A Cross-National Investigation of Students' Perceptions of Mathematics Classroom Environment and Academic Efficacy in Secondary Schools

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Abstract

Research was conducted on associations between classroom psychosocial environment in mathematics classrooms and academic efficacy. A sample of 3,602 mathematics students from Australian, British and Canadian secondary schools responded to an instrument that assessed 10 dimensions of mathematics classroom environment (viz. Student Cohesiveness, Teacher Support, Investigation, Task Orientation, Cooperation, Equity, Involvement, Personal Relevance, Shared Control, Student Negotiation). These scales were from 2 existing instruments: What Is Happening In This Classroom and the Constructivist Learning Environment Survey. A 7-item scale assessed students' academic efficacy at mathematics-related tasks. Simple and multiple correlation analyses revealed statistically significant correlations between these classroom environment dimensions and academic efficacy. Results showed that classroom environment relates positively with academic efficacy. A commonality analysis showed that the 3 Constructivist Learning Environment Survey scales did not contribute greatly to explaining variance in academic efficacy beyond that attributed to the 7 What Is Happening In This Classroom scales.

Introduction

This article reports a cross-national correlational study of students' perceptions of classroom environment and academic efficacy. Classroom environment research focuses on the perceptions of classroom life usually from the students' perspective. Academic efficacy research draws attention to the importance of fostering self-belief and self-regulatory capabilities in students (Zimmerman, 1995). While many variables contribute to a student's sense of academic efficacy (Bandura, 1997), it is plausible that the quality of the classroom environment in a particular subject area is related to perceived academic efficacy in that subject area. The present study aims to investigate the closeness of this relationship in secondary school mathematics classes.

The present study makes three distinctive contributions to the field of learning environments. First, it is the only study to date that has investigated the relationship between classroom environment and academic efficacy. In fact, Lorsbach and Jinks (1999) drew attention to the lack of research relating psychosocial learning environments with student academic self-efficacy and called for an investigation in this area. The research reported in this article responded to that deficiency. Second, although reviews of research by Chavez (1984) and Fraser (1994, 1998b) have shown the learning environment field to be an active area of investigation, few studies have been conducted in mathematics classes. Third, by using scales from two well-established instruments (viz. What Is Happening In This Classroom, Constructivist Learning Environment Survey), it was possible to establish the unique and joint contributions of each instrument to explaining academic efficacy. This analysis provides insights into the usefulness of both instruments in future research in this area. To provide a theoretical basis for this research, classroom environment and academic efficacy are reviewed briefly.

Background

Classroom Environment

Research conducted over the past 30 years has shown the quality of the classroom environment in schools to be a significant determinant of student learning (Fraser, 1994, 1998a). That is, students learn better when they perceive the classroom environment positively. Numerous research studies have shown that student perceptions of the classroom environment account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics. For example, Goh and Fraser (1998) used the Questionnaire on Teacher Interaction (QTI: Wubbels & Levy, 1993) to establish associations between student outcomes and perceived patterns of teacher-student interaction in primary school mathematics classes in Singapore.

Apart from Goh and Fraser’s work, two other studies that were conducted in mathematics classrooms are noteworthy. O’Reilly (1975) investigated the relationship between achievement and classroom environment in 48 mathematics classes in Ontario and found that the set of 15 Learning Environment Inventory scales (Fraser, 1986) accounted for 67% of variance in raw achievement scores. From a methodological perspective, O’Reilly’s study is significant in that it confronted the unit of analysis issue of learning environment research. In that study, the class was taken as the unit of analysis with the mean score as the measuring statistic. Fraser, Malone and Neale (1989) reported the use of actual and preferred forms of the My Class Inventory with Year 3 mathematics classrooms in Sydney. Using these assessments, practical ways to improve primary school mathematics classrooms were identified and implemented. Results showed that significant pre-test – post-test differences were found on the only dimension of the MCI for which specific change strategies were implemented.

Other studies have used classroom environment scales as dependent variables in investigating variations in environment across different settings. Studies reviewed by Fraser (1998b) have shown that classroom environment varies according to school type (i.e. coeducational, boys’ and girls’), year level and subject area. Some areas of contemporary classroom environment research include investigating classroom environment differences between resilient, average, and non-resilient students (Read & Waxman, 2001), studying university computer classrooms in Indonesia (Soerjaningsih, Fraser, & Aldridge, 2001), and using environment assessments in improving teaching and learning in secondary school biology classes (Moss & Fraser, 2001).

The learning environment field has developed rapidly with an array of validated instruments and research in at least twelve domains (e.g. comparison of actual and preferred environments, school psychology, and teacher education) (see Fraser, 1998b). Typically, empirical studies have employed these instruments or contextually modified derivatives to assess the particular environment under investigation. For example, the University-Level

Environment Questionnaire was developed specifically to assess academics' perceptions of their work environment in universities (Dorman, 2000). The present study builds upon and extends the learning environment field by studying associations between classroom environment and academic efficacy.

Academic Efficacy

The broad psychological concept of self-efficacy has been the subject of much theorising and research over the past two decades (see e.g. Bandura, 1997; Schunk, 1995). Within this field, one particularly strong area of interest is that of academic efficacy which refers to personal judgments of one's capabilities to organise and execute courses of action to attain designated types of educational performances (Zimmerman, 1995). Consistent with self-efficacy theory, academic efficacy involves judgments on capabilities to perform tasks in specific academic domains. Accordingly, within a classroom learning environment, measures of academic efficacy must assess students' perceptions of their competence to do specific activities. It is therefore not surprising to find that much academic efficacy research has focused on specific areas of the formal school curriculum. For example, Pajares (1996) investigated academic efficacy at mathematics related tasks. Similarly, Schunk and Rice (1993) studied self-efficacy among students receiving remedial educational services. Recently, Zeldin and Pajares (2000) explored the self-efficacy beliefs of women in mathematical, scientific and technological careers.

Research studies have provided consistent, convincing evidence that academic efficacy is positively related to academic motivation (e.g. Schunk & Hanson, 1985), persistence (Lyman et al, 1984), memory performance (Berry, 1987), and academic performance (Schunk, 1989). Multon, Brown and Lent (1991) performed a meta-analysis of research studies that related academic efficacy to the attainment of basic cognitive skills, coursework, and standardised achievement tests. This analysis revealed that academic efficacy is a consistent positive predictor of academic achievement. However, the influence of academic efficacy was not uniform. Whereas the strongest effect was for the influence of academic efficacy on basic cognitive skills, the weakest effect was for the influence of academic efficacy on standardised tests. According to Schunk (1996), the relationship between academic efficacy and both motivation and effort is reciprocal. That is, motivation and effort influence, and are influenced by, academic efficacy. This suggests a type of multiplier effect: as students perceive their progress in acquiring skills and gaining knowledge, their academic efficacy for further learning is enhanced. Schunk notes that academic efficacy influences persistence provided that the task is sufficiently difficult. In this situation, low academic efficacy students opt out whereas students with high academic efficacy persevere with the task.

According to Bandura (1997), there are four sources of self-efficacy: enactive mastery experiences, vicarious experiences, verbal persuasion and physiological and affective states. Analogously, Schunk (1996) believed that students appraise their academic efficacy through performance, vicarious (observational) experiences, forms of persuasion and physiological reactions. While not explicitly recognised by efficacy theorists, some of these sources can be attributed to the psychosocial learning environment that students experience in their schools and classrooms. For example, students in classrooms regularly observe their peers performing tasks successfully and unsuccessfully. Even a cursory review of the learning environment literature of the past three decades indicates that the learning environment is not an inert contributor to the sources of academic efficacy identified by Bandura and Schunk. Indeed it is striking that academic efficacy theory has not recognised the potential of psychosocial environment in explaining academic efficacy. The present study investigated this gap in knowledge.

The Present Research

Aims

The study had three aims:

- to validate scales from the What Is Happening In This Classroom and Constructivist Learning Environment Survey questionnaires in mathematics classes in Australia, the United Kingdom and Canada,
- to examine associations between students' perceptions of mathematics classroom environment and their perceptions of academic efficacy at mathematical tasks, and
- to establish whether scales of the What Is Happening In This Classroom and the Constructivist Learning Environment Survey account for unique variance in Academic Efficacy.

Sample

The sample employed in this study consisted of 3,602 students drawn from 9 Australian, 4 Canadian and 16 British secondary schools. Students from Years 8, 10 and 12 participated in the study. Table 1 describes the sample. It should be noted that students were grouped according to year level. Overall, the sample formed 76 school year groups, 61 of which were coeducational. This grouping of students was important because subsequent analyses used the school year group as the unit of analysis.

Table 1
Description of Sample by Country, Gender and Year Level
(*N* = 3,602 students)

Year Level	Sample Size							
	Australia		Canada		United Kingdom		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
Year 8	191	172	266	286	338	318	795	776
Year 10	172	230	224	175	355	360	751	765
Year 12	134	156	-	-	150	75	284	231
Total	497	558	490	461	843	753	1830	1772

Assessment of Classroom Environment

An important principle of the present study was to provide a comprehensive, parsimonious assessment of contemporary classroom environment. Significant recent work that attempts to bring parsimony to the field of learning environments by combining the most salient scales from existing questionnaires has produced an instrument called the What Is Happening In This Classroom questionnaire (WIHIC: Aldridge & Fraser, 2000; Fraser, 1998b). While the WIHIC is comprehensive, it is not designed to assess constructivist classroom environments. In a constructivist environment, meaningful learning is a cognitive process in which students make sense of the world in relation to the knowledge which they have constructed. The Constructivist Learning Environment Survey (CLES: Fraser, 1998b; Taylor, Fraser, & Fisher, 1997) was developed to assist researchers to assess the constructivist dimensions of classrooms.

To provide a comprehensive assessment of classroom environment and yet keep the study manageable, seven scales from the WIHIC and three scales from the CLES were chosen. Based on scale descriptions provided by the WIHIC and CLES developers, it was thought that the three CLES scales complemented the seven WIHIC scales. From the original 56-item WIHIC, 42 items from its seven *a priori* scales were selected. From the CLES, 18 items from three scales were selected. Table 2 shows each of these six-item scales and their common sense descriptions. Each item used a 5-point response format (viz. Almost Never, Seldom, Sometimes, Often, Almost Always). Additionally, Table 2 shows the classification of each scale according to Moos's (1974) three general categories for conceptualising human environments (viz. Relationship, Personal Development, and System Maintenance and System Change).

Table 2
Descriptive Information for 10 Classroom Environment Scales

Scale Name	Scale Description	Sample Item	Moos's Schema
Student Cohesiveness	The extent to which students know, help and are supportive of one another.	I know other students in this class. (+)	R
Teacher Support	The extent to which the teacher helps, befriends, trusts and is interested in students.	The teacher takes a personal interest in me. (+)	R
Involvement	The extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class.	I explain my ideas to other students. (+)	R
Investigation	The extent to which skills and processes of inquiry and their use in problem solving and investigation are emphasised.	I carry out investigations to test my ideas. (+)	P
Task Orientation	The extent to which it is important to complete activities planned and to stay on the subject matter.	I pay attention in this class. (+)	P
Cooperation	The extent to which students cooperate rather than compete with one another on learning tasks.	I work with other students in this class. (+)	P
Equity	The extent to which students are treated equally by the teacher.	I am treated the same as other students in this class (+)	S
Personal Relevance	The extent to which school mathematics connects with students' out-of-school experiences.	I learn how mathematics can be part of my out-of school life. (+)	R
Shared Control	The extent to which students are invited to share with the teacher control of the learning environment.	I help the teacher to decide which activities are best for me. (+)	P
Student Negotiation	The extent to which opportunities exist for students to explain and justify to other students their newly developing ideas.	I talk to other students about how to solve problems. (+)	S

Note. R: Relationship P: Personal Development S: System Maintenance and System Change

Assessment of Academic Efficacy

Perceived academic efficacy refers to students' judgments of their ability to master the academic tasks that they are given in their classrooms. A 7-item scale using items developed by Midgley and Urdan (1995), Midgley et al. (1997), and Roeser, Midgley and Urdan (1996) was used to assess perceived academic competence at mathematics class work. Each academic efficacy item was modified to elicit a response on academic efficacy at mathematics. The response format for all Academic Efficacy items was a 9-point scale with anchors of 0 (not at all true) and 8 (very true). The Appendix contains a copy of the academic efficacy scale.

Methods of Analysis

An important consideration in learning environment research is the choice of unit of analysis. In the present study, individual students were nested within school year groups. Use of the individual as the unit of analysis can provide spurious results because an unjustifiably small estimate of the sampling error is employed in tests of significance. Additionally, students in year groups are not statistically independent and the results of any subsequent test of significance could be questioned. In the present study, validation data have been provided for both the individual and school year group mean as units of analysis.

Associations between environment dimensions and academic efficacy were investigated using simple and multiple correlation analyses. Separate analyses were conducted with the individual and the year group mean in each school as units of analysis. To examine the amount of variance in Academic Efficacy explained by the WIHIC and CLES scales used in the present study, commonality analyses of unique and common variance were conducted for the student and school year group as units of analysis (Cooley & Lohnes, 1976; Goh & Fraser, 1998). In this context, the uniqueness was the variance in Academic Efficacy attributable to either the WIHIC or the CLES scales beyond that attributable to the other instrument. Commonality is the confounded contribution shared by both the WIHIC and CLES scales in predicting Academic Efficacy.

Validation of Scales

Scale Internal Consistency

Estimates of the internal consistency of the ten classroom environment scales and the Academic Efficacy scale were calculated using Cronbach's Coefficient alpha. Table 3 shows these values using the individual student and school year mean as units of statistical analysis. As expected, the values of Coefficient alpha based on school year means were somewhat larger than those obtained with the individual as the unit of analysis (Fraser, 1986). All scales had good internal consistency for both the individual and school year mean as units of analysis.

Discriminant Validity

Table 3 also reports data about the discriminant validity of the classroom environment scales using the mean correlation of a scale with the remaining nine scales as an index. These data indicate that the scales do overlap but not to the extent that would violate the psychometric structure of the instrument. Additionally, the data compare favourably with discriminant validity data of other well-established classroom environment instruments (see Fraser, 1998b).

Ability to Differentiate Between School Year Groups.

As shown in Table 3, one-way ANOVAs for each with the student as the unit of analysis and school year group membership as the main effect showed that each scale differentiated significantly between school year groups (p<.001). The *eta*^{2} statistic, which is a ratio of "between" to "total" sums of squares (Cohen & Cohen, 1975), indicates that the proportion of variance explained by school year group membership ranged from 6% for the Involvement scale to 13% for the Personal Relevance scale.

Table 3
Validation Data and Scale Statistics for Classroom Environment and Academic Efficacy Scales
(N = 3,602 students in 76 school year groups)

	Alpha Reliability		Mean Correlation		ANOVA Results		Scale Statistics[a]	
Scale	Student	School Year Group Mean	Student	School Year Group Mean	$F(75, 3527)$	Eta^2	*M*	*SD*
Student Cohesiveness	.83	.93	.32	.34	3.9*	.09	25.56	1.48
Teacher Support	.84	.93	.42	.38	5.3*	.12	19.68	1.93
Involvement	.79	.81	.45	.41	2.3*	.06	19.41	1.17
Investigation	.85	.90	.40	.27	3.1*	.08	16.68	1.39
Task Orientation	.82	.83	.35	.28	2.9*	.07	24.23	1.20
Cooperation	.76	.86	.42	.46	3.4*	.08	21.62	1.57
Equity	.84	.93	.38	.35	3.8*	.09	23.57	1.52
Personal Relevance	.76	.89	.30	.21	5.4*	.13	17.72	1.77
Shared Control	.88	.93	.32	.28	3.0*	.07	13.42	1.51
Student Negotiation	.80	.85	.41	.45	2.9*	.07	19.57	1.43
Academic Efficacy	.86	.92	-	-	3.2*	.08	36.57	3.14

* p< .001
[a] Scale statistics are based on school year group means.

Results

Associations Between Classroom Environment Scales and Academic Efficacy

Simple and multiple correlation analyses were conducted on the data. When the student was employed as the unit of analysis, all 10 simple correlations between the classroom environment scales and Academic Efficacy were statistically significant (p<.001). This result is 100 times that which could be expected by chance alone. As shown in Table 4, these correlations ranged from .13 for Student Cohesiveness with Academic Efficacy to .40 for Task Orientation with Academic Efficacy. While statistically significant, these correlations were small with Task Orientation accounting for the most variance in Academic Efficacy (16%).

Table 4

Simple and Multiple Correlations for 10 Classroom Environment Scales and Academic Efficacy for Two Units of Analysis

(*N* = 3,602 students in 76 school grade groups)

Classroom Environment Scale	Academic Efficacy			
	Simple Correlation		Multiple Correlation Standardised Regression Coefficient (β)	
	Student	School Year Group	Student	School Year Group
Student Cohesiveness	.13***	.29**	-.04	-.22
Teacher Support	.22***	.32**	-.04	-.04
Involvement	.33***	.26**	.18***	-.02
Investigation	.33***	.17	.15***	.12
Task Orientation	.40***	.52***	.30***	.39**
Cooperation	.16***	.35***	-.12***	.17
Equity	.25***	.52***	.06*	.47***
Personal Relevance	.17***	.11	.01	-.17
Shared Control	.14***	.10	-.03	-.02
Student Negotiation	.22***	.19	.06*	-.13
Multiple Correlation, *R*			.47***	.62***

**p*<.05 ** *p*<.01 ****p*<.001

For comparisons conducted with the school year group as the unit of analysis, similar correlations were found. Coefficients ranged from .10 for Shared Control with Academic Efficacy to .52 for Task Orientation with Academic Efficacy with 8 of the 10 correlations significant (*p*<.05). It is noteworthy that, irrespective of the unit of analysis, all simple correlations were positive.

To provide a more parsimonious representation of the relationship between classroom environment and Academic Efficacy, separate multiple correlation analyses with the student and school year group as unit of analysis were conducted. With the student as the unit of analysis, it was found that the 10 classroom environment scales accounted for 22% of variance in Academic Efficacy. With the school year group as the unit of analysis, the classroom environment scales accounted for 38% of variance in Academic Efficacy. Table 4 shows standardised regression coefficients for these analyses. These indices suggest that, of the ten classroom environment scales used in this study, Equity had the most potent effect on Academic Efficacy. Consideration of the standard deviations for Equity and Academic Efficacy scales (1.52 and 3.14 respectively) and the standardised regression coefficient (0.47) with the school year group as the unit of analysis indicated that an increase in Equity by 1.52 units would increase Academic Efficacy by 1.48 units, assuming no influence of Equity on other predictor variables.

Commonality Analyses of Unique and Common Variance in Academic Efficacy Associated with Seven WIHIC and Three CLES Scales

As indicated above, commonality analyses were conducted for the student and school year group as units of analysis. The square of the multiple correlation (R^2) was used to examine what proportion of variance in Academic Efficacy was attributable to either the WIHIC scales or the CLES scales beyond that attributable to the other instrument. The commonality was that portion of the variance that was shared by both instruments. Table 5 reports the results of these analyses.

Table 5
Commonality Analysis of R^2 Statistic for Seven WIHIC and Three CLES Scales for Two Units of Analysis

Variance Component	R^2	
	Individual	School Year Group
Uniqueness for Seven WIHIC Scales	.17	.35
Uniqueness for Three CLES Scales	.01	.02
Commonality	.05	.02
Total	.23	.39

For both the student and school year group as units of analysis, the three CLES scales accounted for a relatively small amount of unique variance (1% and 2% respectively) when compared with that explained by the seven WIHIC scales (17% and 35% respectively). In fact, the CLES scales accounted for no more variance in Academic Efficacy that did the confounded contribution shared by both measures. This analysis suggests that the three CLES scales did not contribute greatly to the present study.

Discussion

As indicated earlier in this article, no previous research has investigated the influence of mathematics classroom environment on academic efficacy. Lorsbach and Jinks (1999) brought this deficiency to the attention of learning environment researchers with a call for the confluence of these two fields. Three important observations can be made from the present study. First, the present study breaks new ground in that it shows mathematics classroom environment to be significantly associated with academic efficacy. Earlier in this paper, attention was drawn to the fact that academic efficacy literature has considered performance, vicarious experience, persuasion and physical and affective states as the four sources of academic efficacy. While from the psychological perspective it may be advantageous to deal with these four broad sources, there is merit in investigating how learning environments might influence academic efficacy.

Since the late 1960s, the use of high inference measures has become accepted practice in the study of learning environments. That is, learning environment theory and research has progressed from the molecular form of psychological constructs (as typified by the behaviourism of the 1960s) to molar assessments. Such summary judgments make sense to teachers and students. It would be desirable if academic efficacy theory embraced the advances made by learning environment researchers and recognised the importance of classroom context in understanding academic efficacy. For classroom practitioners, and theorists interested in pedagogy, it would seem obvious that psychosocial environment has the potential to influence many outcome variables. Empirical evidence shows that this is the case (see, e.g. Fraser, 1998a) but this process may be direct or indirect via mediating variables (e.g. academic efficacy). It is critical that the context of student learning in schools – principally the classroom – is recognised as important to understanding how students perceive their academic capabilities in certain task domains.

Second, the study has provided further validation data for scales of the WIHIC and CLES. Clearly, the scales are valid and can be used in a range of educational settings. While the WIHIC is a relatively new instrument, it has already been used in Australia (Aldridge & Fraser, 2000), Brunei (Riah & Fraser, 1998), Taiwan (Aldridge & Fraser, 2000), Korea (Kim, Fisher & Fraser, 1999) Singapore (Chionh & Fraser, 1998; Khoo & Fraser, 1998) and the United States (Moss & Fraser, 2001; Sinclair & Fraser, 2001). Similarly, the CLES has become popular because of present academic interest in constructivism as one way of thinking about how students learn and what teachers should be doing to enhance this learning. While it may not have achieved bandwagon status yet, the move towards a social constructivist epistemology as a perspective for shaping educational research and curriculum development in science and mathematics education is strong (Cobb, Wood, & Yackel, 1993; Tobin, 1990).

Third, it is clear from the specific results of this study that scales of the WIHIC – a contemporary instrument for conventional classrooms – were better predictors of academic efficacy at mathematics than the three CLES scales. Given the theoretical viewpoints introduced earlier in this paper, this result is unexpected. At the theoretical level, Lorsbach and Jinks (1999) advocate a preference for the constructivist learning environment as supportive of Academic Efficacy. The commonality analyses reinforce the weak position of the CLES scales in predicting Academic Efficacy compared to the WIHIC scales. As only three of five CLES scales were used in the present study, further research involving all of the CLES scales should be conducted.

Conclusion

This study has extended the classroom environment field by linking it with the self-efficacy domain. Despite the conceptual distinctiveness of these two fields, the practical relationship between psychosocial classroom environment and self-efficacy is close. Classroom environment researchers should be vitally interested in academic efficacy. While a substantial body of research has demonstrated that classroom environment is a strong predictor of student outcomes, self-efficacy researchers have strong evidence on the importance of academic efficacy to student outcomes. The next step in unravelling the relationships among mathematics classroom environment, academic efficacy at mathematical tasks and student outcomes is to study all three constructs simultaneously so that a structural model relating these constructs can be empirically derived.

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Appendix

Academic Efficacy Scale

1. I'm certain that I can master the skills taught in maths this year.
2. I can do even the hardest work in this maths class if I try.
3. If I have enough time, I can do a good job on all my maths class work.
4. I can do almost all the maths class work if I don't give up.
5. Even if the maths is hard, I can learn it.
6. I'm certain I can figure out how to do the most difficult maths work.
7. No matter how hard I try, there is some maths work I'll never understand.*

* Item 7 is reverse scored