<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>Classroom climate and student outcomes in elementary mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author(s)</strong></td>
<td>Swee Chiew Goh and Barry J. Fraser</td>
</tr>
<tr>
<td><strong>Source</strong></td>
<td>ERA - AARE Joint Conference, Singapore, 25-29 November 1996</td>
</tr>
</tbody>
</table>

This document may be used for private study or research purpose only. This document or any part of it may not be duplicated and/or distributed without permission of the copyright owner.

The Singapore Copyright Act applies to the use of this document.
Classroom Climate and Student Outcomes in Elementary Mathematics

Swee Chiew Goh
Barry J. Fraser
Nanyang Technological University
Curtin University of Technology
Republic of Singapore
Australia

ABSTRACT
This study examined associations between classroom climate and affective and cognitive outcomes among primary mathematics students in Singapore. Also gender differences in students' achievement, attitudes and perceptions of classroom climate were explored. A random sample of 1,512 boys and girls from government primary schools was used. For the analysis of climate-outcome associations, a series of statistical analyses were conducted using two units of analysis, namely, the individual student and the class mean. For the analysis of gender differences, multivariate analyses of variance for repeated measures was performed for the two outcome measures and the classroom climate scales. The study led to the validation of a widely-applicable and convenient learning environment questionnaire for future use by researchers and teachers at the primary school level. Overall the different methods of analysis yielded consistent associations between classroom climate and student outcomes. Gender differences were detected in mathematics achievement, in favour of boys, but girls generally viewed their classroom climate more favourably than the boys did.


Introduction
Any thorough analysis of the classroom learning environment must consider the key players involved, namely, the teacher and the students. The interplay of the behaviour of the teacher and the students determines the classroom or psychosocial climate. Classroom
practices and developments, particularly during the last 30 years, have indicated that a positive classroom climate is needed for effective learning (Brophy & Putnam, 1979; Emmer, Evertson, & Anderson, 1980). The concept of a learning environment has taken root since the 1930s, especially with the emergence of Murray's Needs-Press model (1938) and Kurt Lewin's social-psychological climate work (1936), which recognised that behaviour is a function of the person and the environment. In 1960, a framework for the analysis of the classroom group as a unique social system was developed by Getzels and Thelen (1960). Stern (1970) formulated a theory of person-environment congruence in which complementary combinations of personal needs and environmental press enhance student outcomes. Later, Doyle (1979) proposed that the classroom be considered from an ecological viewpoint, hence placing strong emphasis on the inter-relationships and communications among all members in the classroom community. The Seventy-eighth Yearbook of the National Society for the Study of Education, dedicated to classroom management, stressed the importance of the human factor in the classroom environment (Johnson & Brooks, 1979). Because learning activities always are accompanied by interpersonal interaction and intrapersonal sentiments, this human element has made the classroom complex and unpredictable (Doyle, 1983). The last 20 years has witnessed the establishment of a strong tradition of studying classroom climate through the perceptions of students and teachers (Fraser, 1986, 1994; Fraser & Walberg, 1991; MacAulay, 1990).

The present study aimed to investigate classroom climate in primary mathematics classes in Singapore. In addition to validating a widely-applicable instrument for use at the primary level, the study investigated associations between two student outcomes (attitudes and achievement) and student perceptions of classroom climate. Also gender differences in learning environment perceptions were investigated.

Review of Research
Over the previous quarter of a century, considerable interest has been shown internationally in the conceptualisation, measurement and investigation of perceptions of psychosocial characteristics of classroom climate at the primary, secondary and higher education levels (Chavez, 1984; Fraser, 1986, 1989; Fraser, 1994; Fraser & Walberg, 1991; Walberg, 1979). Classroom climate instruments have been used as sources of predictor and criterion variables in a variety of research studies. Use of student perceptions of actual classroom climate as predictor variables in numerous countries has established consistent relationships between the nature of the classroom climate and various student cognitive and affective outcomes (Fraser, 1986; Fraser & Fisher, 1982; Haertel, Walberg, & Haertel, 1981). Furthermore, research involving a person-environment fit perspective has shown that students achieve better where there is greater congruence between the actual classroom climate and that preferred by students (Fraser & Fisher, 1983).

Studies involving use of the actual form of classroom climate scales as criterion variables have revealed that classroom psychosocial climate varies between different types of schools (Trickett, 1978) and between
coeducational and single-sex schools (Trickett, Trickett, Castro, & Schaffner, 1982). Both researchers and teachers have found it useful to employ classroom climate dimensions as process criteria of effectiveness in curriculum evaluation because they have differentiated revealingly between alternative curricula when student outcome measures have shown little sensitivity (Fraser, Williamson, & Tobin, 1987). Research in the USA (Moos, 1979), Australia (Fisher & Fraser, 1983) and The Netherlands (Wubbels, Brekelmans, & Hooymers, 1991) compared students' and teachers' perceptions and found that, first, both students and teachers preferred a more positive classroom climate than that perceived as being actually present and, second, teachers tended to perceive the classroom climate more positively than did their students in the same classrooms. In promising small-scale practical applications, teachers have used assessments of their students' perceptions of their actual and preferred classroom climate as a basis for identification and discussion of actual-preferred discrepancies, followed by a systematic attempt to improve classrooms (Fraser & Fisher, 1986; Thorp, Burden, & Fraser, 1994).

Some of the exciting recent or current lines of classroom climate research involve (1) developing a new instrument for evaluating the degree to which a classroom is consistent with a constructivist epistemology (Taylor, Dawson, & Fraser, 1995), (2) investigating the links between and the joint influence of classroom, school, family and other environments on student outcomes (Moos, 1991), (3) incorporating classroom climate as one factor in a multi-factor model of educational productivity (Fraser, Walberg, Welch, & Hattie, 1987), (4) exploring ways in which classroom climate instruments can be used to advantage by school psychologists (Burden & Fraser, 1993), (5) incorporating learning environment ideas into teacher education (Fraser, 1993), (6) investigating changes in classroom climate during the transition from primary to high school (Midgley, Eccles, & Feldlaufer, 1991), (7) incorporating the assessment of classroom climate in teacher assessment schemes (Heroman, Loup, Chauvin, & Evans, 1991), (8) the development and application of a new instrument for science laboratory classroom climate (Fraser, Giddings, & McRobbie, 1995; Fraser & McRobbie, 1995), and (9) research on the distinctiveness of the learning environment of Catholic schools (Dorman, Fraser, & McRobbie, 1994).

Although the study of learning environments has a history of 25 years in other countries, it made its first appearance in Singapore only recently with a study of student perceptions of computer-assisted classroom climates (Fraser & Teh, 1994; Teh & Fraser, 1994). This study led to the development and validation of a new climate instrument for computer-assisted instructional settings. It also established that computer-assisted learning for below-average secondary students was a more efficacious instructional method than a traditional teaching method. Furthermore, an investigation of associations between student outcomes and computer-assisted learning environments in secondary geography classes replicated past research in that achievement and
attitudes were better in classes perceived to have positive classroom climates.

Another Singaporean study used the Individualised Classroom Environment Questionnaire (ICEQ) in exploring secondary students' perceptions of their classroom climate in different types of schools, streams and subject specialisations (Lim, 1993). The study indicated, among other things, that students preferred a more positive classroom climate than actually was present.

Wong and Fraser's (1994) recent study focused on determinants and effects of chemistry laboratory classroom climate in secondary schools. It revealed differences in perceptions between teachers and students, that preferred chemistry laboratory classroom climates were more favourable than actual perceptions, and that students from different streams differed in their preferred (but not their actual) perceptions. Also relationships were found between student affective outcome and the perceived climate of chemistry laboratories, and gender differences in perceptions emerged.

As practically all past studies in Singapore have been undertaken in secondary classrooms, it was timely to initiate the present study focusing on classroom climate at the primary level. Therefore, we examined, through student perceptions, the impact of classroom climate on student cognitive and affective outcomes in primary mathematics classes. This study is distinctive because it is the first classroom climate research in primary mathematics classes in Singapore.

Research on gender differences in mathematics learning in Singapore is comparatively scarce (Kaur, 1992; Ministry of Education, 1988). Despite the paucity of research in this area, it is evident that a gender gap exists in mathematics achievement among Singaporean students (Kaur, 1992). Although currently, considerable educational research in Singapore has focused on issues and problems relating to secondary schools, less research work has been done concerning primary schools, as is the case also in developed western countries (Raviv, Raviv, & Reisel, 1990).

In the Singapore primary school curriculum, the teaching of mathematics and languages (English as a first language and mother-tongue as a second language) are equally important, beginning with the pre-primary stage right through the primary school into secondary and post-secondary schooling. In view of the importance of mathematics in the school curriculum, we investigated whether the teacher-student-context triad promotes or hinders student liking for mathematics and student achievement in primary schools in Singapore. Therefore, this study examined how classroom climate affects grade 5 students' cognitive and affective outcomes.

The Sample

A random sample of 39 mathematics classes from 13 government coeducational primary schools provided (1) a teacher sample size of 39 mathematics teachers, one for each of the 39 classes and (2) a student sample size of 1,512, comprising 815 boys and 697 girls. These students
were 10 to 11 years of age, of mixed ability, and in the EM2 stream (where they learn English as a first language, Chinese/Malay/Tamil as a second language, Mathematics and Science). These 39 classes were intact classes because the principals gave the researchers permission only to administer the questionnaires to whole classes during mathematics curriculum time.

The Instruments

The three instruments used were the My Class Inventory, the Liking Mathematics Scale and the Mathematics Exercise. Classroom climate was assessed with a modified version of the My Class Inventory (MCI; Fisher & Fraser, 1981; Fraser & O'Brien, 1985). This modified 20-item version provides information regarding student perceptions of the four classroom climate scales of Cohesion, Competition, Friction and Task Orientation. Descriptive information for the MCI is provided in Table 1.

Table 1
Descriptive Information for MCI Scales

Items in the My Class Inventory are arranged in cyclic order so that the first, second, third and fourth item in each group of four items assesses, respectively, Cohesion, Competition, Friction and Task Orientation. Items with their item numbers underlined are scored 3, 2 and 1, respectively, for the responses Seldom, Sometimes and Most of the Time. All other items are scored in the reverse manner. Omitted or invalid responses are scored 2. Scores for a particular scale can be obtained by adding the scores obtained for the five items in that scale. For example, the sum of the scores for items 1, 5, 9, 13 and 17 represents the scale score for Cohesion, while the total score for items 2, 6, 10, 14 and 18 represents the scale score for Competition. The higher the scale score, the more a class would demonstrate that particular dimension of the classroom climate.

The affective outcome was assessed with the Liking Mathematics Scale (LMS), which is based on a 10-item instrument developed specifically by the researchers to measure student liking and interest for mathematics, with guidance provided by attitude scales developed by Keeves (1974) and Fraser (1981). The LMS comprises 10 statements which are expressed in a simple, direct and concise manner, such as "I enjoy mathematics classes" and "Mathematics is fun". For the MCI and the LMS, students respond on a three-point Likert scale consisting of Seldom, Sometimes and Most of the Time.

Student cognitive achievement was assessed with a 10-item mathematics achievement test, the Mathematics Exercise (ME), which was based on a sample of school mathematics assessment papers and primary mathematics textbooks and workbooks. This instrument was developed by the researchers in three stages, taking cognizance of the importance of feedback from experts in the field (school mathematics teachers and mathematics experts or content experts). Items in the ME were developed after a careful examination of the grade 5 mathematics syllabus for
Singapore primary schools and samples of mathematics assessments (class tests or continuous assessments). Each item was designed with a problem/situation as the stem, and had four alternative responses.

With regard to the reliability of measures of affective (LMS) and cognitive (ME) student outcomes, estimates provided by the Cronbach alpha coefficient for two units of analyses (the individual and the class mean) were satisfactory. The reliability of the LMS was 0.91 and 0.98, respectively, and of the ME was 0.69 and 0.96, respectively, for the individual student and class levels of analysis. A pilot study was carried out with two grade 5 classes of the EM2 stream in one government primary school to gather subjective information to guide smooth administration of instruments during the main study. This field testing was also necessary to evaluate (1) the comprehensibility and clarity of the items in the three instruments, (2) the suitability of the three-point Likert response scale consisting of Seldom, Sometimes and Most of the Time, (3) the procedures for data collection, and (4) the approximate amount of time required by students to complete each of the instruments. In addition, the researchers interviewed six students concerning the clarity of the instruments and the three-point rating scale. To improve the comprehensibility and clarity of the instruments, difficult words identified by students during interview were substituted with simpler words, if possible or appropriate. Also, a few other items were reworded to ensure that the reading level was more appropriate. The response format in the questionnaires was found to be appealing and clear to the students. The procedures used for data collection in the two classes proved logical and systematic, and students found the directions simple and straightforward. Overall, the total time taken by the students to respond to the instruments was about 40 minutes. In the main study, one of the researchers personally administered the three instruments in every class involved in the study. Students used pencils to shade their responses on Optical Answer Sheet, a process with which they were familiar during school assessments. Each instrument was printed on paper of a different colour to aid administration and add variety to the process. Validation of My Class Inventory The modified version of the MCI was administered during mathematics curriculum time and in the absence of the mathematics teachers, in order to ensure that student responses would not be inhibited in any way by the presence of the teacher. A series of data analyses was conducted to establish the MCI's internal consistency reliability, discriminant validity and ability to differentiate between perceptions of students in different classes. Table 2 reports the internal consistency of the MCI at two levels of analysis. The alpha reliability figures in Table 2 show that three out of four MCI scales (Cohesion, Friction and Task Orientation) have values above 0.90 at the class level, which are higher than those
reported previously by Fraser, Malone and Neale (1989). The data in Table 2 suggest that MCI scales have good internal consistency reliability for use with either students or classes as the unit of analysis.

Table 2
Internal Consistency Reliability (Cronbach Alpha Coefficient) and Discriminant Validity (Mean Correlation with other Scales) for Two Units of Analysis and ANOVA Results for Class Membership Differences for MCI

Data concerning discriminant validity were obtained using the mean correlation of a scale with the other three scales of the MCI as a convenient index (see Table 2). The data indicate that the discriminant validity of these scales is satisfactory, but suggest that the MCI assesses distinct but somewhat overlapping aspects of classroom climate.

A series of analyses of variance with class membership as the main effect and using the individual as the unit of analysis indicated significant differences (p<0.01) for every scale on the MCI between the perceptions of students in different classes. The eta2 statistics, which provides an estimate of the amount of variance in classroom climate scores attributable to class membership, ranged from 0.07 to 0.24 (see Table 2). Overall, the data presented in Table 2 for the Singaporean sample suggest that the MCI displayed satisfactory reliability and discriminant validity at two levels of analysis and was able to differentiate between the perceptions of students in different classrooms.

Climate-Outcome Associations
As the main purpose of the study was to examine associations between classroom climate and student outcomes (attitude and achievement), the data were subjected to a series of correlational analyses (including simple, multiple and canonical), using the student and the class as two levels of analysis.

Simple, Multiple and Canonical Correlation Analyses
The results of simple, multiple and canonical correlation analyses reported separately in Table 3 for the two student outcomes (Liking and Achievement) and for two levels of analysis (the student and the class), generally replicate past research into associations between classroom climate and student learning (Fisher & Fraser, 1982; McRobbie & Fraser, 1993). The first type of correlational analysis reported in Table 3 involved the simple correlation between each outcome and each MCI scale. The major advantage of this analysis is that it furnishes information to educators interested in associations between a particular teacher interpersonal behaviour and a particular outcome. The number of significant simple correlations (p<0.05) in Table 3 is 8
with the individual as the unit of analysis and 7 with the class as the unit of analysis. Generally the simple correlational analysis suggests that all climate dimensions are related to student attitudes and achievement.

Table 3
Simple Correlations (r), Multiple Correlations (R), Canonical Correlations and Standardised Regression Coefficients (b) for MCI Scales and Two Student Outcomes for Two Units of Analysis

The second type of correlational analysis consisted of a multiple regression involving the set of four MCI scales performed separately for the two student outcomes and for two levels of analysis (Table 3). Relative to the simple correlational analysis, the multiple regression analysis provides a more parsimonious picture of the joint influence of correlated classroom climate dimensions on outcomes and reduce the Type I error rate. The multiple correlation was statistically significant (p<0.05) for both units of analysis for both outcomes, with the magnitude being 0.81 for the attitude outcome and 0.71 for the achievement outcome at the class level of analysis (Table 3).

In order to interpret which classroom climate dimensions were making the largest contribution to explaining variance in learning outcomes, the standardised regression coefficients (b) in Table 3 were examined. The tests of significance for the (b) weights indicate which individual MCI scales are related significantly to an outcome when the other three MCI scales are mutually controlled. Although the number of significant results for the multiple regression analysis (6) was smaller than for the simple correlational analysis, Competition was the only scale that was not related significantly to either outcome for either unit of analysis.

Although the use of multiple regression analysis overcomes the problem of relationships among MCI scales, a relationship between the two outcome measure still could give rise to an inflated Type I error rate for the study as a whole. Canonical analysis can provide a parsimonious picture of relationships between a set of correlated learning outcomes and a set of correlated climate variables. The bottom row shows that one significant canonical correlation (p<0.01) of 0.42 emerged for the analysis at the student level and a canonical correlation of 0.84 emerged at the class level. To interpret the results of the canonical analysis, we examined the magnitudes and signs of the structure coefficients (i.e., the simple correlations between a canonical variate and its constituent variables). Substantive interpretations were based on structure coefficients in preference to canonical weights because the latter can be misleading because of redundancy and suppression effects (Cooley & Lohnes, 1976). The overall conclusion from the
canonical analysis was that achievement and attitudes were linked with greater Cohesion and less Friction. The findings from the series of correlational analyses discussed above indicated that, of the four scales of classroom climate scales, Friction (negative) and Cohesion (positive) accounted for the largest amount of variance in student outcomes. It appears that a class with greater cohesion among its students and less friction has a conducive classroom environment that enhances student achievement and attitudes. It is interesting to note that Competition had a less strong but consistently negative association with student outcomes, especially attitudes.

Gender Differences in Outcomes and Perceptions of Classroom Climate

For the investigation of gender differences, the same sample of 1,512 students from 39 mathematics classes (815 boys and 697 girls) was used. In addition to investigating gender differences in classroom climate perceptions, we also explored gender differences in student achievement and attitudes. The unit of analysis chosen was the within-class mean computed separately for boys and girls. That is, for each class, the boys' mean and the girls' mean were calculated as a matched pair of scores. The unit of analysis, thus, was the within-class gender subgroup. This particular unit of analysis was appropriate because it avoided the confounding effects, as in some previous studies, of using the individual student as the unit of analysis. That is, if boys and girls were represented disproportionately in different classes, then any gender differences detected could be explained by differences in classes rather than gender per se. This problem was avoided by having each class provide a matched pair consisting of the boys' mean score and the girls' means score.

The first step in analysing the data for gender differences in the 6 dependent variables (the two outcome measures of attitude and achievement and the four MCI scales) was a multivariate analysis of variance (MANOVA) for repeated measures. Because each class furnished a matched pair of scores (the boys' mean and the girls' mean), repeated measures analyses were appropriate. The multivariate test yielded significant results (p<0.05) in terms of Wilks' lambda criterion, indicating that there were gender differences in the set of criterion variables as a whole. Because the multivariate F was significant, a t test for dependent samples was conducted and interpreted for each of the 6 individual dependent variables. Table 4 shows that there were no significant gender differences in terms of student attitude towards learning of mathematics, but that a small but significant gender difference in student achievement (approximately one quarter of a standard deviation) emerged in favour of boys. In addition, girls perceived their classroom climate more favourably than boys did as in previous research (Fraser, Giddings, & McRobbie, 1995; Lawrenz, 1987). Girls held more favourable perceptions of their classroom climate and did not consider their classrooms as competitive as did the boys.
Although the magnitudes of significant gender differences on MCI scales generally were small, measuring approximately half a standard deviation, the pattern of gender differences in classroom environment was small in magnitude but consistent in direction for all climate scales.

Table 4
Gender Differences in Student Outcomes and Perceptions of Classroom Climate Using the Within-Class Gender Subgroup as the Unit of Analysis

Conclusion and Discussion
Because this research broke new ground in terms of being one of the first studies in Singapore in the area of classroom learning environment, one of its important contributions is the modification and validation of a widely-applicable classroom climate instrument. When a modified version of the My Class Inventory was used with 1,512 students in 39 grade 5 mathematics classes in Singapore, each scale exhibited satisfactory internal consistency reliability and discriminant validity (with either the student or the class mean as the unit of analysis) and was able to differentiate between the perceptions of students in different classrooms.

In order to explore outcome-climate associations in primary mathematics classrooms, data were subjected to a series of correlational analyses (simple, multiple and canonical correlation), using two levels of analysis (the student and the class). The results were fairly similar (in both patterns of significance and the direction of relationships) for the different types of analysis. In particular, Friction was a significant independent predictor for student mathematics achievement. The more friction that prevailed in class, the lower was the achievement. Overall, a class that enjoys greater cohesion among its students and sees less friction contributes to a conducive classroom environment that enhances student achievement and attitudes. These findings inform educators in Singapore about how to improve student achievement and attitudes by consciously fostering greater cohesion among students. A typical Singaporean classroom in a neighbourhood school is multiracial in composition, comprising students of mainly Chinese, Malay and Indian origin. Teachers are also from the same ethnic mix. Class cohesion will bring about increased cooperation and bonding among students and lessen friction among individual students. Ultimately, this will help establish a conducive classroom learning environment that is vital to student learning.

An investigation of gender differences revealed no differences in the attitude of boys and girls towards mathematics, but boys showed superior mathematics achievement. Generally, gender differences in perceptions of classroom climate were small in magnitude but consistent in direction for all scales, with girls generally holding more favourable climate perceptions than boys.
Overall, the distinctive contributions made to the field of classroom climate research can be summarised as follows:
• Although much research on classroom climate has been completed at the secondary school level, this study provides one of the most comprehensive of the relatively small number of studies undertaken at the primary school level.
• This study is one of a small handful that marks the beginning of the field of classroom climate research in Singapore.
• The My Class Inventory was adapted and crossvalidated for use in Singapore.
• The research included one of the few investigations of gender differences in students' classroom climate perceptions.

Although the present pioneering study predominantly involved the use of quantitative methods, the qualitative methods used in the pilot study formed an important part of the overall study. Moreover, now that the present initial study has used quantitative methods to validate a widely-applicable instrument for future use, it is highly desirable to combine qualitative and quantitative methods in future research with these instruments as recommended by Fraser and Tobin (1991).

References
preferred classroom environments as perceived by science teachers and students. 

Fraser, B. J. (1981). Test of Science-Related Attitudes (TOSRA). 
Melbourne, Australia: Australian Council for Educational Research.