Students' Perceptions and Attitudes in

Upper Primary Computer-assisted Mathematics Classrooms

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ABSTRACT

The main aim of this study was to examine the relationship between the nature of the classroom learning environment and the students' attitudes towards computer-assisted Mathematics classes. In addition, the students' actual and preferred perceptions of the computer laboratory learning environment and gender differences in students' perceptions of computer-assisted Mathematics classroom environment were also explored.

The sample used in this study comprised 177 Primary 5 pupils from a government primary school located in a densely populated housing estate in Singapore. The instruments used were the actual and preferred versions of the My Computer Class Inventory (MCCI) and the Computer Lesson Attitude Questionnaire (CLAQ). A series of data analyses were conducted to establish the MCCI's internal consistency reliability, discriminant validity and ability to differentiate between perceptions of students in different classes.

The investigation of attitude-environment association involved using simple and multiple correlational analyses using the student as the unit of analysis. The findings from this study revealed the existence of positive associations between the nature of the computer-assisted Mathematics classroom environment and the students' attitudinal outcomes. In addition, it was found that the perceptions of boys and girls differed; i.e., the girls held more favourable perceptions than the boys.

Key Words: Classroom environment, attitude, achievement, science education

INTRODUCTION

Over the past thirty years, considerable interest has been shown in the investigation of relationships between the nature of the classroom climate and various student cognitive and affective outcomes (Fraser, 1986; Fraser & Fisher, 1982; Haertel, Walberg & Haertel, 1981). The most common type of research has been the investigation of associations between students' cognitive and affective learning outcomes and their perceptions of their classroom environment (i.e., environment dimensions as predictor variables) (Fraser, 1994). The practical implication of such studies is that student outcomes might be improved by creating classroom environments found empirically to be conducive to learning. With this objective in mind, the present study was embarked upon.

The purpose of the present study is to examine how computer-assisted Mathematics classroom climate is related to primary 5 (grade 5) students' attitudinal outcomes towards computer-assisted learning in Mathematics classes. Mathematics was chosen in view of its importance in the Singapore education system. It is a core subject in the Singapore primary school curriculum, right from primary one (grade 1) to primary 6 (grade 6). Mathematics classes have been conducted in a traditional manner with the teacher as a disseminator of information until recently with the introduction of computers in the classrooms.

Educational computing was introduced to the Singapore education system to facilitate the learning process of Mathematics as it has the flexibility and capacity for individualizing instruction by permitting on-going active involvement of students, evaluating their responses and adapting instructional strategies that meet individual needs, levels of achievement and specific interests. The incorporation of technology can help support teachers and their professional development, connect students' learning to the real world, connect schools to the home and community. However there is a dearth of research on the effects of computer-assisted instruction (CAI) in Singapore. Hence, in view of the potential such research has for our understanding of computer-assisted learning environments in the Singapore primary school classrooms, the present study was conceptualised and conducted.

BACKGROUND

Traditionally, research and evaluation in education have tended to rely heavily and sometimes exclusively on the assessment of academic achievement and other valued learning outcomes. Although few responsible educators would dispute the worth of outcome measures, they cannot give a complete picture of the educational process. Some educators often speak of a classroom's environment, climate, ambience, tone and atmosphere and consider it to be important and influential. Because students spend up to 15000 hours at school by the time they finish senior high school, students have a large stake in what happens to them at school and their reactions to and perceptions of their school experiences are significant.

Hence, progress has been made over the past 30 years in terms of conceptualizing, measuring and analysing classroom environment (Fraser, 1989). Herbert Walberg and Rudolf Moos began seminal independent programmes of research which formed the starting points of educational environment research thirty years ago. Walberg developed the widely-used *Learning Environment Inventory* (LEI) as part of the research and evaluation activities of Harvard Project Physics (Walberg & Anderson, 1968). Moos began developing the first of his social climate scales, including those for use in psychiatric hospitals and correctional institutions, which ultimately resulted in the development of the *Classroom Environment Scale* (CES) (Moos, 1979; Moos & Trickett, 1987) for school settings. The important pioneering work of Walberg and Moos on perceptions of classroom environment developed into major research programmes and spawned a lot of other research.

In the past three decades, classroom environment research has encompassed studies using environment dimensions as predictor variables or as criterion variables (Fraser, 1994). However, the most common type of research has been the investigation of associations between students' cognitive and affective learning outcomes and their perceptions of their classroom environment (Fraser, 1994). The strongest tradition in past classroom environment research has involved investigation of association between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Fraser & Fisher, 1982; Haertel, Walberg & Haertel, 1981). Numerous research programmes have shown that student perceptions are associated with appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics.

The practical implication from this research is that student outcomes might be improved by creating classroom environments found empirically to be conducive to learning. For example, Fraser's (1994) tabulation of 40 past studies in science education showed that associations between outcome measures and classroom environment perceptions were replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments and a variety of samples (ranging across numerous countries and grade level).

Using the Science Laboratory Environment Inventory (SLEI), associations of classroom environment perceptions with students' cognitive and affective outcomes had been established for a sample of approximately 80 senior high school chemistry classes in Australia (Fraser & McRobbie, 1995), 489 senior high school biology students in Australia (Fisher, Henderson & Fraser, 1997) and 1592 grade 10 Chemistry students in Singapore (Wong & Fraser, 1996b). Using an instrument suited for computer-assisted instruction classroom, Teh and Fraser (1995) established associations between classroom environment and achievement and attitudes among a sample of 671 high school Geography students in 24 classes in Singapore. Using the QTI, association between student outcomes and perceived patterns of teacher-student interaction were reported for samples of 489 senior high school Biology students in Australia (Fisher, Henderson & Fraser, 1997), 3994 high school Science and Mathematics students in Australia (Fisher, Fraser & Rickards, 1997) and 1512 primary school Mathematics students in Singapore (Goh, Young & Fraser, 1995).

Although there has been a revolution in recent years in terms of both the scope and variety of the roles which computer-assisted learning has played within education, the field of classroom learning environment (Fraser, 1986, 1993 ; Fraser & Walberg, 1991) has lagged behind in three major ways. Firstly, there has existed no learning environment instrument which has been tailor-made specifically for use in classrooms using computers. Secondly, innovations in computer-assisted learning rarely have been evaluated in terms of their impact on the nature of the classroom learning environment as perceived by students. Lastly, little has been done on gender differences on general computer-assisted learning environment outcomes and classroom environment.

It is with this knowledge in mind that the present study was embarked upon.

RATIONALE FOR THE STUDY

As the Head of the IT department in a government primary school, the researcher would like to find out if IT was used appropriately to enhance teaching and learning of Mathematics in the school. Mathematics was chosen among other core subjects as it had been the school's area of concern for the past two years. The researcher would also like to find out about the students' attitudes towards the current computer-assisted learning environment in the school. This study will help determine which aspects of the computer-assisted Mathematics classroom environment could contribute to the attitudinal outcomes of the students towards computer-assisted learning in Mathematics classes. The findings will inform teachers about how they may improve students' attitudes by giving greater emphasis to learning environment aspects correlated positively to outcomes and less emphasis to those correlated negatively with the outcomes.

The researcher would also like to find out if the students were happy with the current computer-assisted learning Mathematics environment. For instance, the researcher would like to know if there were enough resources for the students and if the teachers were giving enough support to the students in the computer-assisted classroom environment. Hence, a comparison of students' actual and preferred perceptions of computer laboratory learning environment will also be discussed in this study. Preferred perceptions of students might be more favourable than their actual perceptions. Teachers can monitor their computer laboratory learning environment and guide attempts to improve the laboratory teaching. It is important that teachers obtain students' feedback about their computer laboratory learning environment so as to enable them to make necessary changes and improvements in their computer-assisted instruction.

Gender differences in students' attitudes and perceptions of classroom environment will also be studied. This will help find out if there are any differences in the attitudes of boys and girls towards computer-assisted instruction. Past studies conducted both in primary and secondary schools show that female students are found to perceive their learning environment more favourably than male students. Thus there is a possibility that teachers treat male and female students differently. To find out if this applies to primary Mathematics computer-assisted classes, gender differences in learning environment perceptions would be investigated in this study.

OBJECTIVES

The objectives of the study are as follows :

- To investigate the associations between students' attitudinal outcomes and the nature of their computer-assisted mathematics classroom environment,
- To compare the students' perceptions of their actual and preferred computer-assisted mathematics classroom environments, and
- To compare the boys' and girls' perceptions of their mathematics computer-assisted classroom environments.

METHODOLOGY

Sample

The sample in this study consisted of 177 primary 5 students (average age 11 years old) from 5 intact classes in a coeducational government primary school in Singapore. Intact classes were used to avoid disruption to the curriculum. There were 98 boys and 79 girls in the sample. Computer-assisted Mathematics lessons were conducted in the computer laboratory weekly for pupils in all the five classes. Mathematics software such as the "Primary Mathematics Series" produced by Curriculum Development Institute of Singapore (CDIS) in 1993 and other titles recommended by the Ministry of Education were used during these lessons.

Instruments

Two instruments were used in this study. The computer-assisted Mathematics classroom environment perceptions of the students were measured using the *My Computer Class Inventory (MCCI).* The students' attitudes towards computer-assisted Mathematics classes were assessed using the *Computer Lesson Attitude Questionnaire (CLAQ).*

The MCCI measured students' perceptions on five environmental scales, namely, Organisation, Gender Equity, Resource Adequacy, Open-Endedness and Teacher Support. These scales were adapted from existing classroom environment instruments. The Gender Equity and Resource Adequacy were adapted from the Geography Classroom Environment Inventory (GCEI) (Teh & Fraser, 1994a). Organisation and Open-Endedness were adapted from the scales in the Computer Classroom Environment Inventory (CCEI) (Maor & Fraser, 1996), and Teacher Support was based on a scale in the "What is happening in this class" questionnaire (WIHIC) (Fraser, Fisher & McRobbie, 1996).

All the five scales were selected because of their relevance to the unique environment of computer-assisted classes used in this study. For instance, the Open-Endedness scale was included to find out if the computer-assisted Mathematics environment encouraged an open-ended setting for the development of inquiry-learning. It was also useful to find out from the students' score on the Organisation scale if the computer-assisted Mathematics lessons were well-planned and organised.

As a teacher-in-charge of the school's computer-assisted learning programme, the researcher also wanted to find out from the Resource Adequacy and Teacher Support scales if the school had provided a learning environment with adequate resources and teacher support for the students. The Gender Equity scale was also included to find out if the boys and girls were treated equally in the computer-assisted learning environment.

There were six items in each of the five MCCI scales. The response alternatives for each item were in the three Likert-type scales, namely "Yes", "Not Sure" and "No". This simplified format is suitable for younger children. Both the actual and preferred versions of the MCCI contained a total of 30 items each. This would help minimise fatigue among the children and less time is also needed to administer and handscore the inventory. Item wordings have also been simplified to enhance readability. Table 1 classifies the meaning of each of the scales and gives a description and a sample item of each scale together with information about scale allocation and scoring.

Table 1 Descriptive information for MCCI Scale

Scale Name	**Description**	**Sample Item**
Organisation	Extent to which classroom activities are planned and well-organised.	There are times when I have to wait for the teacher to help me. (-)
Gender Equity	Extent to which boys and girls are treated equally by the teachers	Girls and boys are treated the same in this class. (+)
Resource Adequacy	Extent to which the computer hardware and software are adequate.	The computers are in good working condition. (+)
Open-Endedness	Extent to which the computer activities emphasize an open-ended approach to inquiry.	I am not allowed to make up any of my own projects in this class.(-)
Teacher Support	Extent to which the teacher helps, befriends, trusts and is interested in students.	The teacher takes a personal interest in me. (+)

Items designated (+) are scored 1, 2 and 3 respectively, for the responses, Yes, Not Sure and No. Items designated (-) are scored in the reverse manner. Omitted or invalid responses are scored 2.

Students had to complete the actual and preferred versions of the MCCI. As one of the objectives of the present study was to study the gender differences in students' perceptions of computer-assisted Mathematics environment, the personal form of the MCCI was used instead of the class form. This was because a personal form was more sensitive than the class form in detecting differences between within-class subgroups (e.g. boys and girls) as it assessed a student's perceptions of his or her own role in the class (Fraser & Tobin, 1991). A class form, however, would elicit an individual student's perceptions of the class as a whole. For example, the boys would find a class less organised than the girls, yet both the boys and girls would still agree when asked for their opinions about the class as a whole. Hence, the personal form of the MCCI was used in this study.

The Computer Lessons Attitude Questionnaire (CLAQ) was adapted from the Test of Science-Related Attitudes (TOSRA) (Fraser, 1981). It has 10 items and it measured the students' attitudes towards computer lessons.

The original TOSRA questionnaire consisted of 70 items designed to measure seven distinct science-related attitudes among secondary school students. However, for the purpose of this study, only items from two of these scales were considered: Adoption of Scientific Attitudes and Enjoyment of Science Lessons. The items were combined to form a single scale for assessing the students' attitude towards computer lessons. In addition, because the present study only assessed computer-related attitudes, the word "Science" was replaced with "computer" for all items. But the original meaning of the statements remained unchanged.

Unlike the TOSRA, which used a five-point response alternative, i.e., Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree, a three-point response scale (Yes, Not Sure, No) was used for the Computer Lessons Attitude Questionnaire. Like the MCCI, the item wording in the Computer Lessons Attitude Questionnaire was simplified to suit the younger children who may experience reading difficulties. The questionnaire contained only 10 items as compared to the original TOSRA questionnaire. Besides providing greater economy in testing and scoring time, children would be able to complete the simplified questionnaire without feeling tired or distracted.

Approximately one hour was needed to administer all the questionnaires to each class. The administration of the test was conducted by the researcher during Mathematics curriculum time in the computer laboratory. The students completed the actual and preferred forms of the MCCI as well as the Computer Lessons Attitude Questionnaire.

DATA ANALYSIS AND RESULTS

Validation of My Computer Classroom Inventory (MCCI)

In this study, individual student's score was used as the unit of statistical analysis for all methods of data analysis. This particular unit of analysis was appropriate as it assumed that students in the same class responded independently of each other and the researcher had decided to analyse the perception scores obtained from the individual students rather than the shared view of all the students within the same class.

A series of data analyses were conducted to establish the MCCI's internal consistency reliability, discriminant validity and ability to differentiate between perceptions of students in different classes. The Cronbach alpha coefficient which is used as the index of internal consistency reliability, was computed separately for each scale for both the actual and preferred versions of the MCCI. Factor analyses was also carried out to assess the MCCI's structure and to identify possible "faulty" items.

Results from the above analyses showed that the Open-Endedness scale had a negative index of internal consistency. Inconsistent results were also obtained for the discriminant validity. Hence, it was obvious that the Open-Endedness scale had to be discarded. A plausible explanation for this trend is that students might not be familiar with open-ended activities in the school. This line of reasoning is probably true in the Singapore context because, coming from a highly examination-oriented school system, students are used to structured activities and feel comfortable with them because in the past they have enabled students to secure a pass grade in the examinations. Also, unlike other studies done involving the assessment of the open-endedness scale, this study involves primary school students who may not understand the term ‘open-endedness’ and hence may respond erroneously to the items.

The item analysis procedures followed by the factor analysis also led to the identification and removal of another 9 items. With the exception of these items, the remaining 15 items were retained in the instrument, resulting in a modified 15-item version of the MCCI. All subsequent data analyses were based on this 15-item version.

As a result of the successive deletion of 15 items from the MCCI, the reliability of the modified MCCI instrument was improved for most of the scales. It also resulted in higher discriminant validity values for most scales. The modified version of the MCCI is left with only 4 environmental scales instead of 5. These four scales are Organisation, Gender Equity, Resource Adequacy and Teacher Support. Unlike the original version of the MCCI which comprised 6 items for each environmental scale, the remaining four scales in the modified version of the MCCI had a total of 4 items each except for the Organisation scale which was left with only 3 items.

Analyses for Effects of Computer-assisted Classroom Environment on Student Attitudes

As the main purpose of the study was to examine associations between classroom climate and student outcomes (attitudes), the data were subjected to simple and multiple regression analyses, using the student as the unit level of analysis.

Simple correlational analysis was used to look at relationships between each environment scale and the attitudinal scale. The results reported in Table 2 revealed that two environment dimensions, Organisation and Resource Adequacy, had statistically significant associations with the attitudinal outcome. Hence, it appeared that computer laboratory classes which were well-organised and had adequate resources had a significant positive effect on the students’ attitude towards computer-assisted learning.

The second type of correlational analysis consisted of multiple regression analysis involving the set of four MCCI scales performed for the student outcomes (see last column of Table 2). Relative to the simple correlational analysis, the multiple regression analysis provided a clearer picture of the joint influence of correlated classroom climate dimensions on attitudinal outcomes and reduced the Type I error rate.

Table 2 Simple Correlations (*r*) , Standardized Regression Coefficients (b) between the scales from the Modified 15-item MCCI and the Attitudinal Outcome

Scale	**No. of items**	**Attitude**	
		Simple Correlation (*r*)	**Standard Regression Coeff, b**
Organisation	3	0.25 **	0.19 **
Gender Equity	4	0.15	0.10

Resource Adequacy	4	0.19 *	0.10
Teacher Support	4	0.13	0.07
Multiple Correlation R	0.30		

* $p < 0.05$

** $p < 0.01$

In order to interpret which classroom climate dimensions were making the largest contribution to explaining variance in learning outcomes, the standardised regression coefficient (b) in Table 2 were examined. The tests of significance for the (b) weights indicated which individual MCCI scale were related significantly to the attitudinal outcome when the other three MCCI scales were mutually controlled. The analysis revealed that only the Organisation scale is related significantly (p<0.01) to the Attitude scale using the individual as the unit of analysis, with magnitude being 0.19. This reaffirmed the significant association between the Organisation scale and the attitude outcome in the simple correlation analysis.

On the whole, the results of the different types of analyses reported in Table 2 established sizeable associations between attitude outcome and student perceptions of certain aspects of their computer-assisted learning environment. This replicated results of past research studies (Fraser & McRobbie, 1993; Wong & Fraser, 1996a; Goh & Fraser, 1996) in that there were statistically significant associations between certain aspects of the nature of the classroom learning environment and students' attitudinal outcomes.

Comparing students' actual and preferred perceptions

The actual and preferred perceptions of the students were compared using the classroom environment profiles, i.e., the scale means, standard deviations and the item means for each scale in the instrument. Table 3 provides information on the classroom environment profiles of each scale for both the actual and preferred versions of the MCCI. The item mean was calculated by dividing the scale mean by the number of items in that scale.

Table 3 Scale Means, Standard Deviations and Item Means for the Actual and Preferred Versions of the Modified 15-item MCCI for the whole sample.

Scale	No. of Items	Scale Mean			Standard Deviation		Item Mean	
		Actual	**Pref**	**Diff**	**Actual**	**Pref**	**Actual**	**Pref**
Organisation	3	8.04	8.79	-0.75**	0.43	0.23	2.68	2.93
Gender Equity	4	11.61	11.60	0.01	0.23	0.26	2.90	2.90
Resource	4	10.02	11.93	-	0.44	0.09	2.51	2.98

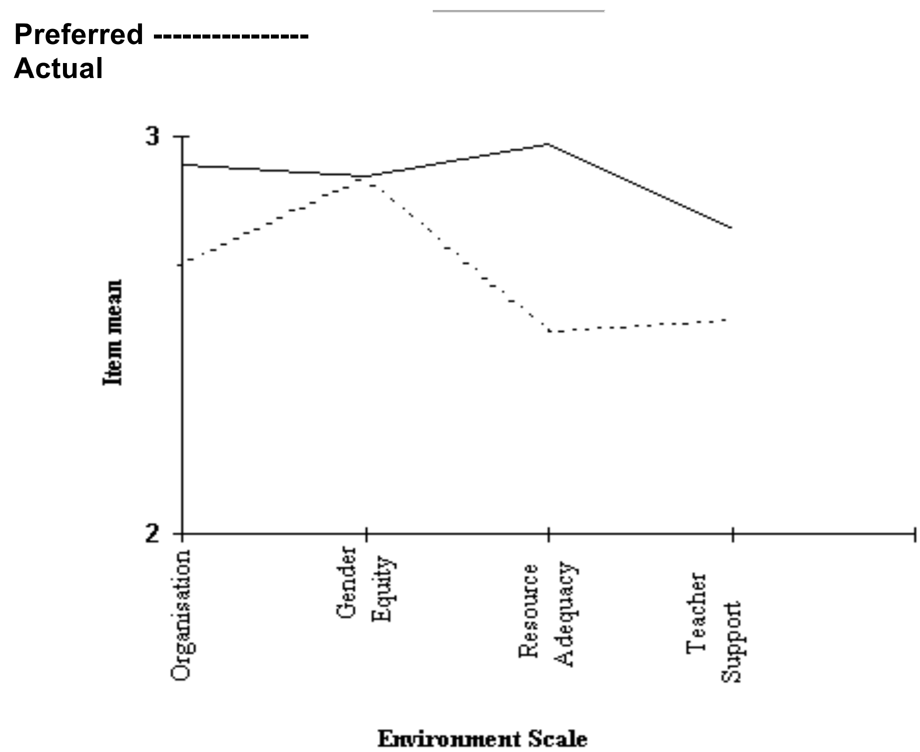
Adequacy				1.91**				
Teacher Support	4	10.15	11.06	- 0.91**	0.39	0.32	2.54	2.77

** $p < 0.01$

A univariate one way analysis of the variance (ANOVA) for repeated measures was examined for each of the four scales individually. The results showed that there were significant differences between the students' actual and preferred perceptions of their computer-assisted classroom learning environment in terms of the Organisation, Resource Adequacy and Teacher Support. Only the Gender Equity scale showed no significant difference for both versions of the inventory.

A simplified graph based on the results in Table 3 was plotted (see Fig 1) to provide a clearer picture of the differences between the students' actual and preferred perceptions of their computer-assisted classroom learning environments. Only score differences which were significantly different (p<0.01) would be plotted. The average of the students' actual and preferred scores were plotted as one single point for those scores which were not significantly differed. The response alternatives of the MCCI instrument corresponding to the value intervals on the item mean axis in the figure are as follows : 1 = "Yes", 2 = "Not Sure" and 3 = "No".

Figure 1 Simplified Plot of Significant Differences between Students' Actual and Preferred Perception Scores



Results from Table 3 and Figure 1 concluded that improvements of the present computer laboratory learning environment in terms of Organisation, Resource Adequacy and Teacher Support were necessary in order to accommodate students' needs and preferences. In other words, the students would like to have a more organised computer-assisted classroom learning environment with more resources in terms of computer software and hardware. Also, the students would like to have more support and assistance from their teachers in the computer-assisted classroom learning environment.

Comparing boys' and girls' perceptions

The actual and preferred perceptions between the boys and girls were compared using the data collected from the modified and validated MCCI. The data for the 5 classes were used to generate four sets of environment perception scores on each of the five MCCI scales: the mean of boys' actual scores, the mean of boys' preferred scores, the mean of girls' actual scores and the mean of girls' preferred scores. Table 4 provides information on the classroom environment profiles such as the scale means, standard deviations and the item means of the environment perception scores for the boys and girls. The item mean was calculated by dividing the scale mean by the number of items in that scale.

Table 4 Scale Means and Standard Deviations for the Actual and Preferred Versions of the Modified 15-item MCCI for both Boys and Girls

Scale	**No. of Items**	**Form**	**Scale Mean**			**Standard Deviation**		**Item Mean**	
			Boy	**Girl**	**Difference**	**Boy**	**Girl**	**Boy**	**Girl**
Organisation	3	Actual	7.82	8.32	-0.50**	1.47	0.99	2.61	2.77
		Preferred	8.76	8.84	-0.08	0.80	0.56	2.92	2.95
Gender Equity	4	Actual	11.49	11.76	-0.27	1.01	0.80	2.87	2.94
		Preferred	11.48	11.75	-0.27	1.23	0.72	2.87	2.94
Resource Adequacy	4	Actual	9.85	10.23	-0.38	1.81	1.69	2.46	2.56
		Preferred	11.94	11.92	0.02	0.37	0.35	2.99	2.98

Teacher Support	4	Actual Preferred	10.31 11.08	9.95 11.04	0.36 0.04	1.42 1.22	1.66 1.32	2.58 2.77	2.49 2.76

** *p* < 0.01

To confirm if significant differences exist overall between the sexes, a one-way analysis of variance (ANOVA) for repeated measures for each of the individual four scales was performed. The set of MCCI scales constituted the dependent variables while the gender is the independent variable. The unit of analysis used was the within-class gender subgroup. An examination of the mean scores obtained by boys and girls on each **actual** scale of the MCCI showed that girls had more positive perceptions of their computer-assisted classroom learning environment than their boy counterparts in terms of the Organisation scale.

In an attempt to provide a clearer picture of the differences between the sexes, a simplified graph based on the results in Table 4 was plotted (see Fig 2). It was decided that only the score differences which were significantly different ($p<0.01$) would be plotted. For those that were not significantly differed, the average of the actual and preferred scores were plotted as one single point. The response alternatives of the MCCI instrument corresponding to the value intervals on the item mean axis in the figure are as follows : 1 = "Yes", 2 = "Not sure" and 3 = "No". An examination of Table 4 and Figure 2 showed that boys and girls differed significantly ($p<0.01$) in **actual** perceptions only for the Organisation scale of the MCCI, i.e., the laboratory environment was perceived as being more organised by the girls than the boys.

There were no significant differences between the sexes for the remaining three scales. A look at the **preferred** perception scores also indicated that both the boys and girls did not differ statistically in any of the four scales. This meant that both sexes had similar expectations of their ideal computer-assisted learning environments.

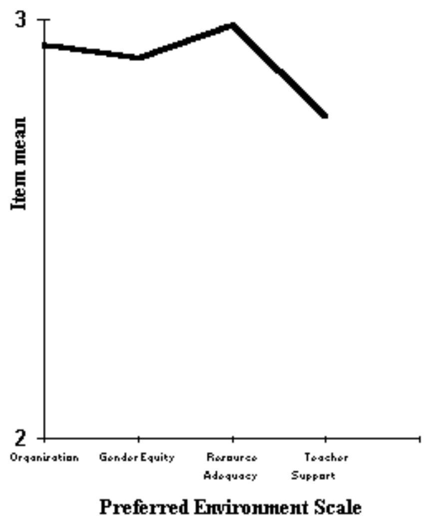


Figure 2 Simplified Plot of Significant Differences between Boys' and Girls' Perception Scores

A one-way analysis of variance was also performed separately for both sexes. Results from Tables 5 and 6 showed that there were significant differences between the **actual** and **preferred** scores for each sex for the following three scales of the MCCI, Organisation, Resource Adequacy and Teacher Support. Both the boys and girls seemed to be contented with Gender Equity as there was no statistically significant difference between their preferred and actual scores. Results from the analysis showed that the greatest amount of changes in which the students would like to see are in the areas of Organisation, Resource Adequacy and Teacher Support. This finding was consistent with results for the overall sample.

Table 5 Scale Means and Standard Deviations for the Actual and Preferred 15-item Versions of the Modified 15-item MCCI for the Boys

Scale	**No. of Items**	**Scale Mean**			**Standard Deviation**		**Item Mean**	
		Actual	**Pref**	**Difference**	**Actual**	**Pref**	**Actual**	**Pref**
Organisation	3	7.82	8.76	-0.94**	1.47	0.80	2.61	2.92
Gender Equity	4	11.49	11.48	0.01	1.01	1.23	2.87	2.87
Resource Adequacy	4	9.85	11.94	-2.09**	1.81	0.37	2.46	2.99
Teacher Support	4	10.31	11.08	-0.77**	1.42	1.22	2.58	2.77

** $p < 0.01$

Table 6 Scale Means and Standard Deviations for the Actual and Preferred 15-itemVersions of the Modified 15-item MCCI for the Girls

Scale	**No. of Items**	**Scale Mean**			**Standard Deviation**		**Item Mean**	
		Actual	**Pref**	**Diff**	**Actual**	**Pref**	**Actual**	**Pref**
Organisation	3	8.32	8.84	-0.52**	0.99	0.56	2.77	2.95

Gender Equity	4	11.76	11.75	0.01	0.80	0.72	2.94	2.94
Resource Adequacy	4	10.23	11.92	-1.69**	1.69	0.35	2.56	2.98
Teacher Support	4	9.95	11.04	-1.09**	1.66	1.32	2.49	2.76

** $p < 0.01$

Both sexes would prefer to have a better equipped computer laboratory. They could have felt that there was not enough software for the teaching of Mathematics in the laboratory. Another reason could be due to the fact that computers in the laboratories often break down during lessons and as a result, students had to share the computers with their classmates. Hence, both the boys and girls preferred a better equipped computer laboratory. Both sexes also wanted a more organised environment with more help and support from their teachers during computer-assisted classroom learning. Most of the classes had a class size of at least 38 and the teachers were new to conducting computer-assisted classroom lessons though they were all trained in this aspect. As a result, the teachers might not be equipped enough in planning such lessons. Owing to the lack of technical assistance, they might not be able to go round the laboratory to provide help to the students individually during the computer-assisted classroom lessons. Hence, that resulted in a less organised learning environment and leaving students very much on their own without enough support from their teachers.

The findings from this study are generally in line with those found in previous research on sex differences in classroom environment perceptions (Fraser, Giddings, & McRobbie, 1995; Henderson, Fisher, & Fraser, 1995; Lawrenz, 1987; Wong & Fraser, 1996b; Goh & Fraser, 1996). Results from these past research showed that female students tended to have more favourable perceptions of their classroom environments than their male counterparts. In this present study, female students' perceptions were either comparable or more favourable than those of their male counterparts.

CONCLUSION

One of the major purposes of this study was to determine which aspects of the computer-assisted Mathematics elementary classroom environment could be associated with the attitudinal outcomes of the students towards computer-assisted learning in Mathematics. In order to explore attitudinal-environment associations in such Mathematics classroom environment, data was subjected to correlational analyses (simple correlation and multiple regression). The findings in this study revealed that favourable student attitudes towards computer-assisted Mathematics classes were found in classes perceived to be well-organised and had sufficient resources. Hence, teachers should give greater emphasis to these learning environment aspects so as to improve the students' attitudes.

Another of the study's major contributions was that a new classroom environment instrument was developed and validated specifically to assess students' perceptions of the unique setting of computer-assisted learning. The scales in this economical instrument, My Computer Class Inventory, (MCCI), were found to display adequate factorial validity, internal consistency reliability, and discriminant validity. Also, each scale differentiated significantly between the perceptions of students in different classrooms.

It is hoped that other researchers will find this new instrument useful in future studies of CAL classroom environments and make use of it in pursuing several research and practical applications. Because of the high cost of computer laboratory teaching, it is important that researchers make use of the MCCI to monitor students' views of their computer laboratory classes, investigate the impact that different laboratory environments have on student outcomes and to provide a basis for guiding systematic attempts to improve these learning environments. Classroom climate dimensions as assessed by the MCCI, as in past research (Fraser, 1981), are likely to provide useful process criteria of effectiveness in evaluating new and innovative approaches to laboratory teaching and to be powerful predictors of student learning outcomes.

On the home front, the study's focus on the learning environment associated with the use of computer-assisted learning in school Mathematics in Singapore is distinctive because only a very small number of classroom environment research previously has been undertaken in the Singapore elementary schools. It is hoped that the findings of this study, the first in Singapore to focus on the learning environment of the computer laboratory elementary class, will prove useful to Singapore teachers and possibly to elementary Mathematics teachers in general. It serves to inform teachers about how their students currently perceive their laboratory classes and what they would prefer them to be like. With this knowledge, teachers are likely to be in a better position to make improvements in their laboratory classrooms so as to help their students foster more positive attitudes towards the subject and in turn help create a more supportive environment for teaching and learning. This is especially crucial for students in a highly competitive education system like Singapore's.

It is important that teachers obtain student feedback about their laboratory classroom environment so as to enable teachers to make necessary changes and improvements in their laboratories. And this can now be facilitated by the use of an instrument like the MCCI. In addition, such research will complement the Mathematics education research going on in Singapore and provide a more complete picture of the process of Mathematics education existing in Singapore.

As in past studies, a comparison of sex differences in their perceptions of the computer-assisted learning environment in this study showed that female students in this study were found to perceive their learning environment more favourably than male students. There is thus a possibility that teachers treat male and female students differently (e.g., providing female students with more guidance in their work). This probably could have led female students to perceive higher levels of Organisation as found in this study. This finding would mean that teachers should try to handle their laboratory procedures more fairly, giving both male and female students similar amounts of guidance and equal opportunities for participation.

Taken together, the evidence emerging from this investigation attested to the potential usefulness of the MCCI in future research in computer-assisted Mathematics education. It is hoped that the present study might provide a foundation and stimulus for future computer-assisted Mathematics education research involving the MCCI. Research involving the MCCI could thus be extended to students of other ages and other cultures and to a variety of cognitive, affective and psychomotor outcomes valued in computer education.

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