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ABSTRACT

This study examines the perceptions of the learning environment and the attitudes held by students using various science-teaching materials in Texas. Using the My Class Inventory (MCI), interviews, and observation, students' perceptions of their classroom environments and their attitudes toward science were assessed. The goal of this study was to evaluate which approach to science teaching, namely, using textbooks or science kits, creates more favorable learning environments and students attitudes. In this report, the discussion of the results is organized in terms of the study's research questions. (KHR)

AN EVALUATION OF ELEMENTARY SCHOOL SCIENCE KITS IN TERMS OF CLASSROOM ENVIRONMENT AND STUDENT ATTITUDES

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INTRODUCTION

The purpose of this study was to examine the perceptions of the learning environment and the attitudes held by students using various science teaching materials in Texas. Student perceptions of their learning environment have been shown not only to affect student academic achievement and attitudes, but also to provide useful criteria of effectiveness for evaluating educational alternatives (Fraser, 1998b; Maor & Fraser, 1996). Using the *My Class Inventory* (MCI; Fraser & O'Brien, 1985), interviews, and observations, we assessed students' perceptions of their classroom environments and their attitudes toward science. The goal of this study was to evaluate which approach to science teaching, namely, using textbooks or science kits, creates more favorable learning environments and student attitudes.

RESEARCH QUESTIONS

1. Can the learning environment be reliably and validly assessed among Grade 3-5 students in Texas?
2. Is textbook-based or science kit-based instruction more effective in terms of changes in students' attitudes and learning environment perceptions?
3. Are there associations between student attitudes toward science classes and the classroom environment?

BACKGROUND

Although the state of Texas relies heavily on statewide achievement test scores to evaluate the success of schools, these scores do not indicate the climate of the classrooms or the students' receptiveness to learning. This study focused on the learning environments in Grades 3, 4, and 5 science classes in three elementary schools, each using different State-approved teaching materials. School A used State-approved science kits, School B used a State-adopted textbook and ancillary materials, and School C used a combination of textbook and kits.

The study of learning environments can be traced back approximately 70 years to the work of Lewin and Murray. In 1936, Lewin 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 (Lewin, 1936). Murray (1938) followed Lewin's 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 for an evaluation of Harvard Project Physics (Walberg & Anderson, 1968). About the same time, Rudolf Moos (1974) developed his *Classroom Environment Scale* (CES). The purpose of these evaluation instruments is to determine how individuals and groups of individuals react to their environment, to investigate what factors can affect their reaction to the environment, and to explore associations between the environment and student outcomes.

Since the time of the pioneering work of Walberg and Moos, many questionnaires have been developed (see review of Fraser, 1998a). Some examples include the *What Is Happening In this Class?* (WIHIC), *My Class Inventory* (MCI), and the *Constructivist Learning Environment Survey* (CLES). These instruments have been used in several lines of research reviewed by Fraser (1998b), including investigations of associations between learning outcomes and classroom environments (McRobbie & Fraser, 1993), cross-national studies (Aldridge, Fraser, & Huang, 1999; Aldridge, Fraser, Taylor, & Chen, 2000), and the evaluation of educational innovations (Maor & Fraser, 1996). Our study evaluated the learning environments associated with textbook-based and science kit-based instruction.

RESEARCH METHODS

Sample

The research questions were answered using a sample consisting of three schools from the Fort Worth area. The validation of the classroom environment instrument, the investigation of attitude-environment associations, and the 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 Grades 3-5 levels in three typical and comparable schools in Texas. School 1 (6 classes) used science kits, School 3 (9 classes) used the textbook, and School 2 (13 classes) combined the use of science kits and the textbook.

Data Collection

Data were collected over one school year using qualitative and quantitative methods. The MCI (My Class Inventory; Fisher & Fraser, 1981; Fraser & O'Brien, 1985) was administered in September as a pretest, again in January (posttest), and again in May (delayed posttest). The preferred version also was given in May to compare the students' actual perceptions of their classes with their preferred science class. All students in all classes responded to the actual and preferred forms on the MCI. The researcher administered the MCI when the teacher was out of the room.

The MCI (My Class Inventory) was designed for use with children aged 8-12 years. The MCI is a shortened version of the Learning Environment Inventory (LEI), which was developed in conjunction with Harvard Project Physics in the late 1960s (Fisher & Fraser, 1981; Fraser, Anderson, & Walberg, 1982; Fraser & O'Brien, 1985). The original MCI differs from the LEI in that the reading level is designed for use with 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 in five scales (Fraser, 1982). Fraser and Fisher (1983), responding to researchers and teachers requests, shortened the MCI to 25 items from the original 38 items, 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-No) format.

The MCI assesses students' perceptions of five classroom environment dimensions: Cohesiveness, Friction, Difficulty, Satisfaction, and Competition. However, following Majeed, Fraser, and Aldridge (2002), we used Satisfaction as a dependent variable or measure of student attitudes in some of our analyses, in order to be consistent with considerable prior research.

All teachers were interviewed and observed once during the study. One class from each grade level was observed three times to get a better idea of what was happening in the elementary science classroom. Teachers were interviewed to determine their teaching experience, what college science classes they undertook, 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 students 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.

Using qualitative data, collected through classroom observations and student and teacher interviews, was beneficial for 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. Also this study was multilevel in that it has combined multiple data sources and grain sizes adding depth and breadth to the data analysis. However, the reporting of qualitative information is beyond the scope of this paper.

Data Analyses

Data collected from the students were analysed 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 satisfaction of three instructional groups (science kits, textbook, and a combination of the two instructional methods). In order to investigate associations between student satisfaction and classroom environment, simple correlation, and multiple regression analyses were used.

RESULTS

The discussion of the results is organized below in terms of the study's three research questions.

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

The validation of the MCI involved data obtained from the administration of the actual form of the MCI as a pretest, a posttest, and a delayed posttest. The preferred form of the MCI also was administered. The sample involved 588 students in 28 third, fourth, and fifth grade classes in three North Texas schools.

Using factor analysis, a data-reduction technique, 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 questionnaire data obtained 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. Varimax rotation is a factor analysis technique that keeps factor axes at right angles to each other, and it has been frequently used to validate learning environment instruments.

As a result of the factor analyses, the Difficulty scale was lost altogether. Also, one item that did not fit the factor structure was removed (namely, Item 7 from the Friction scale). This improved the internal consistency reliability and factor structure. In Table 1, all factor loadings smaller that 0.4 have been omitted. Table 1 clearly shows that nearly all of the 19 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, and delayed posttest.

The bottom of Table 1 shows the total amount of variance accounted for by the 24 items is 47.29% for the pretest, 49.40% for posttest, and 51.84% for the delayed posttest. Table 1 also shows the eigenvalues for the pretest range from 1.27 to 4.37, for the posttest from 11.34 to 4.18, and for the delayed posttest from 1.22 to 5.07. Overall the data in Table 1 provide strong support for the factorial validity of a four-scale version of the MCI.

Table 1. Factor Loadings for Four Refined MCI Scales for Actual Form

Item No.	Factor Loading											
	Satisfaction			Friction			Competitiveness			Cohesiveness		
	Pretest	Post1	Post2	Pretest	Post1	Post2	Pretest	Post1	Post2	Pretest	Post1	Post2
1	0.61	0.55	0.57									
6	–	0.46	–									
11	0.75	0.78	0.56									
16	–	0.48	0.52							0.41		
21	0.76	0.64	0.75									
2				0.50	0.49	0.79						
7				–	–	–						-0.45
12				0.88	0.88	0.79						
22				0.88	0.88	0.78						
3							0.61	0.51	0.58			
8							0.69	0.64	0.63			
13							0.67	0.74	0.77			
18							0.62	0.69	0.75			
23							–	0.70	0.65			
5										0.77	0.83	0.82
10										0.80	0.76	0.75
15										0.64	0.64	0.75
20										0.68	0.76	0.75
25										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

N= 534 students in pretest, 550 in posttest 588 for posttest 2 and 541 preferred all in 28 classes.
Factor loadings less than 0.30 have been omitted

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, delayed posttest, and preferred versions for the four 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 0.60 to 0.76 for the pretest, from 0.52 to 0.78 for the posttest, from 0.53 to 0.80 for the delayed posttest, and from 0.52 to 0.83 for the preferred form. Reliability figures are higher with the class mean as a unit of analysis. Overall the reliability of MCI scales is satisfactory for short scales containing four or five items.

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 Statistics) 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		
			Pre	Post 1	Post 2	Prefer	Pre	Post 1	Post 2	Pref	Pre	Post 1	Post 2
Friction	4	Student	0.61	0.53	0.69	0.52	0.32	0.27	0.38	0.38	0.18**	0.09**	0.21**
		Class	0.81	0.78	0.92	0.78	0.31	0.55	0.65	0.71			
Competition	4	Student	0.61	0.65	0.71	0.76	0.30	0.25	0.35	0.42	0.12**	0.11**	0.15**
		Class	0.72	0.84	0.87	0.94	0.42	0.51	0.62	0.79			
Cohesiveness	5	Student	0.76	0.78	0.80	0.83	0.32	0.28	0.34	0.41	0.15**	0.15**	0.14**
		Class	0.88	0.91	0.93	0.96	0.45	0.56	0.61	0.76			
Satisfaction	5	Student	0.60	0.52	0.53								
		Class	0.74	0.63	0.77								

** $p<0.01$

N= 534 students in pretest, 550 in posttest 588 for posttest 2 and 541 preferred all in 28 classes.

Discriminant validity is a measure of the extent to which 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 from 0.30 to 0.45 for the pretest, from 0.25 to 0.56 for the posttest, from 0.31 to 0.65 for the delayed posttest, and from 0.38 to 0.79 for the preferred form. 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 analysis of variance (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 ($p<0.01$) between classrooms. The eta^2 statistic (i.e. the proportion of variance) ranges from 0.14 to 0.21.

Research Question 2: Is textbook-based or science kit-based instruction 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 impact on students' satisfaction and their perceptions of the classroom learning environment. This research question involved comparing three groups, namely, classes using kits only, classes using the textbook only, and classes using a combination of kits and the textbook.

The three treatment groups were compared in terms of satisfaction and environment scores on the delayed posttest. However, 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 (namely, Friction, Competition, and Cohesiveness) and for the Satisfaction scale, an analysis of covariance (ANCOVA) was performed with delayed posttest 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.

The interpretation of the ANCOVA results is illustrated in Figure 1 which provides a graph of the changes between pretest and delayed posttest on each scale for each of the three treatment groups (kits only, textbooks only, and a combination of kits and the textbook). 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 graphs for Cohesiveness and Satisfaction are interpreted here because the treatment groups were significantly different only for these two variables. For both Cohesiveness and Satisfaction, clearly the group using the kits experienced considerably larger changes in scores than did either of the other two groups (textbook only or combination of kits and textbook). Also, for Cohesiveness, the group using a combination of kits and textbook had larger changes than the textbook-only group. Therefore, overall, the results support the effectiveness of using the kits.

Table 3. ANCOVA Results (F and Eta^2) for Differences Between Three Treatment Groups on the Delayed Posttest 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.

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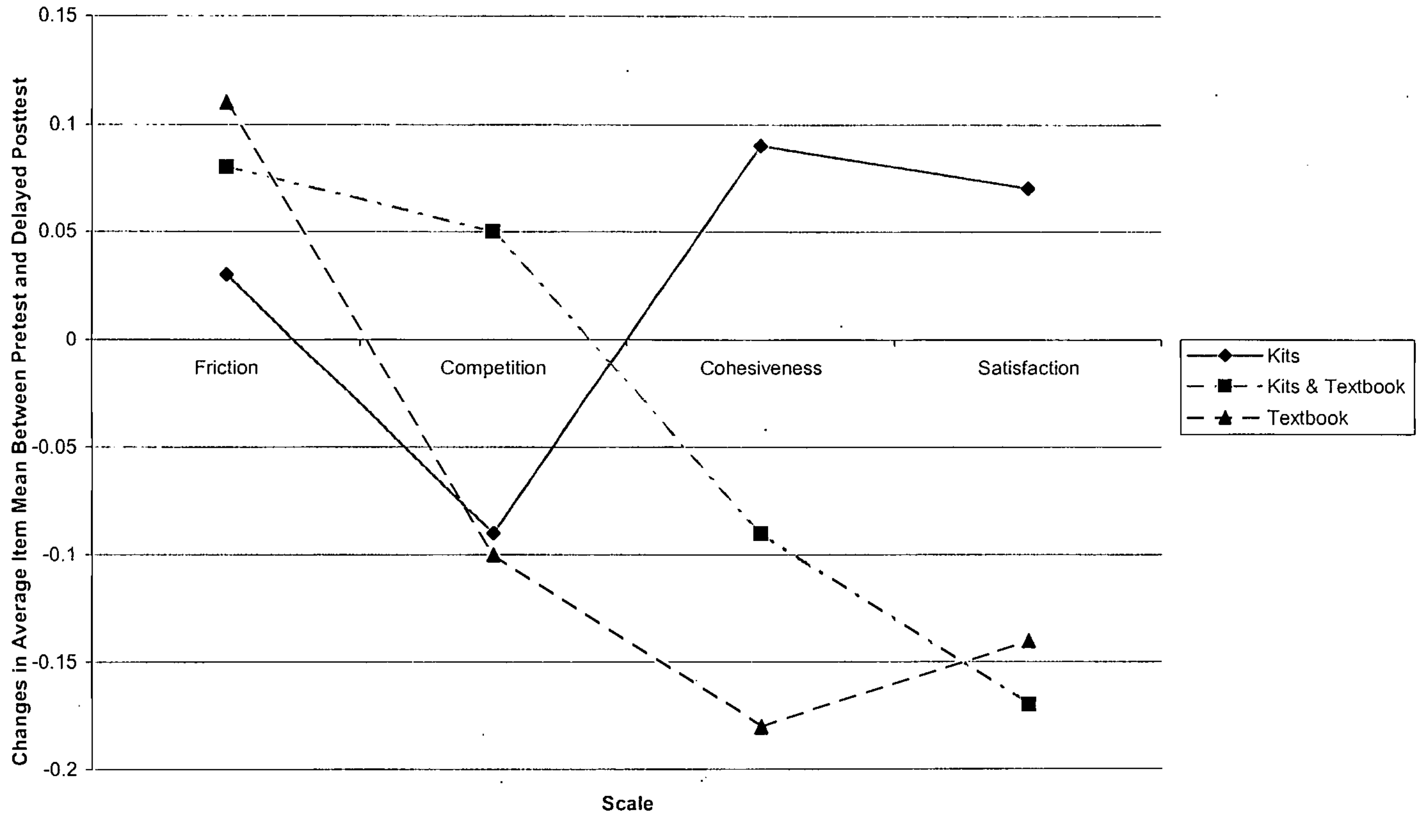

Figure 1. Comparison of Three Treatment Groups' Changes in Classroom Environment and Satisfaction

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Research Question 3: Are there associations between student attitudes toward science classes and the classroom 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, Fraser, and Aldridge (2002) and employed the Satisfaction scale from the MCI as a dependent or outcome variable. Data were analysed using two methods of analysis (simple correlation and multiple regression analysis) and two units of analysis (the individuation student and the class mean). Also all analyses were conducted for the three occasions when the actual classroom environment was assessed (pretest, posttest, and delayed posttest).

The results in Table 4 generally are consistent with past research (Fraser, 1998b) in that statistically significant associations exist between student satisfaction and their perceptions of classroom environment. The simple correlation between satisfaction and classroom environment is statistically significant ($p<0.01$) for each of the three environment scales, each testing occasion, and 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 favourable classroom 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 from 0.71 to 0.81 for class means. All multiple correlations are significantly greater than zero ($p<0.01$).

Table 4. Simple Correlations (r), Multiple Correlations (R) and Standardised Regression Coefficients (β) for Associations between Satisfaction and MCI Scales for Two Units of Analysis

MCI Scale	Unit of Analysis	Simple Correlation (r)			Standardised Regression Coefficient (β)		
		Pretest	Post 1	Post 2	Pretest	Post 1	Post 2
Friction	Individual	-0.41**	-0.28**	-0.40**	-0.27**	-0.18**	0.22**
	Class Mean	-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 Mean	-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 Mean	0.75**	0.69**	0.66**	0.58**	0.43*	0.48*
Multiple Correlation	Individual				0.52**	0.43**	0.51**
	Class Mean				0.81**	0.75**	0.71**

**$p<0.01$

Sample: 588 students in 28 classes

In order to identify which individual classroom 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 environment scales is significantly related to Satisfaction when the other two environment scales are 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.

SUMMARY

Analyses of responses from 588 students in 28 classes supported a four-factor structure for the My Class Inventory (Friction, Competition, Cohesiveness and Satisfaction) for a pretest, a posttest, and a delayed posttest for the actual form. For the delayed posttest, 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.

The three treatment groups (kits, textbook only, and a combination of kits and textbook) were compared 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 kits only than for students in either of the other two groups. Classroom Cohesiveness was highest among students using kits only, was lowest for students using the textbook only, and was at an intermediate level for the group which was using a combination of kits and textbook. Therefore the results support the usefulness of using these kits to promote student satisfaction and a cohesive classroom learning environment.

When student satisfaction was used as a dependent variable, multiple regression analyses revealed a statistically significant multiple correlation 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.

My study also involved qualitative data collection, analysis, and reporting that were guided by the interpretative methods of Erickson (1998). Because these data also were collected through interviews and classroom observations, triangulation of the different data sources was used to identify patterns. However, the reporting of qualitative information is beyond the scope of this paper.

This study is significant for two reasons. First, our study adds to the limited list of past studies that have used classroom environment dimensions in evaluating educational programs. Second, in the textbook-based and science kit-based literature, the environment in the classroom directly affects learning. One of the outcomes of this study is to suggest methods to facilitate the creation of a positive learning environment where students feel comfortable and accepted and achieve well. Because schools are very interested in methods that will improve students' classroom learning environments, information gained from this study could prove useful in future textbook/science kit adoptions.

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