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An Evaluation of Elementary School Science Kits in Terms of Classroom Environment and Student Attitudes

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Abstract

Student perceptions of classroom environment can provide useful criteria for evaluating educational alternatives. The My Class Inventory (MCI) was used with 588 3rd- to 5th-grade students in Texas in evaluating the effectiveness of instruction using a textbook, science kits, or a combination of both. Various analyses attested to the factorial validity and reliability of the MCI and suggested that using science kits was associated with a more positive learning environment in terms of student satisfaction and cohesiveness. Higher student satisfaction was found in classrooms with greater cohesiveness and less friction and competition. Qualitative data generally supported the findings from surveys.

Students spend a large amount of time at school. Jackson's (1968) *Life in Classrooms* estimates that this is as high as approximately 7,000 hours by the end of elementary school. Therefore, students certainly have a great interest in what happens to them at school, and students' reactions to and perceptions of their educational experiences are important. Despite the importance of what goes on in school classrooms, however, teachers and researchers have relied heavily and sometimes exclusively on the assessment of academic achievement. Although no one would dispute the worth of achievement, it cannot give a complete picture of the educational process.

In this article, the approach to conceptualizing, assessing, and investigating what happens to students during their schooling involves students' perceptions of important aspects of the classroom learning environment. Clearly, having positive classroom environments is a valuable goal of education, but past research also provides compelling evidence that the classroom environment so strongly influences student outcomes that it should not be ignored by those wishing to improve the effectiveness of schools (Fisher & Khine, 2006; Fraser, 1998b, 2007; McRobbie & Fraser, 1993).

Therefore, when evaluating the effectiveness of alternative instructional methods in science, it is highly desirable to include learning environment dimensions among the criteria of effectiveness (Lightburn & Fraser, 2007; Maor & Fraser, 1996; Martin-Dunlop & Fraser, 2008). However, in Texas, where this study was carried out, the evaluation of science materials and instruction typically is over-reliant on the statewide achievement testing (Texas Assessment of Knowledge in Science [TAKS] [Texas Education Agency, 2008]), even though this provides insight into neither the classroom climate nor students' receptiveness to learning. Consequently, in the study reported in this article, the relative effectiveness of three different state-approved instructional approaches in 3rd- to 5th-grade science—namely, using a textbook, science kits, or a combination of both—was evaluated in terms of the learning environment and student attitudes.

Research Questions

1. Can the learning environment be validly and reliably assessed among 3rd- to 5th-grade students in Texas?

2. Is instruction using a textbook, science kits, or a combination of both more effective in terms of changes in student attitudes and learning environment perceptions?

3. Are there associations between student attitudes toward science classes and the classroom learning environment?

Background

The study of learning environments can be traced back approximately 70 years to the foundational work of Lewin (1936) and Murray (1938). Lewin (1936) wrote about relationships between the environment and the personal characteristics of the inhabitants as well as the environment's effects on human behavior. His formula, $B = f(P, E)$, states that behavior is a function of the person and the environment. Murray (1938) followed Lewin's (1936) research on behavior and the environment and introduced his famous needs-press model. During the 1960s and 1970s, Herbert Walberg developed the Learning Environment Inventory (LEI) to use in evaluating Harvard Project Physics (Walberg & Anderson, 1968). At about the same time, Rudolf Moos developed the Classroom Environment Scale (CES) (Moos & Trickett, 1974). Since the original work of Walberg and Moos (1968), many questionnaires have been developed (Fraser, 1998a, 2007), including the What Is Happening In this Class? (WIHIC) (Aldridge, Fraser, & Huang, 1999; Dorman, 2003; Ogbuehi & Fraser, 2007), Science Laboratory Environment Inventory (SLEI) (Fraser, Giddings, & McRobbie, 1995; Lightburn & Fraser, 2007), My Class Inventory (MCI) used in our study (Fraser & O'Brien, 1985), and the Constructivist Learning Environment Survey (CLES) (Aldridge, Fraser, Taylor, & Chen, 2000; Nix, Fraser, & Ledbetter, 2005).

The strongest tradition in past classroom environment research has involved investigation of associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Fraser, 2007; Goh & Fraser, 1998; McRobbie & Fraser, 1993). Numerous research programs have shown that student perceptions account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics. For example, Fraser's (1994) tabulation of 40 past studies in science education shows that associations between outcome measures and classroom environment perceptions have been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments, and a variety of samples (ranging across numerous grade levels and countries). Furthermore, positive associations between science students' outcomes and the nature of the classroom learning environment have been reported in a meta-analysis involving 17,805 students in four nations (Haertel, Walberg, & Haertel, 1981), a study involving the use of multilevel analysis with 1,592 chemistry students in Singapore (Wong, Young, & Fraser, 1997), and secondary analysis of National Assessment of Educational Progress data (Fraser, Welch, & Walberg, 1986).

Another important application of learning environment questionnaires is as a source of process criteria in curriculum evaluation. In early studies of the effectiveness of national science curriculum projects, the use of learning environment criteria revealed interesting differences between traditional curricula and Harvard Project Physics (Welch & Walberg, 1972) and the Australian Science Education Project (Fraser, 1979) when achievement measures showed little differentiation between curricula. Teh and Fraser (1994) and Maor and Fraser (1996) used learning environment instruments advantageously in their evaluations of computer-assisted instruction. Recently, classroom environment questionnaires were used in science classes in evaluations of the use of anthropometry activities (Lightburn & Fraser, 2007), an innovative course for prospective elementary students (Martin-Dunlop & Fraser, 2008), and inquiry-based laboratory activities (Wolf & Fraser, 2008).

Other lines of past learning environment research include cross-national studies of science classroom environments in Australia and Taiwan (Aldridge et al., 1999, 2000); changes in classroom environment during the transition from middle school to junior high school (Ferguson & Fraser, 1998); an investigation of differences between students', teachers', and parents' perceptions of actual and preferred classroom learning environments (Allen & Fraser, 2007; Fisher & Fraser, 1983); and teachers' practical attempts to use feedback from learning environment questionnaires to improve their classrooms (Aldridge, Fraser, & Sebela, 2004; Sinclair & Fraser, 2002).

For the present study of elementary students, the MCI was selected because of the suitability of its reading level for students of this age. The validity and usefulness of the MCI for assessing the classroom environment perceptions of younger children has been confirmed in studies in the United States (Mink & Fraser, 2005; Sink & Spencer, 2005), Singapore (Goh & Fraser, 1998), Brunei (Majeed, Fraser, & Aldridge, 2002), and Australia (Fraser & O'Brien, 1985).

Research Methods

Sample

The sample consisted of three schools from the Fort Worth area in Texas, each with roughly the same percentage of students in each ethnic and socioeconomic subgroup. Validation of the classroom environment instrument, investigation of attitude-environment associations, and evaluation of the science kits (in terms of changes in the attitudes and classroom environment perceptions for different instructional groups) involved a sample consisting of 588 students in 28 classes. Students were at the 3rd- to 5th-grade levels in three typical and comparable schools. One school (nine classes, with three classes each in 3rd, 4th, and 5th grades) used a textbook, another school (six classes, with two classes each in 3rd, 4th, and 5th grades) used science kits, and the other school (13 classes, with four classes each in 3rd and 4th grades and five classes in 5th grade) combined the use of a textbook and science kits. In selecting these three schools, care was taken to ensure the comparability of these schools to each other (internal validity) and that they were typical of schools in the Fort Worth area (external validity). Also, the sample was selected to ensure a similar proportion of students at each of the three grade levels (3rd, 4th, and 5th grades) in each of the three schools.

One possible weakness with our sample is that the volunteer teachers at the three different schools might not have been strictly comparable. Therefore, teachers' varying personal and professional experiences possibly could account for some of the variation in the educational learning environment found in the classes. Also, there possibly could have been some differences in the students at the three schools. Even though the students were comparable demographically, there might have been variations in students' life experiences, which possibly could partly explain some of the differences found between the instructional groups.

Data Collection

Data were collected over one school year using qualitative and quantitative methods. The MCI was administered in September as a pretest, again in January (posttest 1), and again in May (posttest 2) (Fisher & Fraser, 1981; Fraser & O'Brien, 1985). All students in all classes responded, and one of the researchers administered the MCI when the teacher was out of the room.

The MCI was designed for use with children 8- to 12-years old. It was a shortened version of the LEI, which was developed in conjunction with research on Harvard Project Physics in the late 1960s (Fraser, Anderson, & Walberg, 1982; Walberg & Anderson, 1968). The original MCI differs from the LEI in that the reading level is suitable for elementary students, whereas the LEI was designed for use with senior high students. The LEI contains 105 statements in 15 scales, but in the MCI, the number of items has been reduced to 38 statements in five scales (Fraser, 1982). Fisher and Fraser (1983), in response to researchers' and teachers' requests, shortened the MCI to 25 statements from the original 38 statements while maintaining the five scales in the original version. This reduced the time necessary for questionnaire administration. Students answer items directly on the inventory itself, which eliminates mistakes in transferring answers to a separate document. The LEI had a four-point response format, but in the MCI, this is shortened to a two-point (Yes or No) format.

The MCI assesses students' perceptions of five classroom environment dimensions: (1) Cohesiveness, (2) Friction, (3) Difficulty, (4) Satisfaction, and (5) Competition. Following Majeed et al. (2002), Satisfaction was used as a dependent variable or measure of student attitudes in some of the analyses reported in this article.

All teachers were interviewed and observed once during the study. One class from each grade level was observed three times to better appreciate the logistical and pedagogical practices taking place in these elementary science classrooms. Teachers were interviewed to determine their teaching experience, what college science classes they had undertaken, and what workshops and/or seminars they had attended. More in-depth interviews were conducted with one teacher from each grade level in each school. Interviews also were conducted with one student from each class. The final interview was conducted in August to determine what the teachers liked about the new textbook or science kits, what they planned to change for the coming year, and what kind of workshops or training would be beneficial in the future.

Qualitative data, collected through classroom observations and student and teacher interviews, helped with the interpretation of findings based on the analysis of the quantitative data. In using qualitative and quantitative data together, greater credibility in the findings was possible through the triangulation of data (Tobin & Fraser, 1998). Also, this study was multilevel in that it has combined multiple data sources and levels of specificity and analysis adding depth and breadth to the data analyses (Fraser, 1999).

Qualitative data collection, analysis, and reporting were guided by the interpretative methods of Erickson (1998), with triangulation of the different data sources being used to identify patterns. Sixteen teachers and 17 students, selected from each of the three schools, answered a predetermined set of questions during each visit and were allowed to share other information during the interview phase. During the interviews, students were asked, "What do you like best/least about your science class?" and to complete statements such as "If I could change my science class, I would . . ." and "I wish my science teacher would . . . ." Teachers' interview questions included, "Do you feel adequately prepared to teach science?" and "How much time do you spend writing your science lesson plans?" All data were compiled into written field notes following each observation or interview.

Data Analyses

Data collected from the students were analyzed to investigate the MCI's reliability and validity using the following criteria: factor structure, internal consistency reliability, discriminant validity, and the ability to distinguish between different classes and groups. Analysis of covariance (ANCOVA) was used to compare the learning environments and the satisfaction of the three instructional groups (a textbook, science kits, and a combination of the two instructional methods) when pretest scores were controlled. In order to investigate associations between classroom learning environments and student satisfaction, simple correlation and multiple regression analyses were used.

Results

The discussion of the results is organized in the following sections in terms of the study's three research questions. Lastly, results based on qualitative data collection are briefly reported.

Research Question 1: Can the learning environment be validly and reliably assessed among 3rd- through 5th-grade students in Texas?

Validation of the MCI involved data obtained from the administration of the actual form of the MCI as a pretest, posttest 1, and posttest 2. The sample involved 588 students in 28 3rd- through 5th-grade classes in three North Texas schools.

Using factor analysis, the set of items in the MCI was reduced to a smaller set of underlying factors, which were compared with the *a priori* structure of the questionnaire. Using the MCI data from the 588 students, factor and item analyses were conducted in order to identify faulty items that could be removed to improve the internal consistency reliability and factorial validity of the MCI scales. Data were subjected to principal components factor analysis with varimax rotation.

Table 1. Factor Loadings for Refined MCI for Actual Form for Three Administrations

Item	Factor Loading											
	Satisfaction			Friction			Competitiveness			Cohesiveness		
No.	Pretest	Posttest 1	Posttest 2	Pretest	Posttest 1	Posttest 2	Pretest	Posttest 1	Posttest 2	Pretest	Posttest 1	Posttest 2
1	0.61	0.55	0.57	--	--	--	--	--	--	--	--	--
5	--	0.46	--	--	--	--	--	--	--	--	--	--
9	0.75	0.78	0.56	--	--	--	--	--	--	--	--	--
13	--	0.48	0.52	--	--	--	--	--	--	0.41	--	--
16	0.76	0.64	0.75	--	--	--	--	--	--	--	--	--
2	--	--	--	0.50	0.49	0.79	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--	--	--	0.45
10	--	--	--	0.88	0.88	0.79	--	--	--	--	--	--
17	--	--	--	0.88	0.88	0.78	--	--	--	--	--	--
3	--	--	--	--	--	--	0.61	0.51	0.58	--	--	--
7	--	--	--	--	--	--	0.69	0.64	0.63	--	--	--
11	--	--	--	--	--	--	0.67	0.74	0.77			
14	--	--	--	--	--	--	0.62	0.69	0.75	--	--	--
18	--	--	--	--	--	--	--	0.70	0.65	--	--	--
4	--	--	--	--	--	--	--	--	--	0.77	0.83	0.82
8	--	--	--	--	--	--	--	--	--	0.80	0.76	0.75
12	--	--	--	--	--	--	--	--	--	0.64	0.64	0.75
15	--	--	--	--	--	--	--	--	--	0.68	0.76	0.75
19	--	--	--	--	--	--	--	--	--	0.49	0.46	0.50
% Variance	10.02	11.30	8.93	11.19	10.84	12.01	10.70	12.84	14.41	15.38	14.42	16.49
Eigenvalue	1.27	1.80	1.22	1.81	1.34	1.63	1.53	2.07	1.93	4.37	4.18	5.07

Sample: 588 students from 28 classes
Factor loadings less than 0.40 have been omitted.

As a result of the factor analyses, the Difficulty scales were lost altogether, which replicates what Sink and Spencer (2005) reported in their recent research. Further, one item that did not fit the factor structure was removed (Item 7 from the Friction scale). This improved the internal consistency reliability and factor structure. In Table 1, all factor loadings smaller than 0.40 have been omitted. Table 1 clearly shows that nearly all of the 19 retained items have a factor loading of at least 0.40 on their *a priori* scale and less than 0.40 on the other three scales for the MCI's pretest, posttest 1, and posttest 2.

The bottom of Table 1 shows that the total amount of variance accounted for by the 19 items is 47.29% for the pretest, 49.40% for posttest 1, and 51.84% for posttest 2. Table 1 also shows that the eigenvalues for different scales range from 1.27 to 4.37 for the pretest, 1.34 to 4.18 for posttest 1, and 1.22 to 5.07 for posttest 2. Overall, the data in Table 1 provide strong support for the factorial validity of a four-scale version of the MCI.

Internal consistency reliability is a measure of whether each item in a scale measures the same construct. The internal consistency reliability of each scale was determined using the Cronbach alpha coefficient for two units of analysis. Table 2 reports the Cronbach alpha coefficient for the pretest, posttest 1, and posttest 2 for the four MCI scales that survived the factor analysis. Reliability is reported for two units of analysis (student and class mean). Using the individual as the unit of analysis, scale reliability estimates range from 0.61 to 0.76 for the pretest, 0.53 to 0.78 for posttest 1, and 0.69 to 0.80 for posttest 2. Reliability figures are higher with the class mean as a unit of analysis. Taken as a whole, the reliability of MCI scales is satisfactory for short scales containing four or five items.

Discriminant validity is a measure of the extent to which the scales are independent of each other. Using the individual as the unit of analysis, the discriminant validity results (mean correlation of a scale with other scales) for the three MCI scales in Table 2 range 0.30 to 0.32 for the pretest, 0.25 to 0.28 for posttest 1, and 0.36 to 0.38 for posttest 2. As expected, discriminant validity values are higher with the class as the unit of analysis. The data suggest that raw scores on the MCI assess somewhat overlapping aspects of the learning environment, although the factor analysis results attest to the independence of factor scores. (The Satisfaction scale was excluded from the discriminant validity analyses because it was used as a dependent variable for Research Question 2.)

Another desirable characteristic of any classroom environment scale is that students within the same class perceive its actual environment relatively similarly, while mean class perceptions vary from class to class. An ANOVA was used to determine the ability of each MCI scale to differentiate between the perceptions of students in different classes. The scores on a particular scale were used as the dependent variable, and class membership was the independent variable. Table 2 reports the results in terms of the eta^2 statistic, which is the ratio of *between* to *total* sums of squares and represents the proportion of variance in scale scores, which is attributable to class membership. Table 2 shows that each of the three MCI scales differentiates significantly ($p < 0.01$) among the classrooms on each of the three response testing occasions. The eta^2 statistic (i.e., the proportion of variance) for different MCI results for different testing occasions ranges from 0.09 to 0.21.

Table 2. Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation of a Scale with Other Scales), and ANOVA Results for Class Membership Differences (Eta^2 Statistic) for Refined Three-Scale MCI and Satisfaction for Two Units of Analysis

Scale	No. of Items	Unit of Analysis	Alpha Reliability			Mean Correlation with Other Scales			ANOVA Results Eta^2		
			Pretest	Posttest 1	Posttest 2	Pretest	Posttest 1	Posttest 2	Pretest	Posttest 1	Posttest 2
Friction	4	Student	0.61	0.53	0.69	0.32	0.27	0.38	0.18*	0.09*	0.21*
		Class	0.81	0.78	0.92	0.31	0.55	0.65			
Competition	4	Student	0.61	0.65	0.71	0.30	0.25	0.35	0.12*	0.11*	0.15*
		Class	0.72	0.84	0.87	0.42	0.51	0.62			
Cohesiveness	5	Student	0.76	0.78	0.80	0.32	0.28	0.34	0.15*	0.15*	0.14*
		Class	0.88	0.91	0.93	0.45	0.56	0.61			
Satisfaction	5	Student	0.60	0.52	0.53						
		Class	0.74	0.63	0.77						

* $p < 0.01$

Sample: 588 students from 28 classes

Research Question 2: Is instruction using a textbook, science kits, or a combination of both more effective in terms of changes in student attitudes and learning environment perceptions?

The second research question involved the effectiveness of using science kits in terms of student satisfaction and their perceptions of the classroom learning environment. This research question involved comparing three groups (classes using the textbook only, classes using science kits only, and classes using a combination of both) in terms of satisfaction and environment scores on posttest 2. To accommodate any differences between the three groups at the time of pretesting, the corresponding pretest performance was taken into account in the analysis. For each environment scale (Friction, Competition, and Cohesiveness) and for the Satisfaction scale, an ANCOVA was performed with posttest 2 scores as the dependent variable, the treatment group as the independent variable, and the corresponding pretest scores on that the covariate.

The ANCOVA results reported in Table 3 show that statistically significant differences exist between treatment groups ($p < 0.05$) for Cohesiveness and Satisfaction. For these two scales, the eta^2 statistic (or the proportion of variance explained by the treatment) is 0.30 and 0.36, respectively.

Table 3. ANCOVA Results (*F* and Eta^2) for Differences Between Three Treatment Groups on Posttest 2 of the MCI with the Pretest Controlled and for the Class Mean as the Unit of Analysis

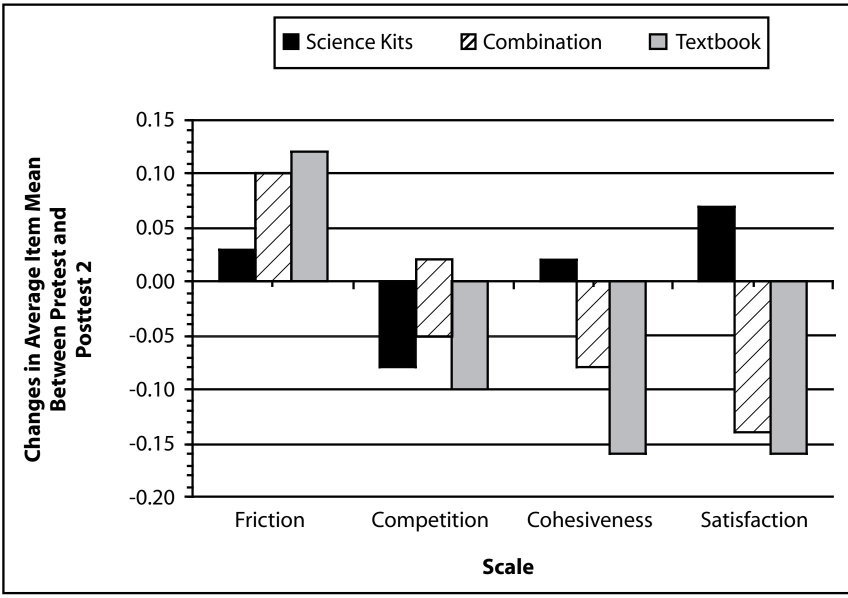
MCI Scale	*F*	Eta^2
Friction	0.57	0.05
Competition	2.50	0.17
Cohesiveness	5.01*	0.30
Satisfaction	6.76**	0.36

*$p < 0.05$
**$p < 0.01$
The sample size was 28 class means.
The eta^2 statistic represents the proportion of variance in MCI scores accounted for by the treatment.

The interpretation of the ANCOVA results is illustrated in Figure 1, which provides a graph of the changes between the pretest and posttest 2 on each scale for each of the three treatment groups (textbook only, science kits only, and a combination of both). The average item mean (i.e., the scale mean divided by the number of items in that scale) is used to allow meaningful comparison between the scales containing differing numbers of items.

Only the results for Cohesiveness and Satisfaction are interpreted here because the treatment groups were significantly different just for these two variables. For both Cohesiveness and Satisfaction, the group using the science kits experienced an improvement between the pretest and posttest 1, whereas the other two groups experienced a decline between these two tests (see Figure 1). Also, for Cohesiveness, the group using a combination of a textbook and science kits experienced a smaller decline than the textbook-only group. Therefore, the results overall support the effectiveness of using the science kits.

Figure 1. Comparison of Three Treatment Groups' Changes in Classroom Learning Environment and Satisfaction



Research Question 3: Are there associations between student attitudes toward science classes and the classroom learning environment?

The third research question involves associations between student Satisfaction and the three learning environment scales of Friction, Competition, and Cohesiveness. For these analyses, we followed the lead of Majeed et al. (2002) and employed the Satisfaction scale from the MCI as a dependent or outcome variable. Data were analyzed using two methods of analysis (simple correlation and multiple regression analysis) and two units of analysis (the individual student and the class mean). Also, all analyses were conducted for the three occasions when the actual classroom environment was assessed (pretest, posttest 1, and posttest 2).

The results in Table 4 generally are consistent with past research (Fraser, 1998b) in that statistically significant associations exist between student satisfaction and students' perceptions of the classroom learning environment. The simple correlation between satisfaction and classroom learning environment is statistically significant ($p < 0.01$) for each of the three learning environment scales, for each testing occasion, and for both units of analysis. All correlations are positive for Cohesiveness and negative for both Friction and Competition. That is, Satisfaction is higher in classes with a more favorable classroom learning environment in terms of less Friction, less Competition, and more Cohesiveness.

The magnitudes of the multiple correlations in Table 4 range from 0.43 to 0.52 with the individual as the unit of analysis and 0.71 to 0.81 for class means. All multiple correlations are significantly greater than zero ($p < 0.01$).

In order to identify which individual classroom learning environment variables are responsible for the significant multiple correlations, the standardized regression coefficients in Table 4 were examined. With the individual as the unit of analysis, each of the three learning environment scales were significantly related to Satisfaction when the other two learning environment scales were mutually controlled. With the class mean as the unit of analysis, Cohesiveness is a significant independent predictor of Satisfaction on all three testing occasions, and Friction is a significant independent predictor of Satisfaction for the pretest. Inspection of the signs of the significant regression weights in Table 4 shows that in every case, greater Satisfaction is associated with a more favorable classroom learning environment in terms of greater Cohesiveness and less Friction and Competition.

Table 4. Simple Correlations, Multiple Correlations, and Standardized Regression Coefficients for Associations between Satisfaction and MCI Scales for Two Units of Analysis

MCI Scale	Unit of Analysis	Simple Correlation (*r*)			Standardized Regression Coefficient (*ß*)		
		Pretest	Posttest 1	Posttest 2	Pretest	Posttest 1	Posttest 2
Friction	Individual	-0.41*	-0.28*	-0.40*	-0.27*	-0.18*	0.22*
	Class	-0.56*	-0.60*	-0.50*	-0.31*	-0.22	0.02
Competition	Individual	-0.30*	-0.23*	-0.36*	-0.13*	-0.11*	0.17*
	Class	-0.52*	-0.57*	-0.61*	-0.10	-0.25	-0.34
Cohesiveness	Individual	0.42*	0.37*	0.41*	0.30*	0.29*	0.27*
	Class	0.75*	0.69*	0.66*	0.58*	0.43*	0.48*
Multiple Correlation	Individual				0.52*	0.43*	0.51*
	Class				0.81*	0.75*	0.71*

*$p < 0.01$
Sample: 588 students from 28 classes

Results Based on Qualitative Information

Qualitative data were based on classroom observations (one class at each grade level at each school) and interviews with 17 teachers and 16 students (evenly distributed among the three school sites). Students were randomly chosen for interview, and interview methods were guided by suggestions made by Erickson (1998). Following Aldridge et al. (1999), Adler and Adler (1994), and Clandinin and Connelly (1994), we used the large amount of qualitative information to construct both student case studies and teacher case studies for each of the three different schools. Although the reporting of multiple and detailed case studies is beyond the scope of this article, it is still useful to consider some of the ways in which the qualitative and quantitative data were triangulated. In the design of this study, greater emphasis was placed on quantitative data collection methods than on qualitative data collection methods.

Generally, the qualitative information supported the use of science kits as a positive means of instruction in that students seemed more satisfied and considered their class more cohesive than students did in other treatment groups. Teachers using the science kits reported fewer student discipline problems and off-task behaviours, whereas teachers at the textbook school reported the greatest frequency of misbehavior among students. This was supported by interviews with students participating in the three treatment groups and observations of the class interactions.

All teachers agreed that using the science kits required extra time for setting up the laboratory experience and putting away materials after the experience. Teachers with an interest in science said that they did not mind the additional time because the experience was so beneficial to the students. The teachers agreed that, at first, setting up for the science kits took a lot of time but that after they became familiar with the kits' contents, less time was required to prepare for class.

All of the students interviewed agreed that they would prefer science to be taught using a lot of activities. The students remembered activities that they had done in science class and most were able to describe the steps that they followed and to discuss the science concept being taught. Students also agreed that they prefer to not use the textbook as the sole source of science information. Several students also mentioned that they would prefer less paperwork and less emphasis on reading assignments. The school using the science kits had the most satisfied students based on the interviews, whereas students from the school using just the textbook expressed the most dissatisfaction. Students mentioned that they completed many worksheets but had very little hands-on experience.

Both qualitative and quantitative data supported the effectiveness of science kits in terms of student attitudes and satisfaction. This is important because student attention and participation in the class are necessary for learning to occur. In classes with a lack of attention or participation, students were not able to accurately explain the science concepts that they had been taught. It was also observed that students who had been more actively involved in the lesson were better at remembering what was learned.

Summary, Limitations, and Implications

Summary

The main purpose of our research was to compare students' classroom environment perceptions and attitudes toward science when experiencing teaching techniques using a textbook, science kits, or a combination of the textbook, science kits, and teacher-created materials. The MCI was the main questionnaire used. Three research questions were investigated: (1) the validity and reliability of the MCI for use among 3rd- to 5th-grade students in Texas, (2) the evaluation of the three treatment groups in terms of changes in student attitudes and classroom learning environment perceptions, and (3) associations between student attitudes toward science classes and the classroom learning environment. Schools selected for this study were similar in socioeconomic and ethnic makeup. Across the three schools, 588 students in 28 classrooms participated in the study. Our research was conducted over a period of one year, with the MCI being administered in September as a pretest, in January as posttest 1, and in May as posttest 2. Along with the MCI, we conducted interviews and observations of teachers and students to permit triangulation of qualitative and quantitative data.

Analyses of responses from 588 students in 28 classes supported a four-factor structure for the MCI (Friction, Competition, Cohesiveness, and Satisfaction) for a pretest, posttest 1, and posttest 2. For posttest 2, the total proportion of variance accounted for the three factors was 57%. Also, for each administration, each MCI scale exhibited satisfactory internal consistency reliability (Cronbach alpha coefficient) and was able to differentiate between the perceptions of students in different classrooms.

We compared the three treatment groups (textbook only, science kits only, and a combination of a textbook and science kits) on Friction, Competition, Cohesiveness, and Satisfaction using ANCOVA with pretest as the covariate. Statistically significant differences occurred for Cohesiveness and Satisfaction. Satisfaction was higher among students using science kits only than for students in either of the other two groups. Classroom Cohesiveness was the lowest for the students using the textbook only, the highest among students using science kits only, and was at an intermediate level for the group that was using a combination of both. Therefore, our results support the usefulness of using these science kits to promote student satisfaction and a cohesive classroom learning environment.

When we used student Satisfaction as a dependent variable, simple correlation and multiple regression analyses revealed a statistically significant association between the set of three MCI scales and Satisfaction for two units of analysis (the student and the class mean). Examination of regression coefficients suggested that student Satisfaction was higher in classes perceived by students to have less Friction, less Competition, and more Cohesiveness among students.

Limitations

The major limitation is that each treatment involved only one school for each treatment group. The schools were similar in demographics and had achieved similar ratings from the State of Texas on prior standardized achievement tests. Nevertheless, the possibility that differences in classroom learning environment found between schools in the present study might be attributable to unknown factors within these schools cannot be dismissed.

Another limitation was that the proportions of the different ethnic groups for each school in the study, although representative of the general population in the district, might not necessarily have been representative of Texas. Therefore, it is uncertain that findings would apply to a more diverse group of students.

The third limitation is that some students in the sample were not proficient in English and so there might have been some questionnaire items that were misinterpreted. Although the researchers read the questionnaire to students who expressed a problem with the words contained in the questionnaire, there still could have been other students who did not feel comfortable with admitting their difficulty with reading in spite of the low reading level of the MCI.

The fourth limitation of the study was that the researchers did not have access to student achievement scores on standardized tests. It would have been beneficial to have students' Texas Assessment of Knowledge and Skills (TAKS) scores. Although originally the researchers planned to evaluate the instructional methods in terms of student test scores, district policy prevented this.

A fifth limitation of the study could be associated with the limited scope of qualitative data collection relative to quantitative data collection. Also, Guba and Lincoln (1985) noted that case studies can oversimplify a situation, which could lead to erroneous conclusions and can have low reliability, validity, and generalizability (Merriam, 1998).

The final limitation involves the instrument chosen. Although the MCI is somewhat dated, it still contains scales which were relevant. Also, the low readability level led to the MCI being chosen rather than one of the newer questionnaires that assess other dimensions that are of more contemporary relevance but are more difficult to read. Although the original five-factor structure could not be replicated, strong factorial validity was found for a revised four-factor version of the MCI, both in the study reported here and in research reported by Sink and Spencer (2005).

Implications

A major contribution of this article is that it has alerted science educators to the importance of the classroom learning environment both as an end in its own right and as a means to the improvement of student outcomes. As well, it has also provided readers with an economical, readable, and valid questionnaire, the MCI (see the Appendix), which can be used for assessing elementary school classroom learning environments for a variety of purposes. The advantages of the MCI for use with young students are its readability for 3rd- to 5th-grade students and that students answer on the questionnaire itself rather than on a separate answer sheet. The MCI is also easy to hand score, which is advantageous to administrators and teachers wanting an instrument to assess the learning environment in their school or classroom.

One particular application of the MCI that is particularly recommended to science teachers is as a means of providing feedback information to guide improvements in their own classrooms. Sinclair and Fraser (2002) describe a simple technique for using feedback based on student perceptions of their actual and preferred classroom learning environment in systematic attempts to make improvements. Furthermore, various case studies report successful application of these techniques in improving classroom learning environments in Australia (Yarrow, Millwater, & Fraser, 1997), the United States (Sinclair & Fraser, 2002), and South Africa (Aldridge et al., 2004).

In the research reviewed by Fraser (1994, 1998b), consistent associations have been found between the learning environment and student outcomes. The results reported in this article showed that students were more satisfied in classroom learning environments with greater cohesiveness and less friction. Therefore, it might be reasonable to believe that these more positive environments will promote greater student achievement. The finding that using science kits for instruction created a more positive learning environment in terms of student satisfaction and cohesiveness is likely to prove valuable in future decisions about teaching materials and methods, and, hopefully, it will lead to improved achievement.

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Appendix: My Class Inventory

Student Actual Short Form

Directions: This is not a test. The questions are to find out what your class is 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 students in our class are good friends.

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

(Yes) No

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

Yes (No)

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

Name ____ Class ___________________

Remember you are describing your actual classroom.

1.	The students enjoy their schoolwork in my class.	YES	NO	____
2.	Students are always fighting with each other.	YES	NO	____
3.	Students often race to see who can finish first.	YES	NO	____
4.	In my class, everybody is my friend.	YES	NO	____
5.	Some students are not happy in my class.	YES	NO	_R*_
6.	Some students in my class are mean.	YES	NO	____
7.	Most students want their work to be better than their friend's work.	YES	NO	____
8.	Some students in my class are not my friends.	YES	NO	_R*_
9.	Students seem to like my class.	YES	NO	____
10.	Many students in my class like to fight.	YES	NO	____
11.	Some students feel bad when they didn't do as well as the others.	YES	NO	____
12.	All students in my class are close friends.	YES	NO	____
13.	Some students don't like my class.	YES	NO	_R*_
14.	Some students always try to do their work better than others.	YES	NO	____
15.	All students in my class like one another.	YES	NO	____
16.	My class is fun.	YES	NO	____
17.	Students in my class fight a lot.	YES	NO	____
18.	A few students in my class want to be first all of the time.	YES	NO	____
19.	Students in my class like each other as friends.	YES	NO	____

* These negatively worded items are reverse-scored.

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

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