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Psychosocial environment and affective outcomes in technology-rich classrooms: testing a causal model

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Abstract Research investigated classroom environment antecedent variables and student affective outcomes in Australian high schools. The Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) was used to assess 10 classroom environment dimensions: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, equity, differentiation, computer usage and young adult ethos. A sample of 4,146 high school students from Western Australia and Tasmania responded to the TROFLEI and three student outcome measures: attitude to the subject, attitude to computer use and academic efficacy. Confirmatory factor analysis using LISREL supported the 10 scale a priori structure of the instrument. Structural equation modeling using LISREL was used to test a postulated model involving antecedent variables, classroom environment and outcomes. The modeling indicated that: improving classroom environment has the potential to improve student outcomes, antecedents did not have any significant direct effect on outcomes, and academic efficacy mediated the effect of several classroom environment dimensions on attitude to subject and attitude to computer use.

Keywords Classroom environment · Outcomes · Casual model · Technology-rich classrooms · Structural equation modeling

This paper reports classroom environment research conducted Australian high schools. The work described here is distinctive for three reasons. First, the study employed

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a new classroom environment instrument, the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) which is designed to assess the environment of classrooms that have an outcomes-focus through the application of technology. Second, it incorporates classroom environment, its antecedents and student affective outcomes in the one empirical study. Third, the paper describes the use of structural equation modeling to develop a comprehensive model representing the relationships among classroom environment, its antecedents and outcomes. Before describing the study, background information on classroom environment research is provided.

1 Classroom environment research

During the past 35 years, the study of classroom environments has received increased attention by researchers, teachers, school administrators and administrators of school systems. The concept of environment, as applied to educational settings, refers to the atmosphere, ambience, tone, or climate that pervades the particular setting. Research on classroom environments has focused historically on its psychosocial dimensions—those aspects of the environment that focus on human behavior in origin or outcome (Boy and Pine 1988).

Overwhelmingly, this research has employed high inference measures of environment which require the respondent to make an inference based on a series of classroom events using specific constructs (e.g. teacher support). Studies which focus on the meaning of school and classroom events have tended to utilize high-inference measures. Walberg (1976) strongly advocated the use of high inference measures of classroom environments. That is, students should be asked to make summary molar judgments about their classrooms rather than reporting on a myriad of molecular events.

Reviews of classroom environment research by (Fraser 1998b, 2002) and Dorman (2002) and edited books by Goh and Khine (2002), Khine and Fisher (2003) and Fisher and Khine (2006) have delineated at least 10 areas of classroom environment research including associations between classroom environment and outcomes, evaluation of educational innovations, differences between students' and teachers' perceptions of classrooms, comparisons of actual and preferred environments, effect on classroom environment of antecedent variables (e.g. gender, grade, school type, subject), transition from primary to high school, school psychology, student metacognition, teacher education, educational productivity research, and using environment instruments to facilitate changes in classroom life.

One of the strongest areas of classroom environment research has been the study of links between classroom environment and student cognitive and affective outcomes.

Because of the ethical dilemma of deliberately manipulating environments in a true experimental design, almost all environment-outcomes research has used ex post facto designs and correlational data techniques. Results of studies conducted over the past 30 years have provided convincing evidence that the quality of the classroom environment in schools is a significant determinant of student learning (Fraser 1994, 1998a). That is, students learn better when they perceive the classroom environment more positively. Importantly, many of these studies have controlled for background variables with students' perceptions of the classroom environment accounting for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics.

Recent studies have substantiated this position. Kerr et al. (2006) established positive relationships between classroom environment and attitudinal outcomes in Australian science classes. In India, Koul and Fisher (2006) found positive associations between scales of the What Is Happening in This Class (WIHIC) and attitude towards science. Similarly, Telli et al. (2006) found positive links between scales of the WIHIC and students' attitude to biology in Turkish high schools. Sencen (2006) reported links between laboratory learning environments and attitudes among hearing-enabled and hearing-impaired chemistry students. Kyriakides (2006) used the Questionnaire on Teacher Interaction (QTI: Wubbels and Levy 1993) with elementary school students in Cyprus to establish positive links between teacher interaction and affective outcomes. Other environment-outcomes studies have investigated school-level environments and student outcomes in mathematics (Webster and Fisher 2004), the relationship between learning environments, family contexts, educational aspirations and attainment (Marjoribanks 2004), the effect of classroom and home environments on student academic efficacy (Claiborne and Ellett 2005) and the effect of technology on learning environments and student attitudes in high school science classes (Temons 2005).

Other recent environment-outcomes studies have investigated the relationship between learning environment, student attitudes and achievement in middle schooling science classes (Wolf et al. 2006); science classroom environment and self-efficacy (Pearson and Fraser 2006); environment and attitudes in the transition from middle school to high school (Barcia and Fraser 2006); and the effect of learning environment on student attitudes in high school mathematics classes (Campbell and Fraser 2006). Recently, Walker and Fraser (2005) studied distance education learning environments and found statistically significant correlations between the six scales of the *Distance Education Learning Environment Survey* (DELES) and student enjoyment.

Another line of classroom environment research has focused on the antecedents or determinants of classroom environments Studies reviewed by Fraser (1998b) have shown that classroom environment varies according to school type (i.e. coeducational, boys' and girls'), grade, and subject area. One significant, uniform finding from research is that teachers perceive classrooms much more positively than do students. Most of these studies have compared the student class means for each scale with the teacher's scale score. Effect sizes for these comparisons are usually very large with teacher scores higher than student class means. The use of actual and preferred forms of an instrument have allowed researchers to study whether students perform better when there is a close alignment of actual and preferred environment. Fisher and Fraser (1983) pioneered this person-environment fit research. Findings suggest that actual-preferred environment congruence is important in predicting outcomes and that outcomes can be enhanced by making the actual environment more like the preferred environment.

During the last decade, significant research on the use of computers in classrooms has been conducted. Much of this research has focused on the effect of computer usage on student attitude, social outcomes, motivation and interest (see Bain et al. 1998; Goh and Tobin 1999; Lajoie 1993; Schofield et al. 1994). Until very recently, few studies have investigated the psychosocial environment of classrooms employing technology. In one study that did involve classroom environment, Mucherah (2003) investigated the environment in social science classrooms using technology. This study raised important issues concerning the inadequacy of training and support of teachers who attempt to integrate the use of computers in the curriculum. Dellar et al. (2006) reported associations between information and communication technology learning and classroom culture. To study ICT infused learning environments, Handelzalts et al. (2007) developed an instrument that assesses active, self-directed and cooperative learning environments for students in preservice teacher education courses. Okan (2008) conducted an environment-outcomes study involving computer laboratories and attitude to computer and computing courses with university students in Turkey.

Some areas of contemporary classroom environment research include measuring the computer classroom environment in New Zealand high schools and tertiary institutions (Logan et al. 2006), investigating parents' and students' perceptions of classroom environments (Allen and Fraser 2007), studying teachers' and pupils' perceptions of science-technology learning environments (Doppelt 2006), contrasting actual and preferred classroom environments (Dorman, in press) and investigating the effect of extended instructional time on learning environment, achievement, and attitudes in middle schools algebra classes (Azimioara and Fraser 2007). Recently, Dorman (2008a,b) illustrated the dramatic effect of ignoring the nested nature of much classroom environment data when conducting tests of statistical significance. Fisher and Khine's (2006) recently edited comprehensive volume of 25 chapters demonstrates the depth and breadth of learning environment research today.

2 The present investigation

As discussed in the previous section, classroom environment research has focused largely on either antecedents (or determinants) of classroom environment or environment dimensions as predictors of cognitive or affective outcomes. Few studies have attempted to provide a more comprehensive model of classroom environments by including antecedents, environments and outcomes in the one study. Such an approach provides a more robust representation of the variables that influence, and which are influenced by, classroom environments. Accordingly, the overarching purpose of the present investigation was to study the antecedents and outcomes of classroom psychosocial environment in high schools. In doing so, the study breaks new ground by taking a more integrated approach to the study of classroom environments.

The aims of the present study were to:

- validate the structure of the Technology Rich Outcomes Focussed Learning Environment Inventory (TROFLEI);
- identify classroom environment dimensions that predict three outcome scales: academic efficacy, attitude to computer use, and attitude to subject;
- identify whether gender, grade, and home computer and internet access influences students' perceptions of classroom environment, academic efficacy, attitude to computer use and attitude to subject; and

- investigate whether a postulated model of relationships among antecedents, classroom environment scales and the three outcome scales fits the data through the use of structural equation modeling.

3 Method

3.1 Sample

The sample employed in this study consisted of 4,146 students from high schools in Tasmania and Western Australia. Table 1 describes the sample which consisted of 453 grade 8–10 students, 2,287 grade 11 students and 1,406 grade 12 students. The female sub-sample constituted 53.3% of the full sample.

3.2 Instrumentation

3.2.1 Assessment of classroom environment

The Technology Rich Outcomes Focussed Learning Environment Inventory (TROFLEI) consists of 80 items assigned to 10 underlying scales (8 items per scale). Table 2 shows scale descriptions and a sample item for each TROFLEI scale. Seven of the 10 TROFLEI scales are from the What is Happening in this Class? (WIHIC) instrument which is a well-established and widely-used questionnaire in classroom environment research (see e.g., Dorman 2003; Koul and Fisher 2006). The WIHIC scales are: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, equity.

The robust nature of the WIHIC's reliability and validity has been widely reported in studies that have used the instrument in different subject areas, at different age levels and in 12 different countries. Since the initial development of the WIHIC, the questionnaire has been used successfully in studies to assess the learning environment in Singapore (Fraser and Chionh 2000), Australia and Taiwan (Aldridge and Fraser 2000), Brunei (Khine and Fisher 2001), Canada (Zandvliet and Fraser 2004), Australia (Dorman 2001), India (Koul and Fisher 2006), Indonesia (Adolphe et al. 2003), Korea (Kim et al. 2000), Turkey (Telli et al. 2006), New Zealand (Saunders and Fisher 2006), the United States (Allen and Fraser 2007), and Canada, England and Australia (Dorman 2003). Within these countries, the WIHIC has assessed the environment in a range of curriculum areas including high school science (Aldridge and Fraser 2000),

Table 1 Description of sample

Gender	Sample size			
	Grades 8–10	Grade 11	Grade 12	Total
Male	206	1,138	591	1,935
Female	247	1,149	815	2,211
Total	453	2,287	1,406	4,146

Table 2 Descriptive information for 10 TROFLEI scales

TROFLEI scale	Scale description	Sample item	Moos's schema
Student cohesiveness	The extent to which students know, help and are supportive of one another	I am friendly to members of this class	R
Teacher support	The extent to which the teacher helps, be friends, trusts and is interested in students	The teacher considers my feelings	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
Task orientation	The extent to which it is important to complete activities planned and to stay on the subject matter	I know how much work I have to do	P
Investigation	The extent to which skills and processes of inquiry and their use in problem solving and investigation are emphasized	I carry out investigations to test my ideas	P
Cooperation	The extent to which students cooperate rather than compete with one another on learning tasks	I share my books and resources with other students when doing assignments	P
Equity	The extent to which students are treated equally by the teacher	I get the same opportunity to answer questions as other students	S
Differentiation	The extent to which teachers cater for students differently on the basis of ability, rates of learning and interests	I do work that is different from other students' work	S
Computer usage	The extent to which students use their computers as a tool to communicate with others and to access information	I use the computer to take part in on-line discussions with other students	S
Young adult ethos	The extent to which teachers give students responsibility and treat them as young adults	I am encouraged to take control of my own learning	P

R: Relationship; P: Personal development; S: System maintenance and system change

mathematics (Margianti et al. 2001), mathematics and science (Raaflaub and Fraser 2002) and mathematics and geography (Fraser and Chionh 2000).

Three new scales of educational importance were developed for the purpose of this study. To capture the individualized nature of an outcomes-based program, a differentiation scale was adapted from the Individualized Classroom Environment Questionnaire (ICEQ; Fraser 1990). This scale assesses the extent to which the teacher provides opportunities for students to choose the topics on which they would like to work and to work at their own pace. Because technology-rich learning environments require students to use computers, the computer usage scale was developed to provide information about the extent to which students used computers in various ways (e.g. email, accessing the internet, discussion forums). Finally, a young adult ethos scale was developed to assess the extent to which teachers give their students responsibility for their own learning.

One important consideration of classroom environment theory since the early 1970s has been Moos' (1979) conceptual framework for human environments which categorizes environment as having relationship, personal growth, and system maintenance and system change dimensions. Whereas relationship dimensions are concerned with the nature and intensity of personal relationships, personal growth dimensions focus on opportunities for personal development and self-enhancement. System maintenance and system change dimensions assess the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change. Table 2 shows the classification of each TROFLEI scale according to Moos' conceptual framework.

3.2.2 Antecedent variables

Data were collected on three antecedent variables: gender, grade, and home computer and internet access. Gender was coded 1 (male) and 2 (female). With regard to grade, students were grouped into three categories: 1 (grades 8–10), 2 (grade 11), and 3 (grade 12). Three response categories were employed with the home computer and internet access variable: 1 (no home computer), 2 (home computer but no internet access), and 3 (home computer with internet access). Where appropriate, biserial and polyserial correlations were computed between these categorical variables and classroom environment and outcome variables for use in structural equation modeling. Accordingly, any interpretation of the influence of antecedent variables needs to recognize the above coding.

3.2.3 Outcome scales

Three outcome scales were employed in the present study. These 7-item scales were: attitude to subject (which assesses the extent to which students are interested in, enjoy and look forward to lessons in that subject); attitude to computer use (the extent to which students are comfortable with and enjoy using computers) and academic efficacy (which refers to personal judgments of one's capabilities to organize and execute courses of action to attain designated types of educational performances in a subject area).

The first scale, attitude to subject, is based on the enjoyment of science lessons scale from the Test of Science-Related Attitudes (TOSRA: Fraser 1981). It was modified to suit a range of school subjects used in the present study. A typical item is "I look forward to lessons in this subject". The second scale, attitude to computer use, is adapted from the Computer Attitude Scale developed by Newhouse (2001). This scale was adopted because technology-rich learning environments require students to spend a considerable amount of their time using computers. One item on this scale is "I am comfortable trying new software on the computer". The third scale, academic efficacy, is based on a scale from the Morgan–Jinks Student Efficacy Scale (MJSES: Jinks and Morgan 1999). A typical item from this scale is "I am good at this subject".

3.3 Data analysis and interpretation

There were four distinct components to the analyses conducted in the present study. First, confirmatory factor analysis (CFA) and scale reliability analysis were employed to substantiate the structure of the TROFLEI. A second-order CFA model was hypothesized. Figure 1 illustrates this model in which classroom environment (as assessed by the TROFLEI) was the second-order variable which was indicated or assessed by 10 first-order variables (the 10 TROFLEI scales). In turn each of these 10 scales were indicated by eight observed variables (the eight items for each TROFLEI scale). The internal consistency of each of the three outcome scales was explored.

Second, correlation and regression techniques were used to identify those TROFLEI scales which were significant predictors of the three outcome scales. Pearson correlations, stepwise multiple regression coefficients and canonical correlations were

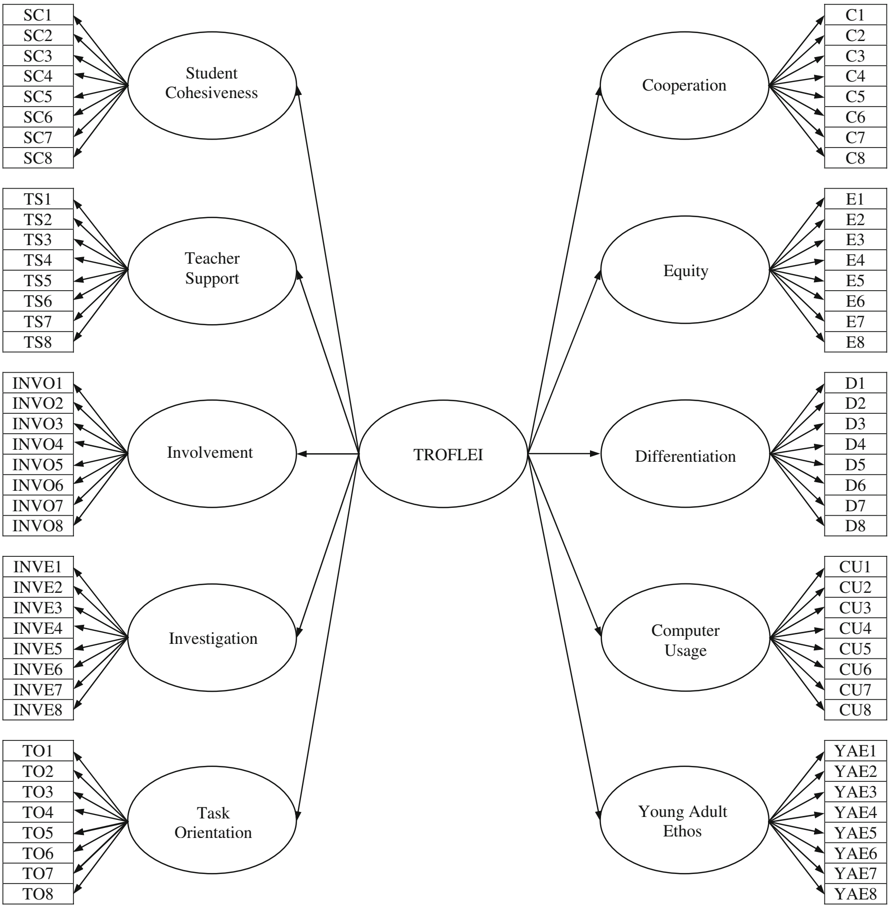

Fig. 1 Second order CFA model for TROFLEI. *Note*: Error variances for each observed variable have been omitted

computed. This information was used subsequently to develop a baseline or *postulated* model for testing in a structural equation model (SEM) using LISREL 8.3.

Third, MANOVA was employed to study the effects of the three antecedent grouping variables (viz. gender, grade, and home computer and internet access) on TROFLEI and outcome scales. The results of univariate F tests and associated effect sizes using Cohen (1977) d as a convenient index assisted in the development of the postulated model. Tukey's post-hoc procedure was employed to identify significant pairwise comparisons.

The final component of data analysis involved the testing of a postulated model involving the three antecedent variables, 10 TROFLEI scales and the three outcome scales. Structural equation modeling examines relationships among *latent* variables. Such variables are not measured directly. Their values are indicated by observed variables. For example, in the present study, the latent variable teacher support was indicated by an observed variable computed from eight teacher support items. Munck (1979) showed that loadings of paths (λ) which link observed variables to latent variables and error variances (θ) for observed variables can be fixed in structural equation modeling and that they are related to reliability (r) by the formulae $\lambda = \sqrt{r}$ and $\theta = 1 - r$. These formulae allow for paths from observed variables to latent variables and error variances of observed composite variables to be fixed. The advantage of this theory is that the number of parameters to be estimated by LISREL is sharply reduced with consequent improvement in model robustness. A Weighted Least Squares (WLS) method with data from correlation and asymptotic covariance matrices was used in the analyses.

Of the many indices available to report model fit, model comparison and model parsimony in structural equation modeling (SEM), three indices are reported in the present article: the Root Mean Square Error of Approximation (RMSEA), the Tucker–Lewis Index (TLI) and the Parsimony Normed Fit Index (PNFI). Whereas the RMSEA assess model fit, the TLI and PNFI assess model comparison and model parsimony, respectively. To interpret these indices, the following rules which are generally accepted in the SEM literature as reflecting good models were adopted: RMSEA should be below 0.08 with perfect fit indicated by an index of zero, TLI should be above 0.90 with perfect fit indicated when TLI = 1.00, and PFNI should be above 0.50 with indices above 0.70 unlikely even in a very sound fitting model. Further discussion on indices and acceptable values is provided in Byrne (1998), Kelloway (1998) and Schumacker and Lomax (1996). While the use of χ^2 tests to report goodness of fit of the model to the data is acknowledged as problematic in SEM, it was used in the present study to report improvements to the overall model fit as post-hoc adjustments were made.

Statistics reported in the present study include the squared multiple correlation coefficient (R^2) for each outcome variable's structural equation and a total coefficient of determination for the final model (Jöreskog and Sörbom 1993). While R^2 is a measure of the strength of a linear relationship, the total coefficient of determination is the amount of variance in the set of dependent variables explained by the set of independent variables. In addition to overall fit statistics, it is important to consider the strength and statistical significance of individual parameters in the model. Each path was tested using a t-test ($p < .05$).

4 Results

4.1 Confirmatory factor analysis

As indicated above, confirmatory factor analysis (CFA) was performed on the data to substantiate the structure of the 80-item Technology Rich Outcomes Focussed Learning Environment Inventory (TROFLEI). Classroom environment (as assessed by the TROFLEI) was the second-order latent variable which was indicated or assessed by 10 first-order latent variables (the 10 TROFLEI scales). In turn each of these 10 scales were indicated by eight observed variables (the eight items for each TROFLEI scale). Fit statistics for this model were: RMSEA = .05, TLI = .95 and PNFI = 0.82. These statistics indicate good model fit to the data and confirm the 10-scale structure of the TROFLEI. Loadings for the 80 paths from observed variables to the 10 TROFLEI scales ranged from 0.39 to 0.92 ($M = 0.80$, $SD = 0.11$). For the paths between the 10 TROFLEI scale latent variables and the TROFLEI latent variable, loadings ranged from 0.21 to 0.76 ($M = 0.62$, $SD = 0.20$).

4.2 Scale statistics

Reliability coefficients (Cronbach coefficient alpha) were computed for each scale (see Table 3). These results show that all scales had very satisfactory internal consistency. Indices ranged from .82 for differentiation to .95 for equity and compared favorably with those reported in previous learning environment research (see e.g., Dorman et al. 2002; Fraser 1998b; Koul and Fisher 2006). Table 3 also shows means and standard deviations for each scale.

Table 3 Internal consistency reliability, scale statistics, fixed path loadings (λ) and error variances (θ) for 10 TROFLEI and 3 outcome scales

Scale	Cronbach α (r)	M	SD	$\lambda = \sqrt{r}$	$\theta = 1 - r$
Classroom environment					
Student cohesiveness	.89	31.92	5.43	.94	.11
Teacher support	.93	29.07	6.92	.96	.07
Involvement	.91	26.54	6.53	.95	.09
Task orientation	.89	31.84	5.59	.94	.11
Investigation	.94	24.28	7.10	.97	.06
Cooperation	.92	30.72	6.36	.96	.08
Equity	.95	32.81	6.67	.97	.05
Differentiation	.82	24.17	6.65	.91	.18
Computer usage	.88	24.55	8.03	.94	.12
Young adult ethos	.94	33.26	6.25	.97	.06
Outcomes					
Attitude to subject	.90	24.16	6.29	.95	.10
Attitude to computer use	.85	27.11	5.68	.92	.15
Academic efficacy	.90	22.17	5.92	.95	.10

4.3 Relationship between classroom environment and outcomes

As a first step to identifying a set of predictor variables to be used in subsequent structural equation modeling, Pearson correlations among the 10 classroom environment scales and the 3 outcome scales were computed. Table 4 shows these results. All 30 correlations were statistically significant ($p < .001$). These correlations ranged from 0.04 for differentiation with attitude to computer use to 0.52 for teacher support with attitude to subject. Corresponding effect sizes (Cohen's d) ranged from 0.08 to 1.22 ($M = 0.59$, $SD = 0.30$) which suggests generally medium effects (Cohen 1977).

Stepwise multiple regression analyses for each of the three outcome measures with the set of 10 environment scales as predictors were conducted. Results for the final steps of these analyses are shown in Table 5. Of the 10 TROFLEI scales, two scales, student cohesiveness and cooperation, did not predict any of the three outcome variables. Two scales (viz. task orientation and differentiation) were significant predictors of all three outcome scales. The three strongest predictors of each outcome scale were: teacher support predicting attitude to subject, computer usage predicting attitude to computer use, and involvement predicting academic efficacy. The square of the multiple regression coefficients for these models (R^2) were: .37 (attitude to subject), .10 (attitude to computer use), and .31 (academic efficacy).

Canonical correlation was also used to provide a more parsimonious interpretation of the relationship between the set of 10 TROFLEI scales and the set of three outcome scales. The first canonical correlation ($R_c = .66$) was significant ($p < .001$). Interpretation of this relationship using canonical loadings and standardized canonical coefficients indicated that higher levels of teacher support, involvement and task orientation were associated with more positive attitudes to subject and increased academic efficacy. A redundancy analysis revealed that 21.7% of variance in the outcomes scales was explained by the TROFLEI canonical variate.

Table 4 Correlations between 10 TROFLEI and 3 outcome scales

Classroom environment scale	Outcome		
	Academic efficacy	Attitude to computer use	Attitude to subject
Student cohesiveness	.30*	.15*	.30*
Teacher support	.32*	.09*	.52*
Involvement	.46*	.15*	.39*
Task orientation	.40*	.20*	.48*
Investigation	.40*	.12*	.34*
Cooperation	.30*	.17*	.33*
Equity	.28*	.16*	.46*
Differentiation	.30*	.04*	.19*
Computer usage	.26*	.21*	.14*
Young adult ethos	.29*	.20*	.44*

* $p < .05$

Table 5 Results of final step regression analyses for TROFLEI scales predicting three outcome scales

Outcome scale	R^2	TROFLEI scale	B	$SE\ B$	β
Attitude to subject	.37	Teacher support	0.27	0.02	0.30*
		Task orientation	0.24	0.02	0.22*
		Equity	0.09	0.02	0.10*
		Differentiation	0.05	0.02	0.05*
		Investigation	0.05	0.02	0.05*
Attitude to computer use	.10	Computer usage	0.15	0.01	0.22*
		Young adult ethos	0.10	0.02	0.11*
		Task orientation	0.10	0.02	0.10*
		Teacher support	0.13	0.02	0.16*
		Differentiation	0.07	0.02	0.09*
		Involvement	0.07	0.02	0.08*
Academic efficacy	.31	Involvement	0.26	0.02	0.29*
		Task orientation	0.22	0.02	0.21*
		Differentiation	0.13	0.02	0.14*
		Computer usage	0.05	0.01	0.07*
		Investigation	0.06	0.02	0.07*

* $p < .05$

4.4 Antecedents to classroom environments

To investigate the effect of gender, grade and home computer and internet access on classroom environment and the three outcome measures, a three-way MANOVA with the 10 TROFLEI scales, academic efficacy, attitude to computer use and attitude to subject as the dependent variables was performed. No interaction effects were evident. The three main effects were significant: gender [$F(13, 4132) = 2.34$ ($p < .001$)], grade [$F(26, 8262) = 2.39$ ($p < .001$)] and home computer and internet access [$F(26, 8262) = 2.23$ ($p < .001$)]. Univariate F tests with $p < .001$ for each dependent variable indicated the following results. Statistically significant differences between male and female students were recorded for seven scales: teacher support [$F(1, 4143) = 45.34$], task orientation [$F(1, 4143) = 61.41$], equity [$F(1, 4143) = 63.12$], differentiation [$F(1, 4143) = 15.07$], young adult ethos [$F(1, 4143 = 93.35$], attitude to subject [$F(1, 41430 = 25.44)$], and attitude to computer use [$F(1, 4143) = 38.50$]. Table 6 shows scale mean scores. Female students held more positive perceptions on these scales apart from differentiation and attitude to computer use. Effect sizes for these comparisons (Cohen's d) ranged from 0.15 for differentiation to 0.35 for young adult ethos.

The effect of grade was statistically significant for eight scales: teacher support [$F(2, 4142) = 3.39$], involvement [$F(2, 4142) = 9.06$], task orientation [$F(2, 4142) = 18.47$], equity [$F(2, 4142) = 10.19$], differentiation [$F(2, 4142) = 15.87$], computer usage [$F(2, 4142) = 67.61$], young adult ethos [$F(2, 4142) = 22.57$], and attitude to subject [$F(2, 4142) = 22.31$] ($p < .001$). Scale mean scores are shown in Table 6. In general, scale scores increase with grade. Pairwise post-hoc comparisons using Tukey's procedure with $p < .001$ indicated significant differences between grade 8–10 and grade 11 students on teacher support, computer usage and attitude to subject; grade 8–10 and grade 12 students on teacher support, computer usage, young adult ethos and attitude

Table 6 Mean scores for TROFLEI and outcomes scales

Scale	Mean score							
	Gender		Grade			Home computer and internet access		
	Male	Female	8–10	11	12	No computer or internet	Computer, no internet	Computer and internet
TROFLEI scale								
Student cohesiveness	30.96	32.80	32.01	31.45	32.76	31.15	31.53	32.06
Teacher support	28.19	29.88	24.97	28.78	30.31	28.60	29.62	29.32
Involvement	26.20	26.86	26.00	26.26	27.34	24.98	25.74	26.94
Task orientation	30.99	32.61	31.09	31.46	32.66	30.54	31.93	31.99
Investigation	24.34	24.23	23.93	24.17	24.85	23.22	24.12	24.50
Cooperation	29.37	31.95	31.22	30.31	31.35	29.12	30.36	30.93
Equity	31.82	33.70	31.80	32.48	33.43	32.53	33.34	32.76
Differentiation	24.62	23.77	23.41	24.82	23.46	25.37	24.35	24.16
Computer usage	24.77	24.35	18.95	23.86	25.62	24.73	24.46	24.97
Young adult ethos	32.11	34.30	31.97	32.87	34.20	32.59	33.43	33.41
Outcome scale								
Attitude to subject	23.56	24.71	21.69	24.10	24.78	23.19	24.39	24.51
Attitude to computer use	27.80	26.50	26.95	27.04	28.45	25.40	26.22	27.35
Academic efficacy	22.32	22.05	22.36	22.02	22.53	21.58	21.46	22.42

to subject; and grade 11 and 12 students on teacher support, involvement, task orientation, differentiation, computer usage and young adult ethos. Effect sizes for these statistically significant comparisons ranged from 0.15 for differences in involvement for grades 11 and 12 to 0.76 for differences in teacher support for grades 8–10 and grade 12.

The effect of home computer and internet access was statistically significant for three scales: involvement [$F(2, 4142) = 10.41$], task orientation [$F(2, 4142) = 6.98$], and attitude to computer use [$F(2, 4142) = 15.68$]. Scale mean scores are shown in Table 6. Pairwise post-hoc comparisons using Tukey's procedure with $p < .001$ indicated significant differences between students who had no home computer or internet access and students who had home computer and internet access on involvement, task orientation and attitude to computer use. Effect sizes for these statistically significant comparisons were 0.39, 0.31 and 0.36, respectively.

4.5 A model for classroom environment, its antecedents and outcomes

This final section reports the use of structural equation modeling to test a postulated model of classroom environment, its antecedents and outcomes based on the results reported above. As such, this section synthesizes these results by studying the extent to which this model fits the data collected in the present study. Values for λ and θ for each scale were computed using Munck's (1979) theory described above (see Table 3). As indicated above, student cohesiveness and cooperation were not identified as predictors of any of the three outcome variables. Accordingly, these two scales were not included in the postulated model shown in Fig. 2.

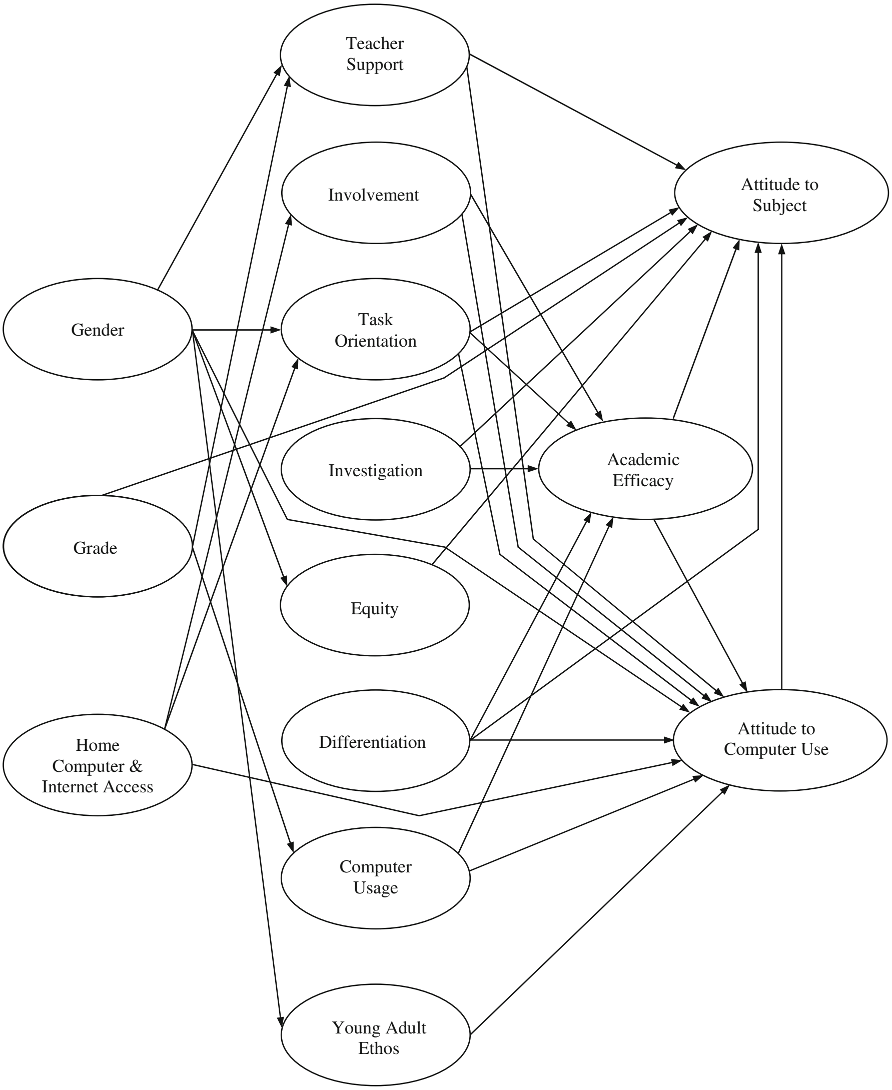

Fig. 2 Postulated model for the prediction of three outcome variables. *Note*: Observed variables, fixed paths from observed variables to latent variables and error variances for observed variables have been omitted

To incorporate the three antecedent variables into this model, the results of the Univariate F tests were studied. Because of the large sample size, effect sizes were considered in conjunction with the results of statistical tests when deciding on which paths from antecedent variables to include in the postulated model. It was decided to include only those paths for which a statistically significant effect was evident and the mean effect size was above 0.25. This condition was met for the effect of gender on teacher support, task orientation, equity, young adult ethos and attitude to computer use; the effect of grade on teacher support, computer usage and attitude to subject;

and the effect of home computer and internet access on involvement, task orientation and attitude to computer use.

This model also shows hypothesized relationships among the three outcome variables. Based on the definitions of these scales, it was hypothesized that academic efficacy would predict attitude to computer use and attitude to subject. It was also hypothesized that attitude to computer use would predict attitude to subject in these technologically-based classrooms.

The LISREL analysis of the postulated model shown in Fig. 2 revealed poor fit to the data with an RMSEA of 0.12 and TLI of .82. (see Table 7). A review of path coefficients revealed several paths for which the coefficients were not statistically significant (e.g., differentiation → attitude to subject). Such paths were removed from the model. Modification indices suggested extra paths that would improve model fit to the data (e.g., home computer and internet access → computer usage). Revised fit indices for three subsequent models are shown in Table 7. Corresponding $\Delta\chi^2$ values for Models 2–4 show a statistically significant improvement in model fit from the preceding model.

Figure 3 shows this final model with standardized path coefficients, all of which were significantly different from zero ($p < .05$). Model fit, model comparison and model parsimony indices for this final model were sound (RMSEA = .06, TLI = .95, PNFI = .51). This model should be interpreted as having good fit to the data.

As shown in Fig. 3, all classroom environment dimensions had positive effects on outcomes. Five classroom environment dimensions had significant direct effects on academic efficacy (involvement, task orientation, investigation, differentiation and computer usage). Whereas teacher support, task orientation and equity had significant direct effects on attitude to subject, four classroom scales (viz. teacher support, task orientation, computer usage, and young adult ethos) had significant direct effects on attitude to computer use. In general, the strength and direction of the statistically significant path coefficients are plausible. For example, teacher support was a moderate, positive predictor of attitude to subject ($\beta = 0.33$). Increased levels of involvement were positively related to academic efficacy ($\beta = 0.29$) which itself was related positively to attitude to subject ($\beta = 0.21$). That is, academic efficacy mediated the effect of involvement on attitude to subject. Task orientation was a significant, positive predictor of all three outcomes scales: academic efficacy ($\beta = 0.23$), attitude to subject ($\beta = 0.16$), and attitude to computer use ($\beta = 0.12$). The effects of most classroom environment scales on attitude to subject were mediated by academic efficacy. For example, the effect of differentiation on attitude to subject was mediated by academic efficacy ($0.19 \times 0.21 = 0.04$). Task orientation's direct effect on attitude to subject ($\beta = 0.16$) was complemented by a small indirect effect ($0.23 \times 0.21 = 0.04$) due to the path via academic efficacy.

The mediating effect of academic efficacy on attitude to subject is particularly noteworthy with four classroom environment scales in the model having only indirect effects on attitude to subject (involvement, investigation, differentiation and computer usage). For example, computer usage did have an effect on attitude to subject but this effect was small due to the mediating effect of academic efficacy ($0.13 \times 0.21 = .03$). One important observation from Fig. 3 is that attitude to computer use did not have a significant effect on attitude to subject.

Table 7 Summary of specifications and fit statistics for four structural models

Model	Actions	χ^2	df	$\Delta\chi^{2*}$	RMSEA	TLI	PNFI
1 (Postulated) (see Fig. 2)	–	1806.46	59	–	.12	.82	.40
2	Path differentiation → Attitude to subject removed, Path investigation → Attitude to subject removed, Path attitude to computer use → Attitude to subject removed, Path gender → Attitude to computer use removed, Path gender → Computer Usage added	1665.93	62	140.53	.10	.83	.43
3	Path involvement → Attitude to computer use removed, Path differentiation → Attitude to computer use removed, Path gender → Involvement added	816.10	63	849.83	.07	.94	.49
4 (Final) (see Fig. 3)	Path home computer & internet access → Computer usage added, Path home computer & internet access → Attitude to computer use removed, Path grade → Teacher support removed, Path grade → Attitude to subject removed	717.75	65	98.35	.06	.95	.51

* $p < .001$

The most striking aspect of the final model is that none of the three antecedent variables had a significant direct effect on the three outcome variables. In fact six of the eight classroom environment scales in the model mediated the effect of antecedents on outcomes. All antecedents had positive effects on classroom environment. Overall, females had a more positive attitude to subject but this effect was attenuated by several classroom environment dimensions: teacher support, involvement, task orientation, equity, and computer usage. The total of indirect effects of gender on attitude to subject was computed to be 0.54 with 43.0% of this total effect due to the teacher support path alone.

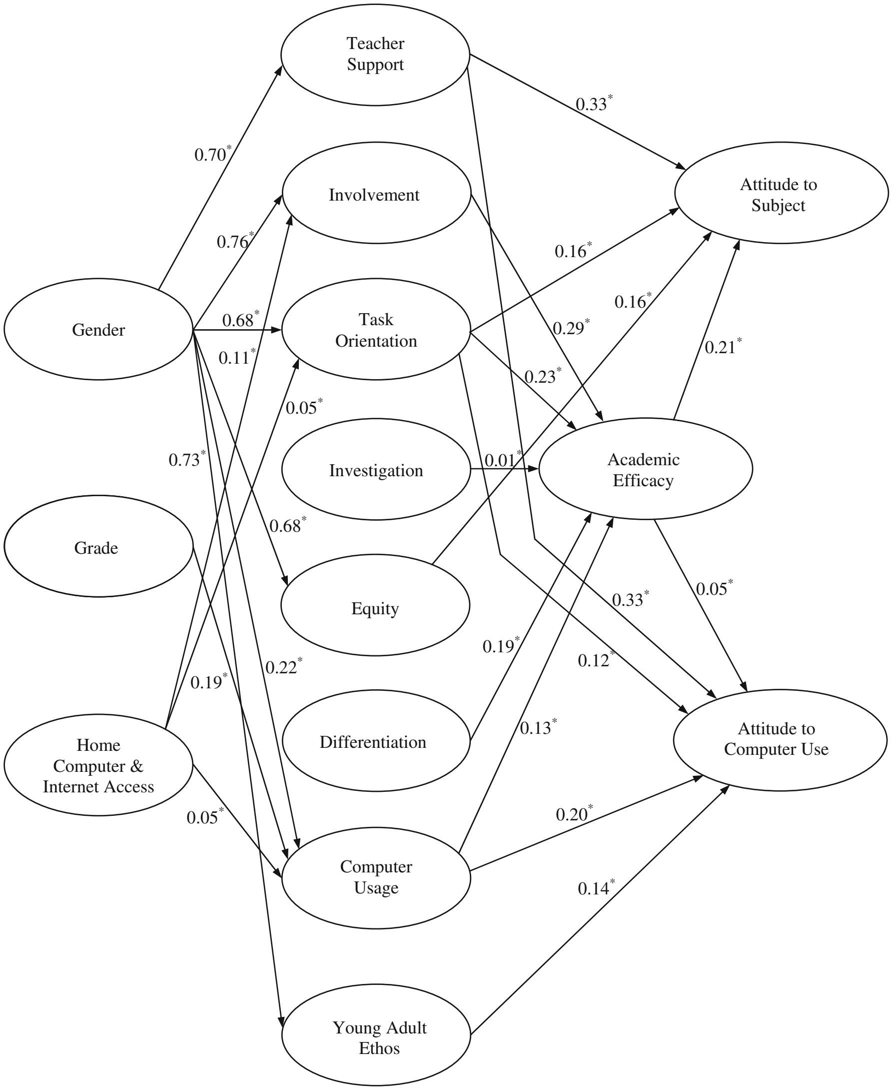

Fig. 3 Final model for the prediction of three outcome variables with standardized path loadings. *Note*: Observed variables, fixed paths from observed variables to latent variables and error variances for observed variables have been omitted. $*p < .05$

The effect of grade on outcomes was particularly weak with a sole path to all three outcomes via computer usage. As grade increased, attitude to computer use increased with the indirect effects of grade on attitude to computer use and attitude to subject computed to be 0.04 and 0.005, respectively. Home computer and internet access had a greater effect on attitude to subject (0.018) than on attitude to computer use (0.01).

For this final model, the squared multiple correlation coefficient for the prediction of attitude to subject was computed to be .41 which indicates that 41% of variance in attitude to subject could be explained by its contributing variables (viz. teacher support, task orientation, equity, and academic efficacy). Similarly, teacher support, task orientation, computer usage, young adult ethos and academic efficacy accounted for nearly 10% of variance in students' attitude to computer use. Over 32% of variance in academic efficacy was attributable to involvement, task orientation, investigation, differentiation, and computer usage. The total coefficient of determination was calculated to be .87 indicating that 87% of variance in the full set of dependent variables (attitude to subject, attitude to computer use, academic efficacy, teacher support, involvement, task orientation, equity, computer usage and young adult ethos) was explained by the remaining variables. Overall, Fig. 3 provides a comprehensive structural model for these three outcome measures based on the classroom environment data collected in the present study.

5 Discussion

The findings of this study of psychosocial environments in Australian high schools has revealed several important conceptual and substantive implications for learning environment researchers, administrators and classroom practitioners.

5.1 Conceptual implications

Three important implications for conceptualizing learning environments are evident from this study. First, the validation of the TROFLEI has added the suite of structurally-sound instruments available for use by researchers and teachers. Although not widely used to date, the TROFLEI has clear potential for use in classrooms where the use of technology and an outcomes focus are emphasized. The TROFLEI builds upon and extends the well-established What Is Happening In This Class (WIHIC) which had been widely used during the past decade.

Second, this study substantiates the multi-dimensional conceptualization of classroom environment/climate. It is one of the few reported attempts to employ confirmatory factor analysis in validating the structure of learning environment instruments. Various reviews of learning environment research and instruments (e.g., Fraser 1994, 1998b) and validation studies of specific instruments (e.g., Fisher and Waldrip 2002; Thomas 2003) have typically used exploratory factor analysis to establish factor structure. Some relatively recent research has employed unidimensional classroom environment scales. For example, Byrne's (1994) research on the determinants of burn-out employed Bacharach et al.'s (1986) 11-item Classroom Environment Scale. It is recommended that context-specific instruments similar to the TROFLEI or WIHIC be employed in studies involving the assessment of classroom learning environment.

Third, this study breaks new ground by demonstrating that it is possible to develop a model encompassing classroom environment, its antecedents and outcomes that fitted the data collected in the present study. Previous learning environment studies employing structural equation modeling have reported models relating environment to students' perceptions of assessment tasks and affective outcomes and teacher burnout (see e.g., Dorman 2003; Dorman et al. 2006). However, very few studies to date have modeled environment and its antecedents and outcomes in the one study. One limitation of the research reported in this article is that it did not address the multilevel nature to the data (i.e., students nested in classes within schools). While research concerning the individual is important, it is also appropriate to fit models at other levels of the data (e.g., class). Further analyses that fit multilevel structural equation models to the data are desirable.

5.2 Substantive implications

Each of the relationships identified in the previous section and illustrated in the final model (Fig. 3) can be discussed in its own right. For example, it is not surprising that attitude to subject was predicted positively by teacher support, task orientation, equity and academic efficacy. Furthermore, involvement, investigation, differentiation and computer usage had small positive indirect effects on attitude to subject via academic efficacy. That is, 7 of the 10 TROFLEI scales were related directly or indirectly to attitude to subject. Previous research reported in Dorman (2002), Fraser (1998b) and Fisher and Khine (2006) has shown similar positive associations between classroom environment dimensions and attitudinal outcomes, especially attitude to science. Teachers should consider these results as confirming long held anecdotal views. Teachers who provide support, demonstrate equity in the classroom, ensure that students complete learning activities, involve students in classwork and cater for diverse students' needs are more likely to enhance student attitudes to their subject.

A particularly noteworthy finding of this study was that, although computers were used widely in classes, there was no significant link between attitude to computer use and attitude to subject. There was neither a significant positive nor significant negative relationship between attitude to computer use and attitude to subject. As noted above, the postulated model set a path from attitude to computer use to attitude to subject but this path was removed in the final model. This suggests that students differentiate between subjects and the use of computers in those subjects. They do not view computers as integrally linked to a subject. Enhancing students' attitude to computer use does not automatically lead to improvements in attitude to subject. On the basis of this study, much more work needs to be done on integrating computers in the formal school curriculum.

The relationship between academic efficacy and classroom environment has been the subject of recent research. Dorman (2001) found significant positive correlations between teacher support, involvement, investigation, task orientation and equity and academic efficacy. The findings of the present study do not match Dorman's earlier findings exactly. Pearson and Fraser (2006) established significant links between classroom environment dimensions and students' self-efficacy. Dorman et al.'s (2006) study of classroom environment, perceptions of assessment tasks, academic efficacy and attitude to science found significant links between classroom environment and academic efficacy. The present study's results add to the growing body of evidence supporting positive links between environment and academic efficacy.

6 Conclusion

This paper has reported the validation and use of a new classroom environment instrument, the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI). A model of classroom environment, its antecedents and outcomes was developed and tested. Overall, the results of the study show that students' perceptions of many classroom environment dimensions are associated with improved affective outcomes. Academic efficacy was identified as a key outcome variable. It is recommended that future research along the lines reported in this paper should occur in three directions. First, analogous research should be conducted in other countries so that the invariance of the model structure across countries can be studied. Second, as on-line learning environments have become the preferred mode of instruction in many colleges and universities, the investigation of on-line learning environments and their relationships with affective outcomes in college and university students needs to be explored. Third, the modeling reported in the present study could be broadened to include key educational productivity variables delineated by Fraser et al. (1987) and Walberg (1991). As such, a multi-factor model of educational productivity research that includes classroom environment as a key factor could be tested.

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