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ABSTRACT

Dull classroom environments, poor students' attitudes and inhibited conceptual development led to the creation of an innovative mathematics program, the Class Banking System (CBS), which enables teachers to use constructivist ideas and approaches. To assess the effectiveness of the CBS, actual and preferred versions of the Individualized Classroom Environment Questionnaire (ICEQ), the actual version of the Constructivist Learning Environment Survey (CLES), the Test of Mathematics-Related Attitudes (TOMRA), and conceptual map tests were administered to two groups of 5th-grade students as pre-tests and post-tests during the course of 2 academic years. To enrich the data collected from these questionnaires, three case studies were undertaken based on observations and interviews of selected students. A comparison of Class Banking System (CBS) students with non-CBS students suggested that CBS students experienced more favorable changes in terms of a mathematics concept test, attitudes to mathematics, and perceived classroom environments on several dimensions of the Constructivist Learning Environment Survey (e.g. Personal Relevance, Shared Control) and the Individualized Classroom Environment Questionnaire (e.g. Participation and Differentiation). Qualitative information based on classroom observations and student interviews reinforced and enriched the patterns of results obtained from the concept test and questionnaires in that it supported the effectiveness of the CBS in providing elementary mathematics students with a constructivist and individualized classroom learning environment that promotes both conceptual development and positive attitudes. (Contains 48 references, 7 figures, and 4 tables.) (Author/MM)

Evaluation of an Innovative Mathematics Program in Terms of Classroom Environment, Student Attitudes, and Conceptual Development

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Abstract

Dull classroom environments, poor students' attitudes and inhibited conceptual development led to the creation of an innovative mathematics program, the Class Banking System (CBS), which enables teachers to use constructivist ideas and approaches. To assess the effectiveness of the CBS, actual and preferred versions of the Individualised Classroom Environment Questionnaire (ICEQ), the actual version of the Constructivist Learning Environment Survey (CLES), the Test of Mathematics-Related Attitudes (TOMRA), and conceptual map tests were administered to two groups of fifth-grade students as pretests and posttests during the course of two academic years. To enrich the data collected from those questionnaires, three case studies were undertaken based on observations and interviews of selected students.

A comparison of Class Banking System (CBS) students with non-CBS students suggested that CBS students experienced more favorable changes in terms of a mathematics concept test, attitudes to mathematics, and perceived classroom environments on several dimensions of the Constructivist Learning Environment Survey (e.g. Personal Relevance, Shared Control) and the Individualized Classroom Environment Questionnaire (e.g. Participation and Differentiation). Qualitative information based on classroom observations and student interviews reinforced and enriched the patterns of results obtained from the concept test and questionnaires in that it supported the effectiveness of the CBS in providing elementary mathematics students with a constructivist and individualized classroom learning environment that promotes both conceptual development and positive attitudes.

Introduction

When a teacher uses constructivist approaches, learning is being built and concepts are negotiated between the teacher and students. As Marshall (1990) recommends, teachers should move away from being authority figures who have status and power (Hand, 1996). The activities that are controlled by the teacher decrease. The teacher becomes more of a facilitator and the students question ideas. The student-centered classroom environment that has been created then can promote a successful classroom approach to teaching and learning. The classroom atmosphere must be carefully structured so that the students become active, sharing partners in the learning process.

Business leaders have called for graduates who can work as team members to solve problems. They stress that the curriculum needs to provide students with opportunities to collaborate, to solve problems, and construct understandings. This new emphasis represents a departure from what appears to be the typical curriculum (Tobin & Gallagher, 1987).

The Class Banking System (CBS) is an interactive program that uses constructivist approaches. The experiences that students encounter through this 10-month program have been designed to enhance their attitudes toward the teaching/learning environment and their conceptualization of selected mathematics skills. Within the CBS, both teaching and learning are purposeful. The curriculum emphasizes learning with understanding rather than the coverage of content, rote learning and obtaining correct answers. The CBS mathematics program requires students to collaborate with other classmates to achieve the goals of the CBS.

The purpose of our research was to investigate whether using the innovative CBS mathematics program provides students with an improved classroom environment, attitudes, and conceptual development relative to students studying a traditional program. This paper is divided into five sections. First, Background for the Study discusses changing classroom environments and the field of learning environments. Second, Research Methods focuses on combining quantitative and qualitative methods in our study, the samples used, the reasons for selecting the instruments for data collection, and case studies. Third, Findings from Quantitative Data are reported in terms of the validity and reliability of instruments, a comparison of actual and preferred classroom environment, changes between pretest and posttest for experimental and control groups, and a comparison between experimental and control groups. Fourth, Findings from Qualitative Data pertains to case studies and a comparison of classroom environments. The last section (Discussion, Significance, and Importance) reviews the significance and importance of our study.

Background to the Study

Class Banking System

In many educational situations, schools deal with 'faceless' students who are identified by their achievement scores. In those schools, individuality is rarely a factor in building a student's educational skills. The structure of most traditional learning situations has provided students with very little practice in self-analysis of background information and interests. In the traditional classroom, therefore, it is not uncommon for student bewilderment to occur (Bishop, 1971).

The Class Banking System (CBS) is designed to improve the classroom environment, students' attitudes, and conceptual development in mathematics with real-life experiences. School system objectives are integrated, thus making this teaching and learning approach one that is interdisciplinary, is individualized, and allows each student to bring his/her own knowledge and interests to the classroom environment. Students explore the applications of the curriculum through various real-life activities. The ultimate outcome is an applied understanding of curriculum. The participants become problem solvers of personal and community issues.

When implementing the Class Banking System, teacher-centered classroom environments becomes student-centered as the teacher takes on the role of facilitator and students becomes problem-setters rather than problem-solvers (Hand, 1996). Authors of school curricula have reflected a strong desire to develop more effective techniques for coping with the individual differences and individual needs of students. Many inservice programs provided for teachers focus on each student as an individual within the organizational situation of each school.

Individualized instruction is a continuous progress plan within the CBS. The curriculum needs to allow each student to progress at rates and in directions consistent with their individual abilities and interests. This instruction becomes the foundation of curriculum planning.

The Class Banking System is a cooperative learning unit. Less able members are helped and supported by more motivated students to complete the group's tasks. Positive interdependence exists because one perceives that one is linked with others. This positive interdependence has numerous effects on individuals' motivation and productivity. For example, when group members perceive their potential contribution to the group as being unique, they increase their efforts (Johnson & Johnson, 1989).

Field of Learning Environments

Interest in the field of learning environments has grown in the last 30 years. The first use of classroom assessments was in an evaluation of Harvard Project Physics (Walberg & Anderson, 1968). Since then, questionnaires have been developed for assessing students' perceptions of a variety of classroom environments (Fraser, 1998b).

Our study drew on and possibly contributed to the field of leaning environments (Fraser, 1994, 1998). The long-standing tradition of employing well-established questionnaires (Fraser, 1998b) to assess students' perceptions of their classroom learning environments was applied. But Tobin and Fraser's (1998) more recent recommendation of combining quantitative methods based on questionnaires with qualitative methods involving observations and interviews was also followed.

Whereas considerable past learning environment research has focused on science classrooms, surprisingly few past studies have involved mathematics classrooms (with recent exceptions being Goh, Young & Fraser, 1995 and Majeed, Aldridge & Fraser, 2001). This study makes a contribution to the field of learning environments not only because it focused on mathematics classrooms, but also because it adds to the relatively small number of prior learning environment studies that have used classroom environment assessments as process criteria of effectiveness in the evaluating of mathematics educational innovations (e.g. Dryden & Fraser, 1998; Maor & Fraser, 1996).

Research Methods

Combining Quantitative and Qualitative Methods

Educational researchers have claimed that there are merits in combining qualitative and quantitative methods within the same learning environment study (Tobin & Fraser, 1998). We employed a combination of qualitative and quantitative data in this study. The qualitative component drew on the interpretive methods of Erickson (1998). It was complemented by a quantitative component involving the use of learning environment and attitude questionnaires and a test of conceptual development. This triangulation of quantitative classroom environment data and the qualitative information gave greater credibility to the findings of our study.

The research methods employed in our study were focused on gaining detailed qualitative data about two samples of fifth-grade students, as well as to more general quantitative information obtained from surveys of other fifth-grade students. The combination of qualitative and quantitative methods was designed so that the data necessary to examine the CBS in terms of the differences in classroom environment, student attitudes, and concept development in mathematics could be collected in context. The quantitative data collection involved a pretest-posttest, comparison-between-groups design (Anderson & Arsenault, 1998). Qualitative data were collected through classroom observations and student interviews and were used to construct case studies.

Quantitative information was gathered by assessing: students' perceptions of the learning environments (Fraser, 1986) using the *Individualised Classroom Environment Questionnaire* (ICEQ) and *Constructivist Learning Environment Survey* (CLES); student attitudes using the *Test of Mathematics-Related Attitudes* (TOMRA); and conceptual development in mathematics using concept map tests. Those measures provided a quantified picture of life in the classrooms involved in the Class Banking System compared to classes that were not involved in the program (Fraser & Tobin, 1989). Data analysis, illuminated whether the class involved in the Class Banking System had an enhanced learning environment, better students' attitudes toward mathematics education and, ultimately, improved student conceptual development in mathematics relative to the classes that were not involved in the CBS program.

Sample

We used mixed research methods that combined qualitative and quantitative approaches (Tobin & Fraser, 1998), using different grain sizes (Fraser, 1999) and sample sizes for different research questions. The data from two samples were analyzed. Each sample consisted of two control classes, taught by traditional methods, and one experimental class taught using the innovative mathematics program, CBS. Sample 1 (N=53) consisted of 35 students in the control group and 18 students in the experimental group. Sample 2 (N=66) consisted of 40 students in the control group and 26 students in the experimental group. This provided comparative data about the effectiveness of the program.

A comparison-between-groups, pre/post design was used to analyze the students' responses to their classroom environment, their attitudes and their conceptual development as they related to mathematics. Two classroom environment instruments were administered to both samples. The first questionnaire was the *Individualized Classroom Environment Questionnaire* (ICEQ). Both samples responded to the actual version but only the first sample responded to the preferred version. Second, the *Constructivist Learning Environment Survey* (CLES) (actual version only) was given to both samples. Third, the *Test of Mathematics-Related Attitudes* (TOMRA) (a modified version of *Test of Science-Related Attitudes*) was used with the two samples to assess students' attitudes toward mathematics. Finally, concept map tests provided cognitive data for the first sample that related to the fifth-grade mathematics competencies of operations, measurement, geometry, algebra, data analysis and probability.

The next four subsections are devoted to the four instruments used for gathering quantitative data from the two samples.

Individualised Classroom Environment Questionnaire (ICEQ)

The *Individualised Classroom Environment Questionnaire* (ICEQ) was chosen for this study because it assesses dimensions, such as Personalization and Participation, that differentiate between individualized and traditional classrooms. Also, Fraser, Williamson and Tobin (1987) recommend the ICEQ as a source of process criteria in the evaluation of educational innovations. The dimensions of the ICEQ help to distinguish an individualized classroom from a classroom that is typically taught using whole-group methods. The short 25-item form was administered to the two samples for easy scoring (Fraser, 1982a; Fraser & Fisher, 1983).

Both samples were administered the ICEQ. The first sample was administered the actual and preferred versions while the second sample was administered only the actual version. Both groups were pretested and posttested and experimental and control groups were compared.

Constructivist Learning Environment Survey (CLES)

Until 1991, classroom environment research focused on the assessment and improvement of teaching and learning within the context of the traditional classroom environment. The *Constructivist Learning Environment Survey* (CLES) was developed to meet the needs of educators who desire to reshape their teaching practice to be consistent with a constructivist epistemology (Taylor & Fraser, 1991).

The scales of the CLES were designed to obtain measures of students' perceptions of the frequency of occurrence of five key dimensions of a critical constructivist learning environment. They are Personal Relevance, Uncertainty of Mathematics, Critical Voice, Shared Control and Student Negotiation. The CLES contains 30 items altogether, with six items in each of the five scales. The response alternatives for each item are Almost Always, Often, Sometimes, Seldom, and Almost Never (Taylor, Fraser & Fisher, 1997, pp. 293-296).

Inherent in the Class Banking System is the constructivist view that defines meaningful learning as a cognitive process in which students make sense of mathematical concepts in relation to the mathematical knowledge which they already have constructed. Therefore, the *Constructivist Learning Environment Survey* (CLES) (Taylor, Dawson & Fraser 1995; Taylor, Fraser & Fisher 1997) was chosen to assess the level of constructivistic teaching and learning practices (Fraser, 1998a, pp. 534-535).

The CLES (Aldridge, Fraser, Taylor & Chen, 2000) provided valuable information it its own right and also guided the creation of interview questions for Sample 1. Sample 1 and Sample 2 were pretested and posttested and comparisons of the level of constructivistic teaching and learning practices were made within and between both of the samples.

Test of Mathematics-Related Attitudes (TOMRA)

In order to assess the students' attitudes towards mathematics education, the Test of Science-Related Attitudes (TOSRA) was modified to the Test of Mathematics-Related Attitudes (TOMRA). For example, "Science lessons are fun" was changed to "Mathematics lessons are fun". Three of the original TOSRA scales were used with six items in each scale. The scales chosen were Normality of Mathematicians, Adoption of Mathematics Attitudes and Enjoyment of Mathematics Lessons. Fraser (1981) recommends that TOSRA could be used as a pretest and a posttest to obtain information about changes in science attitudes.

We administered TOMRA in that way to obtain information about changes in mathematics attitudes. The instrument was used for examining the attitudes of the two samples toward mathematics instead of science. Both samples were pretested and posttested and comparisons were analyzed.

Mathematics Conceptual Development Test

We chose concept maps to assess conceptual development because, according to Novak (1991), they are the most useful and best researched of the conceptual relationship measures (Novak, 1991, p. 32). Concept mapping was used to investigate conceptual relationships in mathematics (Duit, Treagust & Mansfield, 1996). The version of the concept mapping used in this study by Novak (1990b) is rooted in a constructivist epistemology that assumes that people construct meanings for events and objects that occur in their experiences. The students' concept maps showed us their understanding of the relationships among mathematics concepts, and it is from those relationships that the students' concepts derived their meaning.

When students were asked to construct their concept maps, they moved from patterns of rote learning to patterns of meaningful learning (Treagust, Duit & Fraser, 1996, pp. 34-36). They were used for identifying students' misconceptions, changing conceptual understandings, evaluating, and therefore improving conceptual development by requiring high levels of synthesis and evaluation (Feldsine, 1983). This form of student evaluation also was used as a powerful method of teaching (Treagust, Duit & Fraser, 1996, pp. 39-40).

Each student from Sample 1 was asked to map out a set of related concepts from the fifth grade mathematics section of Miami-Dade County Public Schools' Competency Based Curriculum. Those concepts were related to operations, measurement, geometry, algebraic thinking, data analysis, and probability. Students were directed to evaluate which concepts were the most significant and also to determine the subordinate concepts. Appropriate linking words were used to describe the concept relationships.

The student maps also provided us with information about the misconceptions held by each student (Fraser & Edwards, 1983). The students who comprised the sample had a two-month practice period at the beginning of the school year in order to become skillful in concept mapping.

We scored the maps first, giving one point for each correctly-used concept. The scores were then placed on a data sheet. After completion, the concept maps were scored by another educator who was unaware of the score that previously had been given to each student. The two sets of scores were then compared to check inter-rater reliability. In order to show growth, the same mathematics concept map test was administered as a pretest to Sample 1 in October, 2000 and again as a posttest in May, 2001. The second sample was not given the achievement test.

Case Studies

The Class Banking System is a bounded system case, emphasizing the unity and wholeness of that system (Stake, 1994). The evaluation of the CBS in part was an empirical inquiry that highlighted the main characteristics of this illustrative case study by investigating a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context were not clearly evident, and in which multiple sources of evidence were used (Yin, 1984).

The CBS, being outcome-based, is a culminating demonstration of the entire range of learning experiences and capabilities that underlie the Miami-Dade County Public Schools curriculum and it occurs in a performance context that directly influences what it is and how it is carried out (Mitchell & Spady, 1978, pp. 9-17). A differentiated curriculum, such as the one used in this study, responds to the unique needs of students and modifications that were used to develop experiences that are qualitatively different from traditional educational programs. Therefore, case studies involving the CBS enriched the quantitative data collected by relating the information to this outcome-based curriculum that allows for individualization, emphasis in the interdependence of subject matter, skills, products, and self understanding, and encourages students to explore the various curriculum modifications appropriate for all learners (Baska, 1988).

Documentation of the case studies was a method that helped to organize social data pertaining to classroom environment, students' attitudes and conceptual development so as to preserve the unitary character of the selected participants of the Class Banking System (Goode & Hatt, 1952). As an illustrative case study, the cases presented were descriptive in character and added greater depth of understanding to the issues of our investigation as it related to the case and identified key informants who were part of the case. The samples involved had inside knowledge of the CBS which was critical to this case and these students enforced the validity of the conclusions drawn. The value added from this perspective was associated with the opportunity to get closer to the students in the study who shared the CBS common experience and those students who did not share the experience.

Interviews for this case study were developed to generate information from nine selected students, three from each control class and three from the experimental class from Sample 1. The interview questions related first to classroom environment and then to student attitudes about mathematics, in order to collect data about the relationship of classroom environment to students' attitudes about mathematics. This data base served as the evidence for a chain reaction that could lead to improved conceptual development for the students who participated in the CBS.

The objectives for the case study interviews were designed for this study's purpose. The interview questions, that were partly derived from the ICEQ and CLES learning environment questionnaires, the TOMRA attitude questions, and the conceptual questions, were used to compare the conceptual development in mathematics of the experimental class to that of the control class.

Findings From Quantitative Data

Our study's research questions involved the evaluation of the CBS in terms of its effectiveness in enhancing classroom environment, students' attitudes toward mathematics, and students' conceptualization of selected mathematics skills. We used two samples in order to strengthen confidence in some of the results of our research by replicating key findings with a second independent sample.

The findings from the quantitative data are discussed in five parts, with each providing the results relating to classroom environment, students' attitudes, and their conceptual development in mathematics:

- internal consistency and discriminant validity of instruments
- factor analysis of CLES
- actual and preferred classroom environment
- changes between pretest and posttest
- comparisons between groups

Internal Consistency and Discriminant Validity of Instruments

The ICEQ (actual form), CLES (actual form), and TOMRA were administered to two samples drawn from the same school. The first sample (N=53) responded using a pre-post design during the 200-2001 school year and the second sample (N=66) during the 2001-2002 school year. The resulting data were subjected to item analysis in order to identify items whose removal would enhance each scale's internal consistency (extent to which items in the same scale measure a common construct) and discriminant validity (extent to which a scale measures a distinct construct that is not assessed by the other scales).

To improve the internal consistency and discriminant validity of each scale, a small number of items were omitted from the ICEQ, CLES, and TOMRA. For the first sample, ICEQ Items 7 (Participation) and 8 (Independence) and CLES Items 7 and 11 from the Uncertainty scale were omitted. For the second sample, ICEQ Item 7 (Participation) and 18 (Independence), CLES Item 11 (Uncertainty), and attitudes Items 2 (Enjoyment of Mathematics) and 3 (Normality of Mathematicians) were removed. The Differentiation scale in the original form of the ICEQ was eliminated completely following statistical analyses.

Table 1 reports the internal consistency (Cronbach alpha coefficient) and discriminant validity (using the mean correlation of a scale with the other scales as a convenient index) for the ICEQ, CLES, and TOMRA scales for the posttest for each of the two samples used in this study. The Cronbach alpha reliability coefficients for the four scales of the ICEQ range from 0.60 (Investigation) to 0.72 (Personalisation) for the first sample and from 0.60 (Investigation) to 0.74 (Personalisation) for the second sample. Cronbach alpha reliability coefficients for the five scales of the CLES range from 0.53 (Uncertainty) to 0.86 (Shared Control) for the Sample 1 and from 0.76 (Uncertainty) to 0.87 (Shared Control) for Sample 2. For the two scales of TOMRA, the Cronbach alpha reliability coefficients for the first sample ranges from 0.64 (Normality of Mathematicians) to 0.90 (Enjoyment of Mathematics) and for the second sample from 0.46 for Normality of Mathematicians to 0.90 for Enjoyment of Mathematics. Generally, the reliability of all scales for the three instruments is satisfactory except for Normality of Mathematicians for second sample (0.46).

Table 1: Internal Consistency Reliability (Cronbach Alpha Coefficient) and Discriminant Validity (Mean Correlation With Other Scales) for ICEQ, CLES, and TOMRA Scales for the Posttest for Two Samples

Scale	Sample	No. of Items	Alpha Reliability	Mean Correlation
ICEQ Actual Form				
Personalisation	First	5	0.72	0.41
	Second	5	0.74	0.56
Participation	First[a]	4	0.62	0.38
	Second[a]	4	0.67	0.52
Independence	First[b]	4	0.65	0.25
	Second[c]	4	0.66	0.44
Investigation	First	5	0.60	0.41
	Second	5	0.60	0.58
CLES Actual form				
Personal Relevance	First	6	0.85	0.27
	Second	6	0.83	0.62
Uncertainty	First[d]	4	0.53	0.33
	Second[e]	5	0.76	0.74

Critical Voice	First	6	0.70	0.20
	Second	6	0.78	0.71
Shared Control	First	6	0.86	0.49
	Second	6	0.87	0.69
Student Negotiation	First	6	0.83	0.26
	Second	6	0.84	0.73
TOMRA				
Enjoyment of Mathematics	First	6	0.90	0.40
	Second[f]	5	0.69	0.34
Normality of Mathematicians	First	6	0.64	0.40
	Second[g]	5	0.46	0.34

The first sample consisted of 53 students in 3 classes, and the second sample consisted of 66 students in 3 classes.

[a] item 7 omitted
[b] item 8 omitted
[c] item 18 omitted
[d] item 7 and 11 omitted
[e] item 11 omitted
[f] item 2 omitted
[g] item 3 omitted

Discriminant validity values are quite high in some cases, suggesting overlap between scales. The mean correlation of a scale with other scales of the ICEQ for the first sample range from 0.25 (Independence) to 0.41 (Personalisation and Investigation) and for the second sample range from 0.44 (Independence) to 0.58 (Investigation). Mean correlations for the CLES for the first sample range from 0.20 (Critical Voice) to 0.49 (Shared Control) and scores for the second sample range from 0.62 (Personal Relevance) to 0.74 (Uncertainty). For the two TOMRA scales of Enjoyment of Mathematics and Normality of Mathematicians, the correlation between the two scales is 0.40 for the first sample and 0.34 for the second sample. Overall, discriminant validity values for the ICEQ and CLES were higher for the second sample compared to the first sample, but these values were higher for the first sample for the TOMRA.

Factor Structure of CLES

Because of the smallness of the sample size, it was not anticipated that it would be possible to generate for each instrument a satisfactory factor analysis that would replicate the *a priori* structure. When a principal component's factor analysis (with varimax rotation) was conducted for each instrument, useful factor analysis results were obtained only for the CLES. These factor analysis results are reported here for completeness and for illustrative purposes.

Table 2 reports the factor loadings for a refined 18-item version of the CLES in which the Personal Relevance scale is omitted altogether, as well as six items from other scales. Factor loadings smaller than 0.40 have been omitted. For this 18-item, four-scale version of the CLES, all items except items 10 and 25 have a loading of at least 0.40 on their *a priori* scale, and no item has a loading greater than 0.40 on any other scale besides its *a priori* scale. Therefore, the results in Table 2 provide support for the factorial validity of the CLES and for the independence of CLES scales.

Table 2: Factor Loadings for the Modified CLES

Item	Factor Loading			
	Uncertainty	Critical Voice	Shared Control	Student Negotiation
7	0.61			
8	0.69			
9	0.41			
10	—			
11				
13		0.77		
14		0.43		
15		0.71		
17		0.60		
19			0.63	
20			0.41	
21			0.65	
23			0.50	
24			0.53	
25				—
27				0.60
28				0.64
29				0.61
30				0.58
Eigenvalue	1.38	4.77	1.80	2.19
% Variance	8.38	11.97	9.56	11.92

Loadings smaller than 0.4 omitted. N=1046 students in 48 classes

The percentage of variance was also calculated for each scale and is shown on the bottom of Table 2. The amount of variance explained is 8.38 % (Uncertainty), 11.97 % (Critical Voice), 9.56 % (Shared Control), and 11.92 % (Student Negotiation), with the total being 41.83%.

Comparison of Actual and Preferred Classroom Environment

Our study's design included the assessment of preferred classroom environment for one questionnaire (ICEQ) at the time of pretesting. Therefore, it was possible to investigate differences between actual and preferred environment for the ICEQ.

The dimensions of the ICEQ characterize the classroom learning environment needed to meet the needs of each student (Fraser, 1990). We used the ICEQ to measure those dimensions which differentiate conventional classrooms from the inquiry-based approaches used in our individualized program. All students in Sample 1 responded to actual and preferred forms, each having the scales of Personalisation, Participation, Independence, and Investigation. Both groups' responses to the pretest were combined for the data reported in Table 3.

Table 3 shows the mean and standard deviation obtained for the first sample (N = 53) for the actual and preferred forms of four ICEQ scales (Personalization, Participation, Independence, and Investigation). The average item mean was chosen so that meaningful comparisons could be made between scales containing different numbers of items. Average perceptions of actual and preferred classroom environment characteristics are listed in the first two columns of Table 3. The means in Table 3 are shown graphically in Figure 1.

Table 3: Average Item Mean, Average Item Standard Deviation and Difference Between Actual and Preferred Classroom Environment (Effect Size and *t*-Test for Paired Samples) Before Intervention for First Sample

Scale	Average Item Mean		Average Item Standard Deviation		Difference	
	Actual	Preferred	Actual	Preferred	Effect Size	*t*
ICEQ (Before)						
Personalisation	3.18	3.27	0.83	0.45	0.14	0.75
Participation	3.71	4.07	0.86	0.70	0.46	2.88**
Independence	2.47	3.08	0.96	1.11	0.59	2.52*
Investigation	2.83	2.92	0.84	0.55	0.13	0.67

* $p<0.05$
** $p<0.01$
N=53 students in 3 classes

In order to examine differences between actual and preferred scores, use was made of *t*-tests for paired samples along with effect sizes (i.e. the difference between means expressed in standard deviation units). Effect sizes were calculated as recommended by Thompson (1998a, 1998b) in order to estimate the magnitude of the actual-preferred differences, whereas the *t*-tests provided information about the statistical significance of differences.

According to the *t*-tests reported in Table 3, differences between actual and preferred scores are statistically significant for Participation ($p<0.01$) and for Independence ($p<0.05$). Moreover, as the effect sizes for each of these two scales is about half a standard deviation (0.46 for Personalisation and 0.59 for Independence), it appears that the magnitudes of actual-preferred differences on these two scales are educationally important.

Figure 1 depicts the profiles of the average item means for actual and preferred perceptions for Personalization, Participation, Independence, and Investigation. Individual scale scores were averaged for the 35 students in the control group and the 18 students in the experimental group for the first sample. These profiles highlight that there are sizable differences between actual and preferred forms for Participation and Independence. The scales with the smallest differences between actual and preferred mean scores are Personalization and Investigation, but differences were in the same direction for all scales.

The first sample's average item means for actual and preferred environment scores furnish a useful overall picture of classroom environment in these elementary mathematics classrooms in Miami. It is clear that Sample 1 would prefer a classroom environment that provides students with more emphasis on each of the ICEQ's four dimensions, but particularly Participation and Independence. This pattern, in which students prefer a more favorable classroom environment than the one perceived to be present, is consistent with past research (Fisher & Fraser, 1983; Fraser, 1982b, Fraser, 1985).

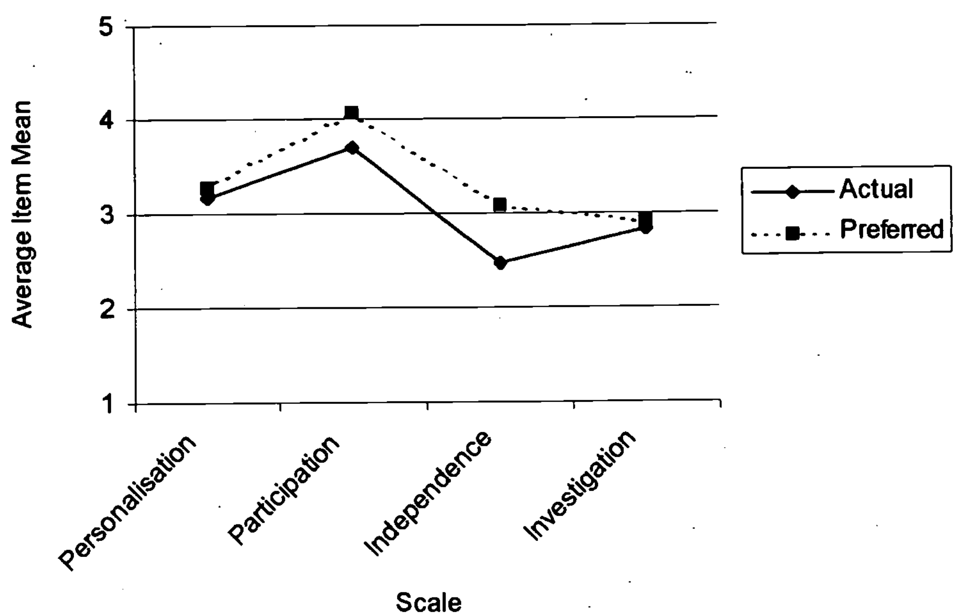

Figure 1: Difference Between Students' Actual and Preferred Perceptions on the ICEQ Before Intervention for the First Sample

Changes Between Pretest and Posttest for Experimental and Control Groups

This section first reports pretest-posttest changes for the second sample, and this is followed later by parallel analyses for the first sample. Analysis of the differences between pretest and posttest scores for the ICEQ (actual form), CLES (actual form), and TOMRA are discussed and displayed in Table 4 and Figure 2 for Sample 2 and in Table 5 and Figure 3 for Sample 1. The data illustrate differences between students' scores before and after intervention of the innovative mathematics program, Class Banking System.

Pre-post Changes for Experimental and Control Groups for Second Sample. Changes that occurred between pretest and posttest in classroom environment (ICEQ actual form and CLES actual form) and attitude (TOMRA) for the second sample are shown in Table 4. Average item means, average item standard deviations, effect sizes and the results of *t*-tests for paired samples are displayed using the student as the unit of analysis. This information is provided separately in Table 4 for the control group and the experimental group in order to permit comparison between the two groups.

Table 4: Average Item Mean, Average Item Standard Deviation, and Difference Between Pretest and Posttest (Effect Size and *t*-Test for Paired Samples) for ICEQ Actual, CLES Actual, and TOMRA Scales for Control and Experimental Groups for the Second Sample

Scale	Group	Average Item Mean		Average Item Standard Deviation		Difference	
		Pre	Post	Pre	Post	Effect Size	*t*
ICEQ Actual Form							
Personalisation	Cont	2.23	2.99	0.46	0.57	1.48	6.96**
	Exp	2.21	4.16	0.50	0.37	4.48	14.43**
Participation	Cont	2.29	3.17	0.64	0.72	1.29	6.38**
	Exp	2.43	3.94	0.57	0.61	2.56	9.02**
Independence	Cont	3.59	2.81	0.55	0.64	1.31	-5.63**
	Exp	3.53	1.94	0.63	0.72	2.36	-9.72**
Investigation	Cont	2.17	2.89	0.49	0.57	1.36	5.94**
	Exp	2.48	3.86	0.39	0.52	3.03	9.56**
CLES Actual Form							
Personal Relevance	Cont	2.28	2.98	0.45	0.78	1.14	5.07**
	Exp	2.33	4.25	0.39	0.37	5.05	20.27**

Uncertainty	Cont	2.24	2.77	0.46	0.82	0.83	3.40**
	Exp	2.23	4.09	0.41	0.37	4.77	16.07**
Critical Voice	Cont	2.18	2.83	0.47	0.83	1.00	4.02**
	Exp	2.22	4.08	0.47	0.35	4.54	14.67**
Shared Control	Cont	2.19	2.33	0.45	0.78	0.23	1.01
	Exp	2.22	4.00	0.49	0.48	3.67	13.29**
Student Negotiation	Cont	2.25	2.85	0.46	0.79	0.96	4.10**
	Exp	2.27	4.13	0.42	0.33	4.96	20.16**
TOMRA							
Enjoyment of Mathematics	Cont	3.34	3.64	0.72	0.67	0.43	2.28*
	Exp	3.35	3.50	0.77	0.48	0.24	0.80
Normality of Mathematicians	Cont	2.77	2.65	0.63	0.73	0.18	-0.73
	Exp	2.96	2.65	0.65	0.39	0.60	-2.90**

* $p<0.05$
** $p<0.01$
N=26 students in experimental class and 40 students in control classes

Pretest-posttest changes (shown in Table 4) for the ICEQ actual form are statistically significant ($p<0.01$) for all four scales of Personalisation, Participation, Independence, and Investigation for both the control group and the experimental group. Differences between pretest and posttest for CLES scales (Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation) are statistically significant ($p<0.01$) for all scales for the experimental group and all scales except Shared Control for the control group.

Pre-post changes for the attitude scale of Enjoyment of Mathematics are statistically significant ($p<0.05$) for the control group but not for the experimental group. Conversely, for the scale of Normality of Mathematicians, statistically significant pre-post changes ($p<0.1$) occurred for the experimental group but not for the control group.

Effect sizes for the ICEQ are consistently large, ranging in magnitude from 1.29 to 1.48 for the control group and from 2.36 to 4.48 for the experimental group. For the CLES, effect sizes for the control group range from 0.23 for the scale of Shared Control to 1.14 for Personal Relevance and for the experimental group range from 3.67 (Shared Control) to 5.05 (Personal Relevance). Overall, effect sizes for both learning environment instruments are large for both the control and experimental group. However, a striking feature of Table 4 is that effect sizes are consistently much larger for the experimental group than the control group.

In contrast to environment scales, effect sizes for TOMRA are 0.18 (Normality of Mathematicians) and 0.43 (Enjoyment of Mathematics) for the control group and 0.24 (Enjoyment of Mathematics) to 0.60 (Normality of Mathematicians) for the experimental group.

Figure 2 contrasts the experimental and control groups in terms of the magnitudes of the differences between students' scores before and after intervention of the CBS on the ICEQ, CLES, and attitude scales for the second sample. Clearly it illustrates that the pre-post changes experienced by the experimental group on classroom environment scales are more favorable than for the control group for all scales except the ICEQ scale of Independence. For attitudes, Figure 2 shows that post-pre changes for TOMRA are relatively small. For Independence and TOMRA scales, the control group's pre-post changes are more favorable than for the experimental group.

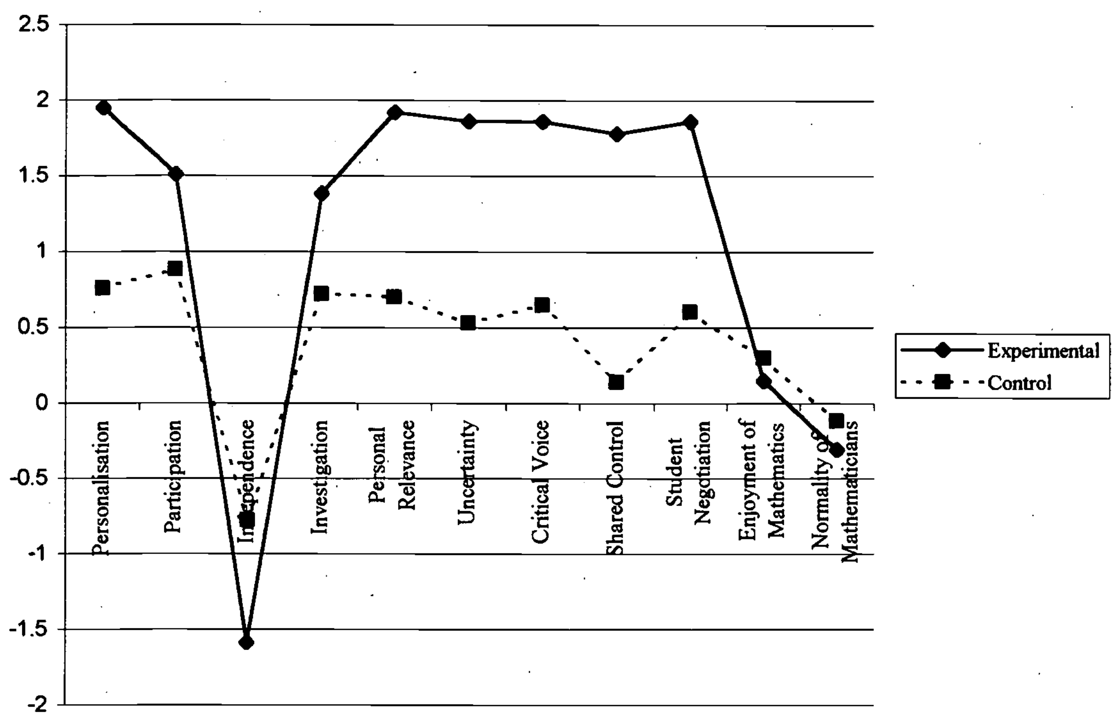

Figure 2: Comparison of Experimental and Control Groups in Terms of Posttest-Pretest Changes on ICEQ, CLES and TOMRA Scales for Second Sample

Of the nine classroom environment scales shown in Figure 2, the experimental group's pre-post changes are more favorable for all scales except for the ICEQ scale of Independence. The strict rules of operating a business within the CBS could have stifled the feelings of the students in the experimental group. Although they were involved in adult-type activities, the students involved in the

CBS could have viewed the world from a child's perspective, expecting the system to conform to their desires.

Pre-post Changes for Experimental and Control Groups for First Sample. Changes in mean classroom environment (ICEQ and CLES) and attitude (TOMRA) that occurred between pretest and posttest are shown for each scale in Table 5. The first two columns display the average item mean for the pretest and posttest assessments. The middle two columns show pretest and posttest average item standard deviations. The last two columns in Table 5 show the difference between pretest and posttest for each scale in terms of the effect size and the result of a *t*-test for paired samples.

Table 5: Average Item Mean, Average Item Standard Deviation, and Difference Between Pretest and Posttest (Effect Size and *t*-Test for Paired Samples) for ICEQ Actual, CLES Actual and TOMRA Scales for Control and Experimental Groups for the First Sample

Scale	Group	Average Item Mean		Average Item Standard Deviation		Difference	
		Pre	Post	Pre	Post	Effect Size	*t*
ICEQ Actual Form							
Personalisation	Control	3.11	3.39	0.77	0.86	0.34	1.81
	Exp	3.32	3.42	0.91	0.87	0.11	0.33
Participation	Control	3.48	3.89	0.88	0.81	0.49	2.08*
	Exp	4.19	4.42	0.60	0.61	0.38	1.14
Independence	Control	2.77	2.65	1.01	0.98	0.12	-0.62
	Exp	1.84	1.94	0.47	0.66	0.18	0.58
Investigation	Control	2.71	3.00	0.83	0.89	0.34	1.44
	Exp	3.07	3.56	0.81	0.79	0.61	2.08*
CLES Actual Form							
Personal Relevance	Control	3.02	2.86	0.92	1.06	0.16	-0.63
	Exp	3.50	3.82	1.03	0.68	0.37	0.91
Uncertainty	Control	3.28	3.07	0.65	0.69	0.31	-1.36
	Exp	3.89	3.55	0.69	0.65	0.51	-0.59
Critical Voice	Control	3.27	2.99	0.90	0.94	0.30	-1.24
	Exp	3.37	3.62	1.22	0.87	0.24	0.56
Shared Control	Control	2.08	1.94	0.89	0.88	0.16	-0.68
	Exp	2.35	2.63	1.13	1.01	0.26	0.70
Student Negotiation	Control	2.73	2.58	0.93	0.99	0.16	-0.71

	Exp	2.96	3.23	0.85	0.91	0.31	0.97
TOMRA							
Enjoyment of Mathematics	Control	4.03	4.00	0.83	0.94	0.03	0.19
	Exp	4.49	4.48	0.51	0.56	0.02	-0.06
Normality of Mathematicians	Control	3.45	3.43	0.49	0.50	0.04	-0.21
	Exp	3.64	3.72	0.73	0.64	0.12	0.44

* $p<0.05$
$p<0.01$
N=18 students in experimental class and 34 students in control classes

Table 5 shows that pretest-posttest changes for the actual form of the ICEQ are statistically significant ($p<0.05$) for Participation for the control group and Investigation for the experimental group, but not for Personalization and Independence for either group. However, differences between pretest and posttest for all CLES scales (Personal Relevance, Uncertainty, Critical Voice, Shared Control, Student Negotiation) and both attitude scales (Enjoyment and Normality) are small and statistically nonsignificant for both the control and experimental groups.

According to Table 5, effect sizes for the control group for ICEQ scales range in magnitude from 0.12 to 0.49 standard deviations (and is statistically significant for Participation). Effect sizes for CLES scales range from 0.16 (Personal Relevance, Shared Control, and Student Negotiation) to 0.31 (Uncertainty). Attitude scales have effect sizes of 0.03 (Enjoyment) and 0.04 (Adoption).

Effect sizes for the experimental group for ICEQ scales range in magnitude from 0.11 to 0.61 standard deviations (and is statistically significant for Investigation). CLES scales ranging from 0.24 (Critical Voice) to 0.51 (Uncertainty). Effect sizes for attitude scales are 0.02 (Enjoyment) and 0.12 (Normality).

Despite the fact that averages for posttests from the CLES and attitudes scales from the first sample revealed that students did not perceive any statistically significant changes, the use of the CBS still could have been important for the treatment group's conceptual development in mathematics. The CBS is designed to motivate, provide an opportunity to apply learned skills, and present students with real-life experiences. Those findings prompted us to examine the perceptions of the students in each of the three classrooms more closely as part of the qualitative data collection that is discussed in the qualitative results section.

When comparing experimental and control groups in Table 5 with experimental and control groups in Table 4, it is evident that effect sizes for the second sample are considerably larger than for the first sample. This suggests a substantial difference between the experimental and control groups of the two samples on the learning environment scales and attitude scales.

Figure 3 contrasts the experimental and control groups in terms of the magnitudes of the differences between students' scores before and after intervention of the CBS on the ICEQ, CLES, and attitudes scales for the first sample. Pre-post changes experienced by the experimental group on classroom environment scales and TOMRA scales are more favorable than for the control group except for the environment scales of Personalisation, Participation, and Uncertainty.

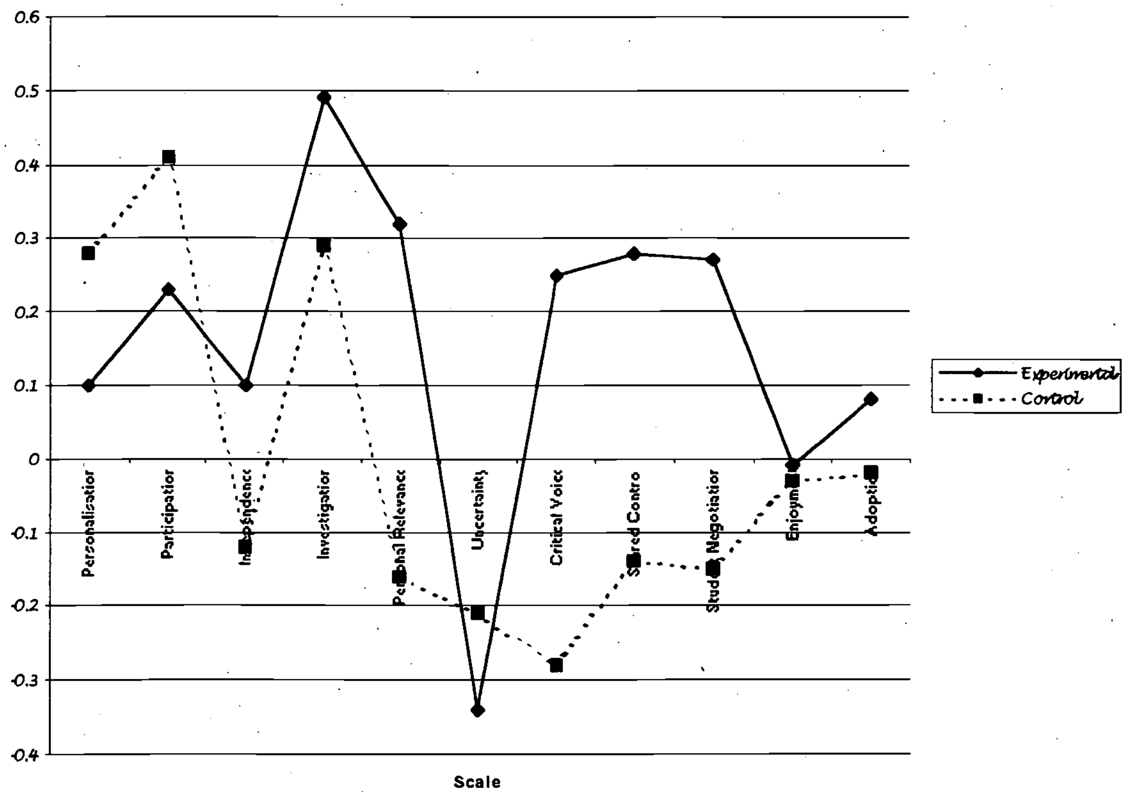

Figure 3: Comparison of Experimental and Control Groups in Terms of Posttest-Pretest Changes on ICEQ, CLES and TOMRA Scales for First Sample

Of the nine classroom environment scales shown in Figure 3, the experimental group's pre-post changes are more favorable except for the ICEQ scales of Personalisation and Participation and the CLES scale of Uncertainty. A mid-year change in the school's administration caused some schedule changes. Although the experimental group students of the first sample were enthusiastic about the Class Banking System, they might have felt uncertain about continuing in the program. After participating in a student-centered classroom environment, perhaps the children felt the new administration might cause a teacher-centered environment where personalization and participation are less important than what the teacher has to say.

Interesting differences exist between Figure 2 and Figure 3. Figure 2 shows that for Sample 2, the experimental group experienced more favorable changes than the control group in all environment scales except Independence and TOMRA scales. Figure 3 shows that for Sample 1, the experimental group experienced more favorable changes than the control group in all scales except the environment scales of Personalisation, Participation, an Uncertainty.

Comparison Between Experimental and Control Groups

This section reports direct comparisons between the experimental and control groups in terms of students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms. All analyses were done separately for each of the two samples. These comparisons are important because, although the two groups in the first sample were held accountable for the same mathematics outcomes, classroom environment variables potentially were quite different for the two groups within the two samples due to the innovative program (CBS) being used with the two treatment groups. Because pretest means were fairly similar for the experimental and control groups for the second sample (see Table 4), a direct comparison was made of the experimental and control groups in terms of posttest scores on all measures. Although pretest and posttest scores were less similar for Sample 1 (Table 5), the same comparisons were made.

Comparison of Posttest Scores for Experimental and Control Groups for First Sample. Using the ICEQ (actual form), CLES (actual form), TOMRA, and concept map tests for the first sample, Table 6 shows posttest comparisons between experimental (N=18) and control (N=33) groups as they relate to classroom environment, achievement and attitudes. All 53 students comprising the first sample were attending fifth-grade classes in the same school.

Table 6: Average Item Mean, Average Item Standard Deviation, and Difference Between Experimental and Control Groups (Effect Size and *t*-Test for Independent Samples) for Posttest Scores on ICEQ Actual, CLES Actual, TOMRA and Achievement Scales for First Sample

Scale	Average Item Mean		Average Item Standard Deviation		Difference	
	Experimental	Control	Experimental	Control	Effect Size	*t*
ICEQ Actual Form						
Personalisation	3.42	3.39	0.87	0.85	0.03	0.14
Participation	4.92	3.88	0.61	0.80	1.52	2.49**
Independence	1.94	2.67	0.66	0.98	0.89	-2.84**
Investigation	3.56	2.99	0.79	0.89	0.68	2.38**

CLES Actual Form						
Personal Relevance	3.82	2.81	0.16	0.18	5.94	4.15**
Uncertainty	3.55	3.05	0.68	1.06	0.57	2.58**
Critical Voice	3.62	2.98	0.87	0.92	0.72	2.44**
Shared Control	2.63	1.93	1.01	0.86	0.75	2.45**
Student Negotiation	3.23	2.55	0.91	0.97	0.72	2.43**
TOMRA						
Enjoyment of Mathematics	4.49	4.02	0.56	0.94	0.65	2.22*
Adoption of Attitudes	3.72	3.43	0.64	0.49	0.57	1.66
Achievement						
Operations	7.89	6.23	1.18	1.42	1.28	4.52**
Measurement	7.94	5.63	1.16	1.14	2.01	6.92**
Geometry	7.06	4.51	1.30	1.25	2.00	6.82**
Algebra	5.11	3.54	1.08	0.89	1.59	5.32**
Data Analysis	9.00	5.97	1.91	2.23	1.55	5.16**
Probability	4.33	2.51	0.91	1.25	1.77	6.06**

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

Overall, the data presented in Table 6 appears to indicate that the experimental group typically had higher posttest scores for classroom environment, attitude, and achievement than did the control group. In particular, higher cognitive achievement was found consistently in the class that was involved in the year-long CBS than in the comparison group. The results of *t*-tests indicate that the experimental group's scores are statistically significantly higher than the control group's scores for 14 of the 17 scales: Participation and Investigation scales from the ICEQ, all five scales of the CLES, the Enjoyment of Mathematics scale for the attitude instrument, and all six achievement measures. Differences between groups are nonsignificant for Personalisation from the ICEQ and Adoption of Attitudes. For the Independence scale from the ICEQ, the experimental group's scores are statistically significantly lower than for the control group. Those three findings also prompted us to examine the perceptions of the students in each of the three classes involved in the study more closely by collecting qualitative information using interviews and case studies that are reported in the qualitative results section.

In Table 6, the effect size expresses the magnitude of the difference in scale scores between the experimental and control groups and are expressed in standard deviation units. The effect size for each scale of the ICEQ ranges from 0.03 standard deviations to 1.52 standard deviations. For the CLES, effect sizes range from 0.57 to 5.94. The attitude scales of Enjoyment and Normality of

Mathematicians have effect sizes of 0.65 and 0.57, respectively. Effect sizes for achievement scales range from 1.28 to 2.01 standard deviations. Generally, these effect sizes suggest that the magnitudes of the differences between the CBS group and the control group are large enough to indicate an educationally important difference between the two groups of the first sample.

The experimental group's impressive scores in mathematical conceptual development could be due to the cooperative learning classroom atmosphere that the CBS provides. The effectiveness of the cooperative learning goal structure is not surprising in the light of the volume of studies completed to support its positive effects (Johnson & Johnson, 1991). The data presented in this study add support for the efficacy of cooperative teaching and learning methods.

Comparison of Posttest Scores for Experimental and Control Groups for Second Sample. The results for the ICEQ, CLES, and TOMRA for the second sample are displayed in Table 7. Unlike the first sample, the second sample was not administered the conceptual map tests to show mathematics achievement, although students did construct concept maps on a regular basis as part of their instructional program. Comparisons from the first sample's achievement posttest scores indicate dramatic differences between the experimental and control groups. The experimental group's scores were all statistically significantly higher than the control group's scores. Therefore, it was not deemed necessary by us to replicate those results with a second sample. Posttest comparisons between experimental (N=26) and control (N=40) groups for Sample 2 are shown as they relate to classroom environment and attitudes. The 66 fifth-grade students comprising the sample attended the same school as the first sample.

Table 7: Average Item Mean, Average Item Standard Deviation for Independent Samples for Differences Between Experimental and Control Groups (Effect Size and *t*-Test) for Posttest Scores on ICEQ Actual, CLES Actual and TOMRA Scales for Second Sample

Scale	Average Item Mean		Average Item Standard Deviation		Difference	
	Experimental	Control	Experimental	Control	Effect Size	*t*
ICEQ Actual Form						
Personalisation	4.16	2.98	0.37	0.57	2.51	10.19**
Participation	3.94	3.17	0.61	0.72	1.16	4.68**
Independence	1.94	2.81	0.72	0.64	1.28	-5.10**
Investigation	3.86	2.89	0.52	0.57	1.78	6.98**
CLES Actual Form						
Personal Relevance	4.25	2.98	0.37	0.78	2.21	8.88**

Uncertainty	4.09	2.77	0.37	0.82	2.22	8.91**
Critical Voice	4.08	2.83	0.35	0.84	2.10	8.45**
Shared Control	4.00	2.33	0.48	0.78	2.65	10.73**
Student Negotiation	4.13	2.85	0.33	0.79	2.29	9.06**
TOMRA						
Enjoyment of Mathematics	3.50	3.64	0.48	0.67	0.24	0.89
Normality of Mathematicians	2.65	2.65	0.39	0.73	0.00	0.03

**$p<0.01$
N=26 students in experimental class and 40 students in control classes

The data presented in Table 7 indicate that, similar to the first sample, the experimental group typically had higher classroom environment and attitude scores than did the control group. The results of *t*-tests indicate that the experimental group's scores are statistically significantly higher than the control group's scores for 8 of the 11 scales: Personalisation, Participation, and Investigation scales from the ICEQ and all five scales of the CLES. Similar to the first sample, the mean for the second sample's experimental group's Independence scale from the ICEQ is statistically significantly lower than the control group's. Differences between groups for the second sample are nonsignificant for the two attitude scales of Enjoyment of Mathematics and Normality of Mathematicians.

As shown in Table 6 for the first sample, Table 7 shows the magnitudes of the difference in scale scores between the experimental and control groups expressed in effect sizes or standard deviation units. The effect size for each scale of the ICEQ range from 1.16 standard deviations to 2.51 standard deviations. Effect sizes for the CLES range from 2.10 to 2.65 standard deviations. The attitude scale of Enjoyment of Mathematics has an effect size of 0.24 while Normality of Mathematicians has an effect size of 0.00. These effect sizes suggest that, like Sample 1, an educationally important difference between the two groups of Sample 2 exists.

Together, the data analyses reported in Tables 6 and 7 provide support for the efficacy of using CBS in terms of its effect on classroom environment, student attitudes, and student conceptual development.

Findings From Qualitative Data

Findings related to the qualitative data are reported as three case studies. Each case study is composed of one observation, interviews with three selected students, and a discussion of the viability of using the CBS for improving fifth-grade students conceptual development and attitudes in mathematics and their classroom environment.

The qualitative data obtained from observing the students in the three different classes provided insights into students' perceptions. Teacher selection was based on their willingness to be involved in the study. The mathematics classrooms are described below in stories. Each case has a different learning environment. Teachers apparently create learning environments to suit a variety of social and administrative factors within their respective classrooms (Aldridge, Fraser & Huang, 1999, pp. 48-57).

In order to develop a full understanding of the effectiveness of this student-outcome curriculum, three individual cases were documented. The case studies provided interesting comparisons of classroom environment, students' attitudes and conceptual development in mathematics of the students who participated in the CBS (experimental group) and students who were taught using other methods (control group) (Punch, 1998, p. 150).

After the observations, the following interview script (Figure 4) was used to interview four students from each of the three classes from the first sample. Each group of students was chosen randomly.

Figure 4: Interview Script

"The purpose of this interview is to help your teachers to understand your thoughts about your classroom. I am going to ask you 11 questions and I want your response to be truthful so that changes can be made to improve your learning environment."

1.0 Students' roles

1.1 In this class, why do you have to learn mathematics?

1.2 In this class, how do you help the teacher to plan your mathematics activities?

2.0 Teachers' roles

2.1 What would you recommend the teacher do to be sure that each student receives individualized attention?

2.2 What does the teacher do if students are having trouble with class activities?

3.0 Classroom environment

3.1 In this class, how does communicating with other students help to enhance the learning environment?

3.2 In this class, why do you need to express your opinions?

4.0 Students' attitudes

4.1 Explain the activities that you enjoy in mathematics class.

4.2 Do you like to use new mathematics methods which you have not used before? Why?

5.0 Conceptual development

5.1 Why is finding out about new mathematics concepts important?

5.2 Tell me some ways that help you to understand mathematical concepts.

6.0 Conclusion

6.1 In conclusion, what have been the most important experiences in helping you to like or dislike your mathematics classes?

The next section discusses the results of observations and interviews as they pertain to each of the three case studies.

Case Studies

Each of the three case studies below is followed by the students comments about their classroom environment in mathamatics. Those comments were transcribed from their answers to the interview script above.

The first story (Case Study 1) represents a fifth-grade class that was part of the control group from the first sample. This is followed by interpretive commentary that uses the results of the interviews that were recorded from the three selected students form Class 5-1.

Case Study 1: Class 5-1

The students entered the mathematics classroom saying good morning to the teacher as she stood in the hallway by her opened door. The students immediately took their assigned seats as they chattered with each other. It appeared that the students reluctantly took out pencil and paper and began to copy four computational problems that the teacher had written on the board. Following the last student into her classroom, the teacher closed the door behind her and began calling the roll.

Following her documentation of her mathematics class's attendance, the teacher began to walk up and down the aisles to monitor the students' assignments. She allowed 15 minutes for them to complete the problems. When she called time, a few students whispered that they were not finished. Ignoring their words, she asked for a volunteer to come to the board to work and explain the first problem.

At 30 minutes after the start of mathematics class, the last of the four problems was explained by a volunteer student. With 20 minutes remaining for the class, the teacher proceeded to write the words: 'perimeter', 'area', 'volume', 'circumference', 'radius', 'diameter' and the formulas for perimeter and area of a rectangle and circle. She directed the students to copy them and look up their definitions in the glossary of their mathematics textbook. The teacher permitted two students to work together until all words were defined.

With approximately 10 minutes remaining in the period, the teacher turned on the overhead projector to explain the concepts of the geometric terms. The students sat quietly as she explained. Two students said that they did not understand the formulas and the teacher invited them to see her after the 3:00 pm dismissal. A few minutes before the end of the period, a page of homework that dealt with the newly introduced geometry concepts was assigned to be completed by the next day's mathematics class.

Students from Class 5-1 felt that learning mathematics would help them in the future. They thought that it would be important to understand if they were receiving the correct change for a purchase and knowing recipe measurements that would result in delicious cooking. They said that they helped their teacher by trying to do their best at all times.

Those students thought that individualized attention from the teacher should manifest itself by the teacher having two students per day go to the board to explain how they solved their mathematics problems. Re-explaining until each student understood the procedures for correct problem solving was considered important.

It was the students' opinion that, in their preferred classroom environment, they would help and be helped by other students. Expressing their opinions was important so that the teacher would know if the students truly understood and so that the teacher would be able to improve instruction.

The activities that were presented to the class were enjoyable. It did not matter if those activities were cooperative or independent. However, regardless of the classroom environment, the students from this class liked to use new mathematics methods which had not been used before because they wanted to achieve higher grades.

Finding out about new mathematics concepts was important. Many students wanted to use the new concepts to teach younger children. They were also proud to explain them to their parents.

The students from Class 5-1 were not specific about their experiences and their comments related to them liking or disliking mathematics class. They said that they learned more than they did the year before.

Case Study 2, like Case Study 1, included students who participated in the control group from the first sample. The story was composed after an observation and is followed by interpretive commentary based on the results of the three students who were interviewed in order to help place the story in context.

Case Study 2: Class 5-2

The students' desks were clustered to accommodate four students. In the center of each cluster were rulers, scissors, glue and teacher-made worksheets. The worksheets were divided into two piles. One pile of worksheets was composed of varying rectangles. The other pile was composed of different-sized circles.

The classroom door opened and the students entered in an orderly fashion. They proceeded to their seats and examined the objects which they saw in front of them. The teacher, who has been monitoring the hallway, entered the classroom and walked over to her podium. She looked at her seating chart, took attendance and began a whole-group lesson.

She walked over to one of her two chalkboards where she had previously drawn several quadrilaterals and circles. Their names and formulas for perimeter, circumference and area were written under each shape. She asked one of the volunteering students to describe each of the shapes. After a brief discussion, the teacher explained the use of the formulas. She walked over to the other chalkboard and solved some examples as the students tried to follow her explanations. Some students took notes. Questions were not asked by the students.

The teacher then instructed each student to take a ruler, scissors and both worksheets. "Cut out the rectangles and measure each to find their perimeters and areas. Then cut out the circles and measure each one of them to find their circumferences and areas."

The teacher walked around the classroom and stopped occasionally to help students. After 15 minutes, she instructed the class to paste the shapes with their calculations on a piece of notebook paper. She reminded them to write the school's standard heading and entitle the activity.
As the period neared closing, the teacher asked the students to be sure to clean their areas and put the rulers, scissors and glue in the center of their tables. She then asked the class of students to push their chairs under the desks and to be sure to hand their activities to her as they left the classroom. No homework was assigned.

Students from Class 5-2 expressed that they had to learn mathematics to pass tests and other assessment tasks so that they can progress to another grade, to get good grades, and to learn new things. The students felt that they did not help their teacher to plan their mathematics activities.

The students recommended that their teacher should spend more time with their classmates who needed help. If a student in the class was having trouble with class activities, the child raised his/her hand and the teacher would help. The teacher explained and explained until the student understood.

Communicating with other students in this class helped to enhance the learning environment because it helped to make sure that everyone understood the mathematics concepts. Expressing opinions informed the teacher of any misconceptions that would interfere with students' understanding.

Projects were the most enjoyable mathematics activities in the class. New mathematics concepts were considered enjoyable because the students believed that those concepts would help them to learn more.

Finding out about new mathematics concepts was important to these students. Any new concepts would allow them to be promoted. By learning new concepts, students thought that they would be able to apply to college. The students believed that new mathematics concepts were explained so well by their teacher that they understood them without difficulty.

Experiences in the mathematics class were mixed. Many students liked learning new concepts and they thought that problem solving was fun. However, abundant homework in computation was considered boring.

Case Study 3 pertains to the students who participated in the Class Banking System (experimental group) from the first sample. Following the story that is based on observation, interpretive commentary describes the results of the three student interviews from this group.

Case Study 3: Class 5-3

While the students are planning with their partners for their Class Banking System business openings, I quietly take attendance by looking at my students and comparing their presence with my seating chart. Before I finish my scan, a student comes over to me at my podium to ask me an investment question regarding his stock split. Content with my explanation, he hurries back to his partner with the information.

After attendance is completed, a short seminar period is necessary to discuss CBS matters. I begin the period by reading my mail that students place in a mailbox that was created by one of them. It is necessary to read and discuss each message with the entire class in order to ensure class satisfaction and the quality of this program. One student, for example, is unhappy about the quality of a chair that he bought for his playhouse. His receipt needs to be examined and both sides of the purchase agreement need to be allowed the opportunity to speak on his/her own behalf. Brainstorming solutions provide decisions about how best to solve this problem. Another student has an idea for a business for the next grading period and wants to discuss some details. A third student is unhappy with his accountant. He says that he thinks that he overpaid his taxes and deserves a refund but his accountant made a calculation error.

After the seminar, I ring the opening bell. That is the signal that the students who are opening their business on this day are to set up.

The classroom atmosphere becomes active with busy students conducting their businesses. The financial investors are excited about news which they are viewing on the computer via the internet. The chairman of the Federal Reserve Board has lowered interest rates by 0.5%. A pharmaceutical company has gained approval to market a generic version of a powerful cancer drug. That company has declared a 3 for 1 stock split. A very popular media giant has added a new adventure to one of their theme parks.

The interior design company is measuring the perimeter and area of a client's house for a round dining room table. The table must be constructed to scale and its circumference needs to be calculated.

A student is concerned that she will be unable to pay her mortgage because her income from her business has not been as lucrative as she had hoped. She is asking her accountant for advice. The homeowners' association is planning to decorate the class's model neighborhood for a holiday. They are meeting to calculate the necessary assessment to each homeowner. They want to put festive wreaths on doors and spruce up the neighborhood with trees and flowers. They also want to create a park.

The interaction of all of the students is exciting to watch. After 40 minutes, I hesitantly ring the closing bell. The last transactions are completed. The students use clips to hold their paperwork together and each puts the paperwork into a folder.

For homework, all students must calculate their earnings and tax payment. Those reports must be submitted to me by the following day. In addition, the financial advisors must track their clients' investments and carefully file their orders. The interior designers must construct furniture and/or accessories that their customers ordered for timely deliveries. The accountants must analyze and write plans to help their clients to satisfy their financial obligations and desires. The homeowners' association must communicate outside the school setting to divide the responsibility of completing and delivering their promised items. They also must prepare a weekly newsletter that informs the homeowners about their ideas, progress, and rules for keeping an attractive neighborhood.

All of the activity slows down and students return to their assigned seats. There is still an atmosphere of excitement as the communication turns to a whisper. It's time for dismissal.

The students from Class 5-3 were glad that they knew how to apply their fifth-grade mathematics concepts. They were proud to be able to count money, calculate stock purchases and sales, balance bank account statements, and analyze their own business and personal financial strategies. The students felt that, in this class, mathematics required them to use critical thinking skills.

Two class periods per week were designated for seminar. The students got the opportunity to express their feelings and ideas. If they encountered any problems, seminar was a great time to brainstorm solutions. One student said: "In this class, students work cooperatively. The teacher assists us by monitoring discussions and activities."

When the students' businesses are open, clear communication is necessary for precise interaction. Conceptual development of fifth-grade mathematics is occurring. For example, interior designers must be certain of their clients' window 'measurements'. Are the windows 'rectangular' or 'circular'? Stockbrokers must report their clients' stock activity on a 'line graph' or compare them using 'bar graphs'. Those concepts become important parts of the students' ideas. This constructivist thinking facilitates meaningful learning (Treagust, Duit & Fraser, 1996, p. 41).

The activities that were most enjoyed included purchasing stocks when the financial planners were open for business and planning for their own businesses. Many students felt that following a stocks' activity was interesting and that they were able to use their skills in creative ways to please their customers. Understanding how to compute tax on merchandise was exciting to this class because the concept was unknown to them before they participated in the CBS. The students expressed that they felt that they were becoming well prepared for the future.

Concept maps were often used. The students thought that the concept maps were fun because they required intense thinking. Creativity was needed when constructing the maps and the students had to draw on their own previous experiences.

This class enjoyed mathematics class for many reasons. Most of all, the CBS consistently helped them to like mathematics while the activities enhanced conceptual development. The enjoyable activities of the CBS created a classroom atmosphere that encouraged students' desire to learn.

Comparison of Classroom Environments

The above case studies compared three separate mathematics classes that had distinct teaching/learning environments. Because these classes received different opportunities, this researcher used case studies to clarify the atmosphere in each example (Anderson & Arsenault, 1998, pp. 90-91).

Students from each of the three classes were interviewed on the basis of student responses to selected questionnaire items. Analysis of the interviews added more insight into those students' perceptions of their learning environment in mathematics classes. In describing the three case studies in terms of similarities and differences, five broad patterns emerged (Miles & Huberman, 1994, pp. 245-62). Those patterns reflected the interview script.

First, the students from each of the classes viewed their roles as learners who were serious about achieving the skills being taught by their mathematics teachers. They perceived the mathematics that they were being taught as being important for successful futures. The students from Class 5-1 gave some simple examples of the need to understand concepts. Class 5-2 students basically viewed the importance of their class as a vehicle to help them to progress to the next grade level. The students from Class 5-3 were able to apply their mathematics concepts to specific, real-world situations and they showed pride in providing examples of their classroom activities.

Second, the students from all three classes reported a desire for individualized instruction. They perceived their teacher as a person who had the potential to provide each student with the instruction necessary for their success. Both of the classes that composed the comparison group revealed a desire for expressing their opinions. The treatment group explained that they were provided seminar periods for discussions.

The students' attitudes were positive in all three case studies. They all enjoyed working on projects. It was noted that treatment group students were the only ones to offer specific examples of exciting activities.

Concept maps were routinely used in the treatment group's instruction. However, the two classes in the comparison group expressed enjoyment when using new concepts.

Overall, the students from the three classes had clear expectations of their roles and their teacher's role. Their classroom environments were distinctly different, ranging from extremely textbook oriented to extremely individualized and creative, using textbooks only as references. In all cases, the students' attitudes were positive, although Class 5-3 students clearly exhibited more excitement for learning mathematics. The teacher's constructivist epistemology was apparent in the treatment's group classroom environment. Constructivism did not seem evident in the comparison group's classroom environment.

Discussion, Significance, and Importance

Our research investigated whether using the innovative Class Banking System (CBS) mathematics program provided students with an improved classroom environment, attitudes, and conceptual development relative to students studying a traditional program. Two samples were involved in our study and both were in good positions to make judgments about their classrooms because they had experienced many different learning environments and had enough time in their present classes to form accurate opinions.

The data sources for this study were students in two experimental groups who participated in the CBS (N=44), together with four classes that did not participate in CBS (N=75). Those students were part of two samples. Sample 1 participated in the present study during the 2000-2001 school year. It consisted of 18 students in the experimental group and 35 students in the control group. The second sample was added during the 2001-2002 school year in order to expand the scope of the study. That sample consisted of 66 students (26 in the experimental group and 40 in the control group).

Our methodology provided comparative data about the effectiveness of the program. The *Individualized Classroom Environment Questionnaire* (ICEQ), in both its actual and preferred forms, and the actual form of the *Constructivist Learning Environment Survey* (CLES) provided quantitative data about students' perceptions of their classroom learning environment (Fraser, 1998b). The *Test of Mathematics-Related Attitudes* (TOMRA) and concept map tests added data that was used for comparing students' attitudes toward mathematics and their achievement in terms of conceptual development of fifth-grade mathematics skills. This quantitative information was useful for providing valuable feedback and for guiding attempts to improve teaching and learning by analyzing the results from the two samples. Sample 1 was administered the ICEQ (both actual and preferred), CLES (actual), TOMRA, and achievement test. To strengthen our findings from the first sample, the second sample was administered the ICEQ (actual), CLES (actual), and TOMRA. These instruments were administered to both samples using a pretest-posttest design for comparison of experimental and control groups.

Qualitative information provided a more in-depth understanding of the results of our study (Punch, 1998, pp. 149-150). Observations and interviews presented as case studies added complementary data to that pertaining to mathematics learning environments and students' attitudes. If we had used only quantitative data, the richness of the mixed methods would have been lacking.

Compared to non-Class Banking System students, Class Banking System students perceived their classroom environments more positively in terms of the ICEQ (Personal Relevance, Participation Independence, and Investigation) and CLES (Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation). They also reported more positive attitudes and experienced more favorable changes on the mathematics concept test. Qualitative results were based on classroom observations and student interviews and they enriched and reinforced the quantitative information obtained from the questionnaires and concept test. Quantitative and qualitative data supported the effectiveness of the CBS in providing elementary mathematics students with an individualized and constructivistic classroom learning environment.

Our study is educationally important because it shows that the CBS provides a stimulating elementary classroom environment that makes use of real-life experiences for the students. We analyzed its effectiveness in enhancing classroom environment, student attitudes toward mathematics, and conceptual development in mathematics.

Our study contributes to the field of learning environments because it is one of the relatively few studies worldwide that have focused on mathematics. Also, this study represents one of the relatively few past studies that have employed learning environment dimensions as criterion variables in the evaluation of educational innovations.

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