16	.25**	.20*	.30**	.24*	.02	.06	.30*	.34* (Order & Org)
	Residuals	.27**	.24*	.15	.25**	.14	.33**	.26**	.03	.00	.39*	.36* (Order & Org)
Enjoyment of Science Lessons	Raw Scores	.42**	.20*	.27**	.17	.13	.45**	.25**	-.02	.20*	.49**	.43** (Order & Org)
	Residuals	.36**	.27*	.16	.22*	.02	.40**	.20*	.05	.03	.44**	.30* (Order & Org)
Attitude to Normality of Scientists	Raw Scores	.12	.10	.07	.23*	.03	.16	.10	.08	-.20*	.39*	.37* (Teach Supp);-.37** (Innov)
	Residuals	.17	.11	.15	.07	-.04	.10	.18	.08	-.04	.31	
Attitude to Inquiry	Raw Scores	.11	.18	.05	.18	.07	.10	.23*	.6.	.03	.30*	.25* (Rule Clar)
	Residuals	.10	.18	.04	.13	.05	.09	.23*	.09	.01	.29	
Adoption of Sci- entific Attitudes	Raw Scores	.07	.29**	.10	.25**	.14	.17	.06	-.04	-.13	.44**	.27* (Affil); -.26* (Innov)
	Residuals	.16	.26**	.21*	.07	-.01	.18	.15	-.02	.06	.	
Leisure Interest in Science	Raw Scores	.28**	.22*	.11	.25**	.08	.41**	.25**	.04	.20*	.51**	.56** (Order & Org); .31** (Innov)
	Residuals	.30**	.12	.11	.12	-.11	.35**	.21*	.00	.23*	.49**	.45** (Order & Org); .32* (Innov)
Comprehension of Science Reading	Raw Scores	.02	.13	-.03	.15	.05	.13	-.05	-.04	-.13	.30	
	Residuals	.11	.13	.00	.03	.03	.17	.06	.06	.01	.27	
Design of Experimental Procedures	Raw Scores	-.08	.03	-.06	.22*	.18	.11	.01	.05	-.20*	.37	
	Residuals	-.05	-.05	-.02	-.05	.09	.05	.09	.12	-.05	.28	
Conclusions and Generalizations	Raw Scores	.08	.17	.06	.31**	.15	.22*	-.02	.04	-.20*	.47**	.35* (Teach Supp); .27* (Task Orien) -.28* (Innov)
	Residuals	.18	.12	.07	.14	.07	.26**	.07	.12	-.02	.38**	.35* (Order & Org)

Canonical Correlations: Raw Scores .67**, .54*; Residuals .62**

*p<.05, **p<.01

[a] Residual scores have been adjusted for performance on the corresponding pretest and general ability.

[b] Beta weights are shown for those individual predictors for which, first, the corresponding block of nine environment scales had a significant multiple correlation and, second, the b weight was significantly different from zero.

regression equations for which the multiple correlation for the whole block of nine environment scales had been found to be significantly greater than zero ($p<0.05$). The right hand side of Table 5 lists the magnitude of the beta weight for those individual environment scales whose *b* weights were significantly different from zero ($p<0.05$) and for which the corresponding block of environment scales also had a significant multiple correlation. This requirement that the multiple correlation for the whole block of environment scales should meet the 0.05 significance criterion provides protection against an inflated experimentwise Type I error rate. This table shows that the number of significant relationships for individual environment variables was 11 for raw criterion scores and 5 for residual criterion scores. Some specific examples of the results for residual scores are that Social Implications of Science scores were higher in classes perceived as having greater Order and Organization, and Leisure Interest in Science scores were higher in classes perceived as having greater Order and Organization and Innovation.

Although use of multiple correlation analyses overcomes the problems of collinearity between environment scales, collinearity between outcome measures could still give rise to an inflated experimentwise Type I error rate Canonical analysis, however, can provide a parsimonious picture of relationships between a domain of correlated learning outcomes and a domain of correlated environment dimensions. Consequently, two canonical analyses were conducted (one involving raw outcome scores and one involving residual scores) using the class mean as the unit of analysis. The bottom of Table 5 shows that both canonical analyses yielded at least one significant canonical correlation. Two significant canonical correlations of 0.67 ($p<0.01$) and 0.54 ($p<0.05$), respectively, were found between environment scales and raw posttest scores, while one significant canonical correlation of 0.62 ($p<0.01$) was found between environment scales and residual posttest scores.

In order to interpret the results of the canonical analyses, an examination was made of the magnitudes and signs of the structure coefficients (i.e., simple correlations of a canonical variate with its constituent variables) associated with each significant canonical variate. The interpretation of the first significant canonical correlation for the analysis involving raw scores was readily interpretable. It indicated that attitude scores on the Enjoyment of Science Lessons and Leisure Interest in Science scales were higher in classes perceived as having greater Order and Organization and Innovation. The interpretation of the second significant canonical correlation for the analysis of raw scores was less straightforward, but it suggested that cognitive outcome scores on the Conclusions and Generalizations scale tended to occur in classes perceived as having more Teacher Support and less Innovation. The straightforward interpretation of the significant canonical correlation for residual scores was that, with corresponding pretest scores and general ability controlled, Leisure Interest in Science scores were greater in classrooms perceived as having greater Order and Organization.

The separate methods of analysis yielded consistent support for the existence of outcome-environment relationships and led to no major conflicts when explicating the specific form of such relationships in terms of particular outcomes and environment dimensions. However, as expected, the interpretation for individual variables varied somewhat with the presence or absence of control for student background characteristics (i.e., the raw scores vs. residuals analyses) and with the extent to which collinearity among variables was allowed for (i.e., simple, multiple, or canonical correlational analyses). Nevertheless the present study still has some important tentative implications for educators wishing to enhance science students' achievement of particular outcomes by creating classroom environments found empirically to be conducive to achievement. For example, practitioners are likely to find useful the present finding that Order and Organization seems to have a positive influence on student achievement of a variety of aims.

Use of Classroom Environment Perceptions as Criterion Variables

Table 6 overviews studies in which classroom environment dimensions were employed as dependent variables for a wide range of purposes. This table organizes past studies under three themes, namely, (a) curriculum evaluation studies, (b) differences between student and teacher perceptions of actual and preferred environment, and (c) studies involving other independent variables. The studies chosen for inclusion in Table 6 are restricted to ones involving samples consisting wholly or partly of science classes (including elementary classes in which students take all of their subjects with the same teacher). Studies involving students in other subject areas, such as social science (Baba & Fraser, 1983; Cort, 1979), are excluded.

Curriculum Evaluation. One promising but largely neglected use of classroom environment instruments is as a source of process criteria in curriculum evaluation (Walberg, 1975, Fraser, 1981b; Fraser, Williamson &

TABLE 6. Studies Using Classroom Environment Perceptions as Criterion Variables

Study	Instrument	Independent Variable
Curriculum Evaluation Studies		
Anderson et al. (1969); Welch & Walberg (1972)	LEI	Use of Harvard Project Physics
Fraser (1976, 1979a); Tisher & Power (1976, 1978); Power & Tisher (1979); Northfield (1976);	LEI CAQ (Steele et al., 1971)	Use of Australian Science Project
Kuhlemeier (1983); Wierstra (1984); Wierstra et al. (1987)	ICEQ	Use of new Dutch physics curriculum
Levin (1980)	LEI	Use of individualized curriculum
Ainley (1978)	Locally developed	Standard of science facilities
Differences Between Student/Teacher and Actual/Preferred Forms		
Fisher & Fraser (1983a); Moos (1979a)	CES	Student actual vs. student preferred; student actual vs. teacher actual
Fraser (1982b)	ICEQ	Four forms (as above)
Fraser (1985)	MCI	Four forms (as above)
Fraser & Treagust (1986)	CUCEI	Four forms (as above)
Other Studies Involving Environment Dimensions as Criterion Variables		
Trickett et al. (1976, 1982)	CES	Single-sex vs. coeducational schools; independent vs. public schools
Fraser & Rentoul (1982)	ICEQ	School-level environment
Ellett & Masters (1978)	MCI	School-level environment
Lawrenz & Welch (1983)	LEI	Sex of science teacher
Walberg (1968)	LEI	Teacher personality

TABLE 6 (Continued)

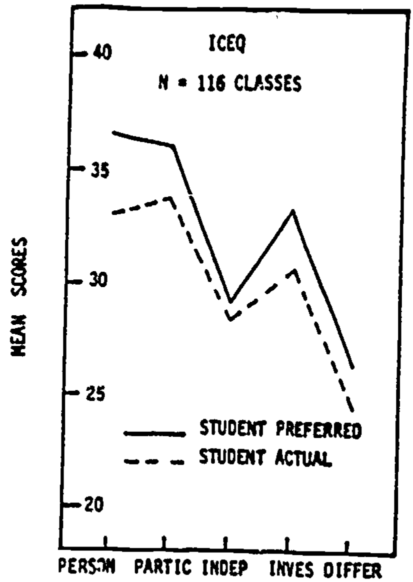
Study	Instrument	Independent Variable
Walberg & Anderson (1968b)	LEI	"Achieving" vs. "creative" classes
Walberg (1969a) Anderson & Walberg (1972)	LEI	Class size
Walberg & Ahlgren (1970)	LEI	Various variables
Shaw & Mackinnon (1973); Randhawa & Michayluk (1975); Welch (1979)	LEI	Grade level
Anderson (1971); Steele et al. (1974); Kuert (1979); Welch (1979)	LEI CAQ (Steele et al., 1971)	Differences between school subjects
Hearn & Moos (1978)	CES	Differences between school subjects classified according to Holland's occupational classification
Randhawa & Michayluk (1975); Hofstein et al. (1980); Sharan & Yaakobi (1981)	LEI	Type of school
Trickett (1978)	CES	Type of public school (urban, rural, suburban, vocational, alternative)
Moos (1979a, 1980)	CES	Differences in overall context, architectural characteristics, organizational characteristics; teacher characteristics; aggregate student characteristics
Walberg et al. (1972)	LEI	Student sex and socioeconomic status; school enrolment
Ellett et al. (1978) MCI		Teacher competency

Study	Instrument	Independent Variable
Walberg et al. (1972)	LEI	Student sex and socioeconomic status; school enrolment
Ellett et al. (1978)	MCI	Teacher competency
Lawrenz & Munch (1984)	MCI	Grouping students in laboratory on formal reasoning ability
Harty & Hassan (1983)	CES	Teacher control ideology
Rentoul & Fraser (1981)	ICEQ	Changes in beginning teachers' preferences for individualization
Owens & Straton (1980); Owens (1981)	Locally developed	Sex differences in classroom environment preferences
Byrne, Hattie & Fraser (1986)	MCI, CES, ICEQ	Sex differences in classroom environment perceptions
Thistlewaite (1962); Astin (1965); Genn (1981)	CCI (Stern, 1970)	College environment as perceived by students following different specialisms
Costello (1988)	CES	Ability grouping

Tobin, 1987). For example, as many curricula attempt to achieve more individualization, the ICEQ provides a useful tool for monitoring changes in student perceptions of five important aspects of individualization. When the ICEQ was used in the evaluation of a project aimed at promoting individualized learning approaches, it was found that students in the school implementing the innovation perceived their classes as significantly more individualized on a number of ICEQ scales than did a comparison group of students (Fraser, 1980a). Another study involving an evaluation of the Australian Science Education Project (ASEP) revealed that, in comparison with a control group, students in ASEP classes perceived their classrooms as being more satisfying and individualized and having a better material environment (Fraser, 1979a). The significance of the ASEP evaluation and Welch and Walberg's (1972) evaluation of Harvard Project Physics is that classroom environment variables differentiated revealingly between curricula, even when various achievement outcome measures showed negligible differences. Clearly, there is scope in science education for teachers and researchers more frequently to include classroom environment measures in their evaluations of new curricula and teaching approaches.

Differences Between Student and Teacher Perceptions of Actual and Preferred Environment. The fact that some classroom environment instruments have different actual and preferred forms which can be used either with teachers or students permits investigation of differences between students and teachers in their perceptions of the same actual classroom environment and of differences between the actual environment and that preferred by students or teachers. This research into differences between forms was reported by Fisher and Fraser (1983a) using the sample of 116 classes in Tasmania for the comparisons of student actual with student preferred scores. For the comparison of student actual with teacher actual form, a subsample of 56 of the teachers of these classes was available for contrast with the student class means for the corresponding 56 classes. The results of this study are depicted in Figure 1, which shows simplified plots of statistically significant differences between forms. Figure 1 clearly shows that, first, students preferred a more positive classroom environment than was actually present for all five ICEQ dimensions and, second, that teachers perceived a more positive classroom environment than did their students in the same classrooms on four of the ICEQ's dimensions. These interesting results replicate patterns emerging in other studies in school classrooms in the USA (Moos, 1979a) and Australia (Fraser, 1982b, 1985), as well as in other settings such as hospital wards and work milieus (e.g., Moos, 1974, 1979b). These studies inform educators that students and teachers are likely to differ in the way they perceive the actual environment of the same classrooms, and that the environment preferred by students commonly falls short of that actually present in classrooms.

Studies Involving Other Independent Variables. The third group of studies overviewed in Table 6 shows that other workers have used classroom environment dimensions as criterion variables in research aimed at identifying how the classroom environment varies with such factors as teacher personality, class size, grade level, subject matter, the nature of the school-level environment, and the type of school. For example, larger class sizes were found to be associated with greater classroom



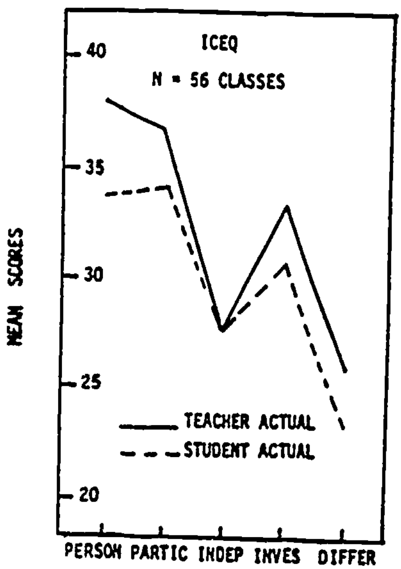


FIGURE 1. Simplified Plots of Significant Differences Between Forms of ICEQ

Formality and less Cohesiveness (Walberg, 1969a; Anderson & Walberg, 1972).

In an interesting study of students' preferences for different types of classroom environments, girls were found to prefer cooperation more than boys, but boys preferred both competition and individualization more than girls (Owens & Straton, 1980). In a similar study, Byrne, Hattie, and Fraser (1986) found that boys preferred friction, competitiveness, and differentiation more than girls, whereas girls preferred teacher structure, personalization, and participation more than boys.

<u>Person-Environment Fit Studies of Whether Students Achieve Better in Their Preferred Environment</u>

Whereas past research has concentrated on investigations of associations between student outcomes and the nature of the actual environment, having both actual and preferred forms of the ICEQ permits exploration of whether students achieve better when there is a higher similarity between the actual classroom environment and that preferred by students. Such research is an example of what is referred to as person-environment fit research (Hunt, 1975) In fact, science education studies have extended prior research in a new direction by using a person-environment interactional framework in classroom environment research (Fraser & Fisher, 1983c, d). The purpose of this research simply was to see whether or not student outcomes depended, not only on the nature of the actual classroom environment, but also on the match between students' preferences and the actual environment.

One person-environment fit study in science education involved using the ICEQ with a large sample consisting of the 116 classes described previously (Fraser & Fisher, 1983c). The class was employed as the unit of analysis. A total of 29 variables was used in exploring relationships between achievement, actual environment, and actual-preferred interaction (i.e., person-environment fit). Student achievement was measured both at the beginning and end of the same school year using six affective and three cognitive outcome measures. The ICEQ was administered at mid-year to obtain students' perceptions of five dimensions of actual classroom individualization and of five dimensions of preferred classroom individualization. As preferred classroom individualization *per se* was not of interest, data obtained from the ICEQ were used to provide five actual individualization variables and to generate five new variables indicating the congruence or interaction between actual and preferred individualization. In addition, the student background characteristic of general ability was measured in the study using a version of the Otis test. The basic design of the study, then, involved the prediction of posttest achievement from pretest performance, general ability, the five actual individualization variables, and the five variables indicating actual-preferred interaction.

This study provided many methodological improvements over prior research (Fraser & Fisher, 1983c). In particular, the study measured the person and the environment as sets of commensurate and continuous variables. it provided control for student background characteristics and actual environment when studying the effect of actual-preferred interaction, and it reduced the overall Type I error rate by ensuring that individual interactions were interpreted only in cases where the block of all interactions was associated with a significant amount of criterion variance. Furthermore, regression surface analysis provided a powerful multivariate method of statistical analysis which enabled person-environment interactions to be represented as the products of continuous variables.

A regression analysis was conducted for the actual-preferred interaction for each of the five ICEQ scales for any outcome for which the block of interactions had accounted for a significant increment in outcome variance. In order to satisfy the requirement that student background characteristics should be controlled, each of these analyses was carried out using residual posttest criterion scores which had been adjusted for corresponding pretest and general ability. Also, in order to meet the condition that an interaction term should account for a significant increment in criterion variance over and above that explainable by the corresponding actual environment variable, each regression equation included an actual environment term in addition to an actual-preferred interaction. Consequently, the form of each of the 20 regression equations was:

$$Y_{res} = a + b_1 A_i + b_2 (A_i \times P_i)$$

where Y_{res} represents residual outcome scores (adjusted for corresponding pretest and general ability), a is the regression constant, b_1 is the raw regression coefficient for the ith continuous actual environment variable, and b_2 is the raw regression coefficient for the interaction formed by taking the product of the ith continuous actual environment variable and the ith continuous preferred variable.

One of the cases for which the conditions outlined above were satisfied was for the Social Implications of Science outcome and the Personalization scale. In this case the regression equation was:

$$Y_{res} = -0.3150 - 0.1171A + 0.0035(A \times P)$$

Since actual-preferred interactions had been formed by taking the products of continuous actual and preferred scores (in order to enhance statistical power), the two-dimensional plots conventionally used with analysis of variance results were inappropriate. Instead, the interpretations of the significant interactions were based upon three-dimensional regression surfaces which permitted actual and preferred scores to be represented as continuous variables. In each of these plots, the vertical axis represented residual posttest scores, one horizontal axis represented continuous scores on an actual environment scale, and the other horizontal axis represented continuous scores on the corresponding preferred environment scale. Each regression surface was plotted using values ranging from a minimum of two standard deviations (for class means) below the mean for the actual and preferred scales to a maximum of two standard deviations above the mean. Figure 2 shows the regression surface for the above case involving Social Implications of Science and Personalization.

Figure 2 shows that the interpretation of the actual-preferred interaction for Personalization and Social Implications of Science was that the relationship between residual Social Implications scores and actual Personalization was negative for classes with preferred Personalization scores two standard deviations below the mean, was

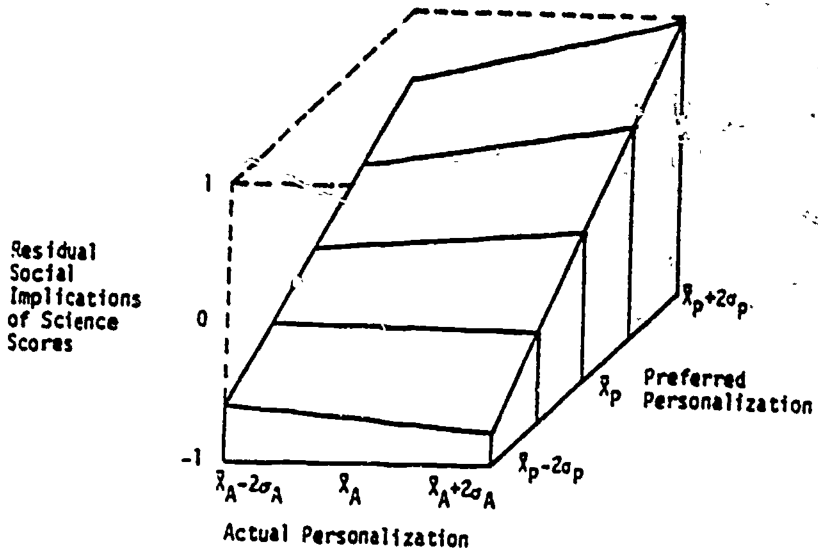


FIGURE 2. Regression Surface for an Actual-Preferred Interaction

approximately zero for classes with preferred Personalization scores one standard deviation below the mean, and was positive for classes with preferred Personalization scores at or above the mean. That is, residual Social Implications scores increased with increasing amounts of actual Personalization for classes preferring high levels of actual Personalization, but decreased with increasing actual Personalization for classes preferring low levels of actual Personalization. This finding, together with others emerging from the same study, suggests that actual-preferred congruence (or person-environment fit) could be as important as individualization per se in predicting student achievement of important affective and cognitive aims.

The research does have interesting practical implications, but one must be careful to ensure that the implications drawn are consistent with the unit of statistical analysis used. It cannot be assumed that an individual student's achievement would be improved by moving him or her to a classroom which matched his/her preferences. Rather, the practical implication of these findings for teachers is that class achievement of certain outcomes might be enhanced by attempting to change the actual classroom environment in ways which make it more congruent with that preferred by the class. Finally, although the reader is cautioned against generalizing the present findings from the class level to the individual level, it is noteworthy that a previous study (Fraser & Rentoul, 1980) involving the use of the individual as the unit of analysis has suggested that the effects of classroom environment on individual student cognitive achievement also were mediated by individual student preferences for classroom environment.

COMBINING QUANTITATIVE AND QUALITATIVE METHODS IN THE STUDY OF CLASSROOM ENVIRONMENTS

For a number of years, workers in various areas of educational research, especially educational evaluation, have claimed that there are merits in moving beyond the customary practice of choosing either quantitative <u>or</u> qualitative methods and, instead, combining quantitative <u>and</u> qualitative methods (Cook & Reichardt, 1979; Smith & Fraser, 1980; Howe, 1988). In the field of classroom environment, research involving qualitative case study methods (Stake & Easley, 1978) has provided rich insights into classroom life and the use of quantitative methods, involving assessment of student and teacher perceptions as described previously in this publication, clearly has advanced our understanding of classrooms. To date, however, only limited progress has been made towards the desirable goal of combining quantitative and qualitative methods within the same study in research on classroom learning environments (see Fraser & Tobin, 1989a). The fruitfulness of a confluence of qualitative and quantitative methods is illustrated below by reporting details of two recent studies in which ethnographic methods and the administration of classroom environment questionnaires were used together to advantage.

<u>A Study of Exemplary Teachers</u>

In order to provide a refreshing alternative to the majority of research which maligns science and mathematics education and highlights its problems and shortcomings, a study of exemplary practice was initiated to provide a focus on the successful and positive facets of schooling. This Australian study took its inspiration from the <u>Search</u>

for Excellence study in the USA (Penick & Yager, 1983). A team of 13 Australian researchers were involved in over 500 hours of intensive classroom observation of 22 exemplary teachers and a comparison group of non-exemplary teachers (Fraser & Tobin, 1989b; Tobin & Fraser, 1987, 1989).

Method. The primary data collection methods were based on the interpretive research methodology of Erickson (1986) and involved classroom observation, interviewing of students and teachers, and the construction of case studies. Field notes were recorded, discussed during team meetings, and used to formulate tentative assertions which were explored further during subsequent classroom observations. But a distinctive feature was that the qualitative information was complemented by quantitative information obtained from questionnaires assessing student perceptions of classroom psychosocial environment. These instruments furnished a useful picture of life in exemplary teachers' classrooms as seen through the students' eyes. In an attempt to make meaningful interpretations of learning environment data, the actual environments of exemplary teachers' classes were compared, first, with the environments of large comparison groups from prior research and, second, with the classroom environments of non-exemplary teachers of the same grade levels at the same school.

Results. The results from use of the qualitative and quantitative data collection methods provided considerable evidence suggesting that, first, exemplary and non-exemplary teachers can be differentiated in terms of the psychosocial environments of their classrooms as seen through their students' eyes and, second, that exemplary teachers typically create and maintain environments that are markedly more favorable than those of non-exemplary teachers. For example, the Classroom Environment Scale was used in two classes of an exemplary biology teacher who had 11 years of teaching experience and was teaching students of middle to lower socioeconomic backgrounds in a government high school (Tobin, Treagust & Fraser, 1988). His Grade 11 biology class consisted of five boys and nine girls and his Grade 12 biology class consisted of seven boys and 12 girls.

Figure 3 compares the environments of this exemplary teacher's two biology classes with a comparison group of 116 science classes (Tobin, Treagust & Fraser, 1988). This figure shows that both classes of the exemplary teacher perceived their classroom climate considerably more favorably than the way that the comparison group viewed their classes. The biggest difference for both the Grade 11 and Grade 12 class occurred for Involvement, Teacher Support, and Order and Organization. That is, while this teacher's class perceived a more favorable classroom environment on all dimensions assessed by the CES, differences were particularly large for three scales. Overall, differences were large, with effect sizes ranging from 1.0 to 2.2 standard deviations for the Grade 11 class and from 0.5 to 2.1 standard deviations for the Grade 12 class.

Another way of interpreting the classroom environment data involved a comparison of the actual environment of the exemplary teacher's classes with the same students' preferred environments. Figure 3 shows the profile of mean preferred scores for the two biology classes combined. In the light of considerable evidence from past research discussed previously in this monograph, Figure 3 depicts quite atypical classrooms in which there is an unusually high similarity between actual and

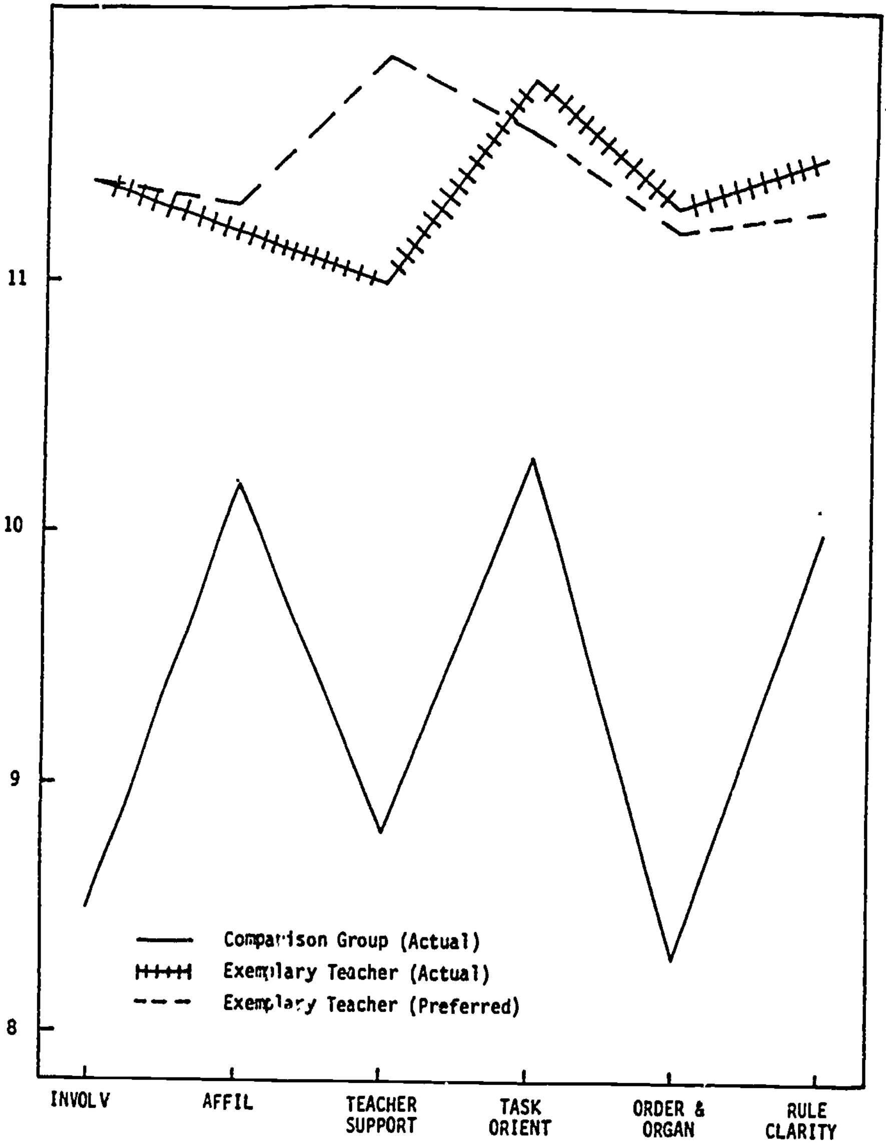


FIGURE 3. Profiles of Actual and Preferred Classroom Environment Scores for an Exemplary Biology Teacher and Actual Environment Scores for a Comparison Group

preferred environment on most dimensions. Clearly this information about preferred environment adds further evidence about the favorableness of the classroom environments created by this exemplary biology teacher.

Tobin, Deacon, and Fraser's (in press) study of two exemplary Grade 11 physics teachers involved the u e of the long form of the CES. The mean scores obtained for each exemplary teacher's class were cor ared with the means of the comparison group of 116 classes. For both teachers, the classroom environment was perceived by students to be markedly more favorable than the comparison group in terms of greater Teacher Support, less Competition, and less Teacher Control. These differences typically were greater than one and a half standard deviations for class means. The high level of Teacher Support is consistent with classroom observations and the low level of Teacher Control is consistent with both teachers' philosophy that students need to take substantial responsibility for their own learning.

Conclusions. Overall, the findings from comparisons of exemplary and non-exemplary science teachers within the same school replicated the results obtained by contrasting exemplary teachers' classroom environments with those of large comparison groups in previous research. The use of these two alternative approaches provides an important validity check and strongly supports the general finding that exemplary and non-exemplary teachers can be differentiated in terms of the more favorable perceptions of classroom environment held by exemplary teachers' students. Moreover, this finding from the Exemplary Practice in Science and Mathematics Education project is consistent with Vargaz-Gomez and Yager's (1987) finding that students in exemplary science programs in the Search for Excellence project in the USA held for more favorable attitudes to their science teachers than did a comparison group of students.

High-Level Cognitive Learning and Teachers' Metaphors

Background and Method. A study of the elusive goal of high-level cognitive learning involved a team of six researchers in an intensive study of the Grade 10 science classes of two teachers (Peter and Sandra) over a 10-week period (Tobin & Fraser, 1988; Tobin, Fraser & Kahle, in press). Each lesson was observed by several researchers, interviewing of students and teachers took place on a daily basis, and students' written work was examined. Observations were written up as field notes, which were discussed at regular team meetings as a basis for formulating assertions and guiding future data collection. In particular, interviews with teachers were used to ascertain teachers' beliefs and metaphors and how these influenced how they implemented the curriculum. Feedback from the teachers on written reports of the study was used as another data source.

The study also involved quantitative information from questionnaires assessing student perceptions of classroom psychosocial environment. The four dimensions of Personalization, Participation (from the ICEQ), Order and Organization, and Task Orientation (for the CES) were selected after the ethnographic component of the study had been in progress for some time. The qualitative and quantitative information led to complimentary views of classroom environment.

Results. The teachers' beliefs about their roles appear to have had a strong influence on the way the curriculum was implemented. Sandra afforded greatest value to her role as facilitator of learning. During interviews, she described her main role in terms of being a "Resource" to assist students to learn with understanding. Her efforts to share that resource equally between the students in her class were always evident as she moved continuously around the room and dealt with groups or individuals for the great majority of the allocated time. In contrast, interviews with Peter suggested that he conceptualized his role in terms of two metaphors, the "Captain of the Ship" and the "Entertainer", and that the lessons varied greatly depending on which metaphor he used. As well, Peter projected a "macho" image which might have been associated with the outdoors type of person he preferred to be. When he interacted with males in the class, he made efforts to be "one of the boys" and when he interacted with females he sometimes made suggestive remarks associated with the students as females, not science students.

Figure 4 depicts the profiles of mean actual classroom environment scores obtained by averaging the indiv dual scale scores of the 31 students in Peter's class and the 31 st[illegible]s in Sandra's class. These profiles have been constructed separately for the first topic of Vertebrates and for the second topic of Nuclear Energy. Figure 4 clearly shows that the two greatest student-perceived differences between the teachers for both topics were that, relative to Peter's class, Sandra's class was characterized b, considerably more Personalization and less Order and Organization. Moreover, two-way analyses of variance with class and gender as independent variables revealed that differences were significant at the 0.01 level of confidence for Personalization and Order and Organization for both topics.

Another question investigated was whether students perceived their classrooms differently during the teaching of the two topics. This was

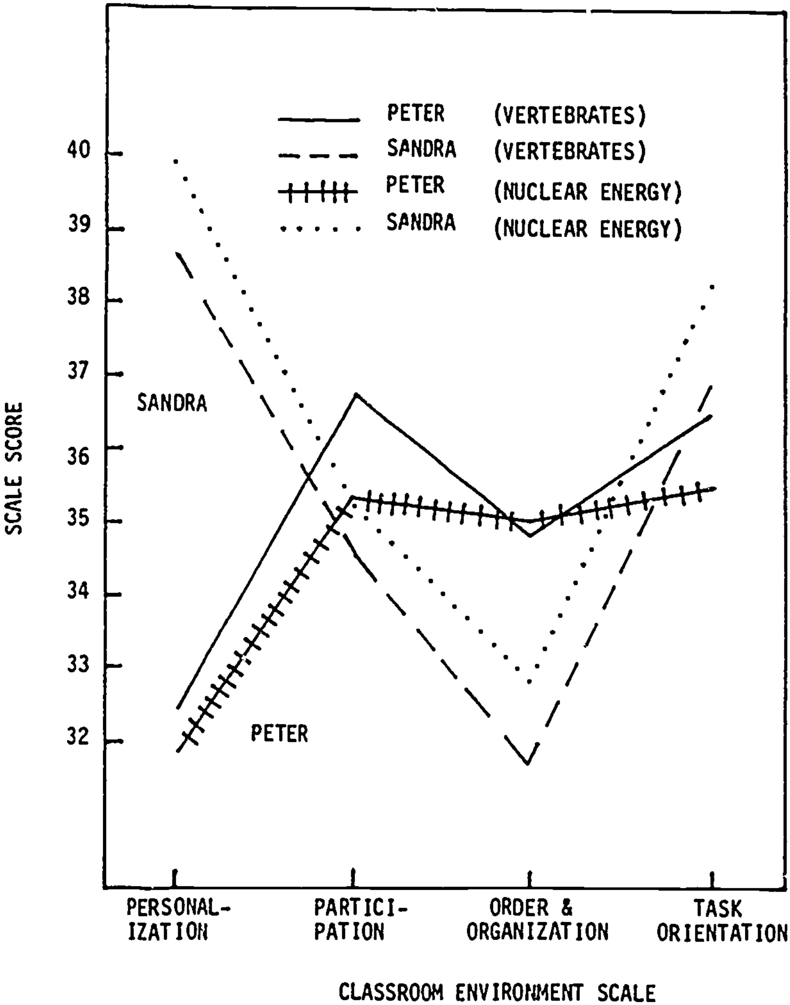


FIGURE 4. Classroom Environment Profiles for Two Teachers for Two Topics

interesting because the researchers had fed back information from the first administration of the classroom environment scales to the teachers and, therefore, there was the possibility that they might have used this information to stimulate and guide improvements. Although the changes in classroom environment occurring between the two topics are not large, the profiles in Figure 4 still reveal some interesting and consistent patterns. First, Peter's classroom environment was less favorable for the second topic than the first on all scales except Order and Organization (for which the difference was negligible). On the other hand, Sandra managed to improve on all four dimensions between the two testing occasions.

The patterns in Figure 4 are consistent with the fact the two teachers differed markedly in their reactions and responsiveness to receiving the researchers' feedback information based on classroom environment results for the previous topic of Vertebrates. Sandra was interested and concerned with this feedback and was determined to change her classroom behavior in ways which would lead to improvements in classroom environment. On the other hand, Peter dismissed the classroom environment information from the previous topic as irrelevant and made no attempt to change his behavior. For example, Peter disbelieved the feedback suggesting that students perceived a relatively low level of Personalization in his classroom because he felt that his attempts to entertain the students through his singing, quips, etc. (i.e. the Entertainer metaphor) would be associated with high Personalization. Although Peter was keen about covering the content and being entertaining, he did not attempt to enhance classroom Personalization as a way of aiding student understanding of the content.

Students' perceptions of the learning environment within each class are consistent with the observers' field records of the patterns of learning activities and engagement in each classroom. The high level of Personalization perceived in Sandra's classroom matches the large proportion of time that she spent in small group activities during which she constantly moved about the classroom interacting with students. Further, when Sandra offered desists, they were often private and she was never heard to use sarcasm or personal criticism in her interactions with students. It is significant that, of the 27 students of Sandra's class intending to return to school the following year, 24 of them expressed the wish to have Sandra as their teacher. The lower level of Personalization perceived in Peter's class is associated partly with the larger amount of time spent in the whole-class mode and the generally public nature of Peter's interactions with students. He spent much less time than Sandra dealing with students in quiet, small group situations.

The second significant difference between the learning environments was the lower level of Order and Organization in Sandra's class compared to Peter's class. Sandra's class was found by the researchers to be noisier than Peter's and the high levels of off-task behavior (mainly social) are consistent with the students' perceptions of a less orderly class. The physical arrangement of the classroom also contributed to the different levels of off-task behavior. To make it easy for them to work together in groups, Sandra's students sat around tables formed by two desks. Unfortunately, this method of seating not only encouraged social interaction, but it also hindered effective scanning of the class for management purposes. As a result, many students, with their backs to Sandra, were able to carry on with their social agenda even during her whole-class presentations. In contrast, Peter's classroom had the desks in rows facing the front of the room where Peter spent about half of the lesson time using the whole-class instructional mode. This seating arrangement facilitated management scanning and Peter quickly targetted potential noise-makers for effective public desists. As a result, Peter's class was more effectively managed than Sanra's in terms of the proportion of student-engaged time.

Nevertheless, because Sandra endeavored to keep the class on task with her quick movement around the class, helping students with problems and encouraging them to keep working, the perceived Task Orientation was moderately high, even on the second topic, when students spent more time off-task.

The differences in the classroom environments created by the two teachers also can be considered in terms of the metaphors adopted. For Personalization for Peter, for example, some students were confused by the way that they were treated in a depersonalized way as crew during whole-class activities (Captain role), but treated in a very friendly way during individual activities (Entertainer role). Moreover, only some students liked their personal interactions with Peter during individualized activities because it was not uncommon for Peter to interact with boys in a "macho" way and with girls in a sexist way. Consequently, it is not surprising that Peter's class on average perceived a relatively low level of Personalization. Similarly, the very high level of Personalization perceived in Sandra's class is also consistent with her metaphor of the teacher as Resource. Her teaching approach almost exclusively involved individualized work (about 75%) and she devoted great amounts of energy to moving around the class to give students individual help.

The low Order and Organization perceived in Sandra's class is linked with her commitment not to use whole-class teaching. Although she appreciated that Order and Organization would be likely to improve in whole-class situations, her strong beliefs led her to concentrate on individualized approaches. In particular, Sandra's time was monopolized by a group of girls who were eager to learn and by a group of disruptive boys who Sandra tried to control through proximity desists. Of course, with so much of her time devoted to those two groups, there was a natural tendency for the other students in the class to be off-task and for the average class level of perceived Order and Organization to be low. On the other hand, Peter's management metaphor, especially his role as Captain of the Ship, resulted in levels of perceived Order and Organization that were higher than in Sandra's class.

The manner in which each teacher implemented the curriculum made it difficult for students to engage in a manner which was conducive to high-level cognitive learning. Sandra had limited time to reflect on what she was doing as she circulated around the class attending to student requests for assistance. In addition, most of her students were off task for large amounts of the allocated time. Peter managed the class in a more teacher-centered manner but focused on the learning of facts and completion of the work prescribed in the workbooks.

Discussion. When this study commenced, we held the view that the major problems in high school science education were associated with the use of whole-class activities for such a large proportion of the time. Implementing activities with a better balance between small group and individualized instruction, however, proved to be no guarantee of success. Although Peter was able to manage student behavior in a variety of activity structures (as Captain of the Ship and as Entertainer), he did not have a sufficient repertoire of discipline-specific pedagogical knowledge to facilitate learning in either topic. In contrast, Sandra appeared to have a strong background in science and had developed the specific pedagogical knowledge to manage the conceptual aspects of each topic. Because she did not manage student behavior effectively, students did not benefit from her knowledge, and her effectiveness as a facilitator of learning was questionable. Discipline-specific pedagogical knowledge and pedagogical knowledge together, therefore, are seen as crucial ingredients of successful teaching. Neither is sufficient alone, and each is required if students are to attain the elusive goal of learning high-level cognitive science outcomes.

The metaphors which Peter and Sandra used as a basis for conceptualizing their teaching roles appear to be influential in defining the roles adopted during instruction. Peter's ability to manage the class in distinctly different ways according to his Captain of the Ship and Entertainer metaphors raises the possibility that he and other teachers might be able to improve their teaching by using different metaphors. The process of teacher change could be initiated by introducing a variety of metaphors and reflecting on the efficacy of basing teaching and learning strategies on each of them.

Two sets of methodological implications emerged from this study. The first relates to the use of quantitative measures of learning environment to augment the qualitative ethnographic methods. Because we selected the scales of the learning environment instrument specifically to be salient in this study, the data were relevant to what was observed in both classes. As well, the use of classroom environment questionnaires provided an important source of students' views of their classrooms. Statistical analyses were undertaken to provide insights into questions concerning what was happening in two classes. The results of the analyses of learning environment data were used in conjunction with other data sources to support or refute assertions. When quantitative scores on learning environment scales are complemented by a substantial base of qualitative descriptive information from classroom observation, then a greater understanding of students' perceptions of the learning environment can result.

TEACHERS' ATTEMPTS TO IMPROVE CLASSROOM ENVIRONMENTS

Although the previous sections of this monograph show that much research has been conducted on student perceptions of classroom learning environment, surprisingly little has been done to help science teachers improve the environments of their own classrooms. Consequently, the purpose of this section is to report how feedback information based on student perceptions was employed as a basis for reflection upon, discussion of, and systematic attempts to improve classroom environments. The basic logic underlying the approach has been described by Fraser (1981e). It involves, first, using assessments of student perceptions of both their actual and preferred classroom environment to identify discrepancies between the actual classroom environment and that preferred by students and, second, implementing strategies aimed at reducing existing discrepancies. This approach can be justified partly in terms of the person environment fit research described previously whi suggests that students achieve better when in their preferred classroom environment. The proposed methods have been applied successfully in previous studies at the elementary (Fraser & Deer, 1982), secondary (Fraser, Seddon & Eagleson, 1982), and higher education levels (De Young, 1977).

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

1. *Assessment*. The CES was administered to all students in the class. The preferred form was answered first, while the actual form was administered in the same time slot one week later.

2 *Feedback*. The teacher was provided with feedback information derived from student responses in the form of the profiles shown in Figure 5 representing the class means of students' actual and preferred environment scores. These profiles permitted ready identification of the changes in classroom environment needed to reduce major differences between the nature of the actual environment and the preferred environment as currently perceived by students. Figure 5 shows that the interpretation of the larger differences was that students would prefer less Friction, less Competitiveness, and more Cohesiveness.

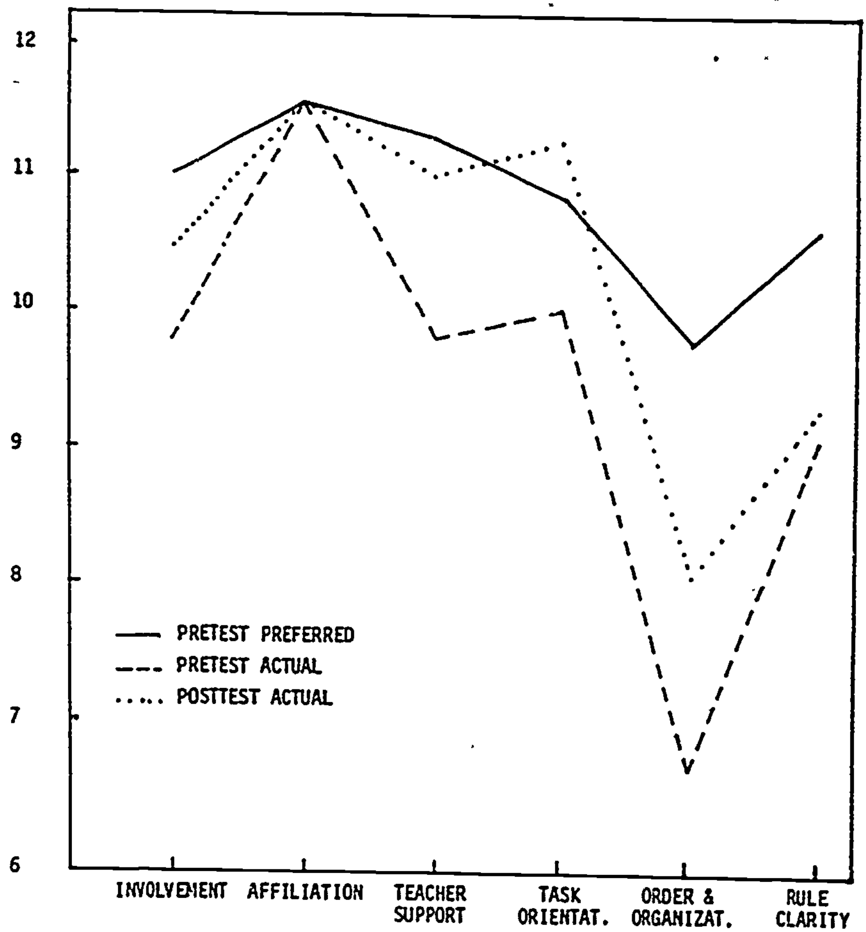


FIGURE 5. Profiles of Mean Pretest Preferred, Pretest Actual, and Posttest Actual Scores

3. *Reflection and Discussion.* The teacher engaged in private reflection and informal discussion about the profiles in order to provide a basis for a decision about whether an attempt would be made to change the environment in terms of some of the CES's dimensions. The main criteria used for selection of dimensions for change were, first, that there should exist a sizable actual-preferred difference on that variable and, second, that the teacher should feel concerned about this difference and want to make an effort to reduce it. These considerations led the teacher to decide to introduce an intervention aimed at increasing the levels of Teacher Support and Order and Organization in the class.

4. *Intervention.* The teacher introduced an intervention of approximately two months' duration in an attempt to change the classroom environment. This intervention consisted of a variety of strategies, some of which originated during discussions between teachers, and others of which were suggested by examining ideas contained in individual CES items. For example, strategies used to enhance Teacher Support involved the teacher moving around the class more to mix with students, providing assistance to students, and talking with them more than previously. Strategies used to increase Order and Organization involved taking considerable care with distribution and collection of materials during activities and ensuring that students worked more quietly.

5. *Reassessment.* The student actual form of the scales was readministered at the end of the intervention to see whether students were perceiving their classroom environments differently from before.

The results are summarized graphically in Figure 5, which includes a dotted line to indicate the class mean score for students' perceptions of actual environment on each of the CES's five scales at the time of posttesting. Figure 5 clearly shows that some change in actual environment occurred during the time of the intervention. When tests of statistical significance were performed, it was found that pretest-posttest differences were significant ($p<0.05$) only for Teacher Support, Task Orientation, and Order and Organization. These findings are noteworthy because two of the dimensions on which appreciable changes were recorded were those on which the teacher had attempted to promote change. (Note also that there appears to be a side effect in that the intervention could have resulted in the classroom becoming more task oriented than the students would have preferred.)

Although the second administration of the environment scales marked the end of this teacher's attempt at changing a classroom, it might have been thought of as simply the beginning of another cycle. That is, the five steps outlined above could be repeated cyclically one or more times until changes in classroom environment reached the desired levels. Overall, the above case study and other previous ones suggests the potential usefulness of science teachers employing classroom environment instruments to provide meaningful information about their classrooms and a tangible basis to guide improvements in classroom environments.

DISCUSSION AND CONCLUSION

The major purpose of this monograph devoted to perceptions of psychosocial classroom environment is to make this exciting research tradition in science education more accessible to wider audiences. In its attempt to portray prior work, attention has been given to instruments for assessing classroom environment (including some recently developed short forms of existing scales), several lines of previous research (e.g., associations between outcomes and environment, use of classroom environment dimensions in curriculum evaluation, person-environment fit studies of whether students achieve better in their preferred environment), recent classroom environment studies which have combined quantitative and qualitative methods, and teachers' use of classroom environment perceptions in guiding practical attempts to improve their own classrooms. Given the ready availability of instruments, the salience of classroom environment, the impact of classroom environment on student outcomes, and the potential of environmental assessments in guiding educational improvement, it seems crucial that science education researchers and science teachers make more frequent use of classroom environment instruments for a variety of purposes.

It has been assumed in this monograph that having a positive classroom environment is an educationally desirable end in its own right. Moreover, the comprehensive evidence presented here also clearly establishes that the nature of the classroom environment has a potent influence on how well students achieve a range of desired educational outcomes. Consequently, science educators need not feel that they must choose between striving to achieve constructive classroom environments and attempting to enhance student achievement of cognitive and affective aims. Rather constructive educational climates can be viewed as both means to valuable ends and as worthy ends in their own right.

Most prior classroom environment research has been correlational in nature. That is, studies have investigated associations between outcomes and actual environment or actual-preferred congruence in naturally occurring classrooms. Consequently, causal conclusions strictly cannot be drawn. What is needed urgently in future research, then, are experimental studies in which the environment is deliberately changed in specific ways in order to establish more clearly the causal effects of these changes on students' outcomes.

In this monograph, more attention has been devoted to reporting past research uses of classroom environment instruments than to describing science teachers' uses of the instruments for a variety of practical, school-based purposes. This balance is an accurate reflection of the fact that classroom environment instruments hitherto have tended to have greater use among researchers than teachers. But this monograph helps to pave the way for much greater involvement of teachers by making economical hand-scorable instruments readily accessible and reporting promising case studies of applications in which classroom environment assessments have been used successfully to guide improvements in classrooms.

In just 20 years, as this monograph has shown, older instruments have been more widely used and cross-validated in various countries, preferred forms have been developed to augment the original actual forms, short and hand-scorable forms have been designed for the convenience of teachers, and new instruments have been developed to fill gaps (e.g., for use in higher education classrooms or science laboratory classes). As this monograph is being written, workers around the world are continuing to translate and adapt instruments for use in different countries, to develop new instruments for settings not ideally catered for with existing questionnaires (e.g. computer assisted instruction, preschool classrooms), and to use the instruments in settings (e.g. various special education classes) in which they have not been used previously. For example, even a Braille form of the My Class Inventory has been prepared recently (Genn, 1988).

Already in various countries the topic of classroom environment is being included in numerous preservice and inservice courses for science teachers, and it is gaining attention among school psychologists. Given the potential usefulness of including classroom environment topics into science teacher education programs (Fraser, in press) and incorporating the use of classroom environment assessments into the work of school psychologists (Fraser, 1987a, c; Burden & Hornby, in press), it is probable that the use of classroom climate in these two areas will continue to grow. For example, because school psychologists and teachers sometimes have tended to concentrate almost exclusively on their roles in assessing and enhancing academic achievement, the field of classroom environment provides an opportunity for them to become sensitized to many important but subtle aspects of classroom life. Also, past experience in using classroom environment assessments suggests several important ways (e.g., in evaluating innovations) in which classroom climate scales might be used to advantage by school psychologists.

Typically, student outcomes have been studied using quantitative approaches based on educational measurement traditions, whereas classroom processes or environment usually have involved qualitative approaches involving informal observation, interview, etc. This monograph illustrates that classroom climate is susceptible to quantitative study.

Admittedly, quantitative measures have well-known limitations; but so too do qualitative approaches. Rather than claiming that quantitative methods are superior to qualitative ones in the study of classroom environments, the intention has been to make a potentially useful tradition of quantitative assessment of classroom climate readily accessible so that studies might benefit from the use of a range of quantitative and qualitative approaches.

Although the focus of this monograph has been classroom-level rather than school-level environment, school-level environment work is also very important in science education. Promising recent work has combined the use of classroom and school environment measures to advantage within the one study (Fraser & Rentoul, 1982; Fraser, Williamson & Tobin, 1987), has used school climate scales to reveal interesting differences between elementary and secondary schools (Docker, Fraser & Fisher, in press), and successfully has applied the methods of improving classroom-level environments described in this publication to the improvement of school-level environments (Fraser, Docker & Fisher, in press). Overall, this recent research attests to the value of school climate research and suggests that the time is ripe for a confluence of the two research traditions of classroom environment and school environment, which historically have remained largely distinct and independent.

In most prior classroom environment studies, researchers have adopted either qualitative or quantitative methods, but seldom both. Therefore, from a methodological perspective, the combination of quantitative measures of classroom environment obtained from questionnaires with a range of qualitative data-gathering techniques in the two studies reported in this monograph is noteworthy for several reasons. First, the complementarity of qualitative observational data and quantitative classroom environment data added to the richness of the data base. Second, the use of classroom environment questionnaires provided an important source of students' views of their classrooms. Third, through a triangulation of qualitative and quantitative classroom climate information, greater credibility could be placed in findings because patterns emerged consistently from data obtained using a range of different data collection methods. Overall the studies described in this publication illustrate the considerable advantages to be obtained by incorporating both qualitative and quantitative methods in future classroom environment research in science education.

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APPENDIX A

MY CLASS INVENTORY

Actual Short Form

DIRECTIONS

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

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

Yes if you AGREE with the sentence
No if you DON'T AGREE with the sentence

EXAMPLE
27. Most children in our class are good friends.

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

(Yes) No

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

Yes (No)

Please answer all questions. If you change your mind about an answer, just cross it out and circle the new answer.

Don't forget to write your name and other details on the top of the next page.

99

NAME ______________________ ______________________ CLASS ______________

Remember you are describing your actual classroom	Circle Your Answer	Teacher Use Only
1. The pupils enjoy their schoolwork in my class.	(Yes) No	3
2. Children are always fighting with each other.	Yes No	___
3. Children often race to see who can finish first.	Yes No	___
4. In our class the work is hard to do.	Yes No	___
5. In my class everybody is my friend.	Yes (No)	1
6. Some pupils are not happy in class.	(Yes) No	R 1
7. Some of the children in our class are mean.	Yes No	___
8. Most children want their work to be better than their friend's work.	Yes No	___
9. Most children can do their schoolwork without help.	Yes No	R ___
10. Some people in my class are not my friends.	Yes (No)	R 3
11. Children seem to like the class.	Yes (No)	1
12. Many children in our class like to fight.	Yes No	___
13. Some pupils feel bad when they don't do as well as the others.	Yes No	___
14. Only the smart pupils can do their work.	Yes No	___
15. All pupils in my class are close friends.	(Yes) (No)	2

Remember you are describing your actual classroom	Circle Your Answer	Teacher Use Only
16. Some of the pupils don't like the class.	Yes (No) R	2
17. Certain pupils always want to have their own way.	Yes No	___
18. Some pupils always try to do their work better than the others.	Yes No	___
19. Schoolwork is hard to do.	Yes No	___
20. All of the pupils in my class like one another.	(Yes) No	3
21. The class is fun.	Yes No	2
22. Children in our class fight a lot.	Yes No	___
23. A few children in my class want to be first all of the time.	Yes No	___
24. Most of the pupils in my class know how to do their work.	Yes No	R ___
25. Children in our class like each other as friends	(Yes) No	3

S 10 F___ Cm___ O___ Ch 12

Appendix 16

END

U.S. Dept. of Education

Office of Education
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ERIC

Date Filmed

March 21,1991