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Partitioning the variance in scores on classroom environment instruments

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ABSTRACT

This paper reports the partitioning of variance in scale scores from the use of three classroom environment instruments. Data sets from the administration of the What Is Happening In this Class (WIHIC) to 4,146 students, the Questionnaire on Teacher Interaction (QTI) to 2,167 students and the Catholic School Classroom Environment Questionnaire (CSCEQ) to 2,211 students in Australian schools were analysed using MLwiN. Variance components models with three levels (viz. student, class and school) for each of the 22 scales were created. Results revealed that statistically significant proportions of variance in all scale scores could be attributed to the student and class levels. Apart from one scale, no school level variance in scale scores was statistically significant. Typically, variance proportions were above 75% at the student level, above 15% at the class level, and below 5% at the school level. Multilevel analyses should be conducted with classroom environment data.

INTRODUCTION

Research on the psychosocial dimensions of classroom environments has made substantial progress during the past 40 years. This research has focused mainly on the individual student's psychological development and how this interacts with the social environment. Accordingly the concept of environment, as applied to educational settings, refers to the atmosphere, ambience, tone, or climate that pervades the particular setting. The strong methodological tradition of classroom environment research has been to conceptualise environments in terms of Murray's (1938) *beta press* – the perceptions of the milieu inhabitants (i.e. students and teachers) – with context-specific instruments assessing particular dimensions of the learning environment. Axiomatic with this methodological tradition has been the long standing "unit of analysis problem" (Burstein, Fischer, & Miller, 1980) which draws attention to the issue of how to analyse data from students in schools. More specifically, researchers who use instruments to study classroom environment invariably survey students within classes within schools. Because beta press assesses classroom

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environment from the student's perspective, the nested or hierarchical nature to the data is inescapable. A central issue in the analysis of such data concerns the distribution or partitioning of variance across the levels of the hierarchy. How is variance in student scores distributed across the levels? For students in schools, this will most likely involve three levels: student, class and school. The purpose of the present paper is to draw attention to this issue by partitioning variance on scale scores from the use of three classroom environment instruments. Before describing the research, its results and implications, the following section provides background information on classroom environment research and variance partitioning.

Classroom Environment Research

Reviews of classroom environment research by Fraser (2007) and Dorman (2002) and edited books by Khine and Fisher (2003) and Fisher and Khine (2006) have reported research on the evaluation, antecedents and consequences of classroom environments. These studies have included 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 of determinants or antecedents on classroom environment of antecedent variables (e.g. student gender, year, subject, school type), transition from primary to secondary school, school psychology, student meta-cognition, teacher education, educational productivity research, and using environment instruments to facilitate changes in classroom life.

The use of the students' perceptions to assess classroom environment can be linked conceptually to Lewin's (1936) *Field Theory* and the Lewinian formula $B = f(P, E)$ (i.e. Behaviour is a function of person and the environment as it exists for that person.). Murray's (1938) *need-press* theory posited the notion that individuals have internal needs and the external environment or press either supports or frustrates that need. Since the late 1960s, an overwhelming feature of classroom environment research and associated instrumentation has been the collection and analysis of high-inference student and teacher perceptual data. Such high-inference instruments require respondents to make judgments based on a sustained period of time in the classroom using specific constructs (e.g. involvement). By contrast, low-inference measures focus on discrete classroom phenomena and usually involve frequency counts (e.g. How many times did the teacher say "ok" in the 90 minute lesson?) Studies which focus on the meaning of school and classroom events have tended to utilize high-inference measures as advocated strongly by Walberg (1976). That is, students should be asked to make summary molar judgments about their classrooms rather than piecemeal reporting on a myriad of molecular events.

Over the past 40 years, a suite of classroom environment instruments have been developed, validated and used in a host of school settings. Some of these instruments include the *Classroom Environment Scale* (CES: Moos & Trickett, 1987), the *Learning Environment Inventory* (LEI: Fraser, Anderson, & Walberg, 1982), the *Individualized Classroom Environment Questionnaire* (ICEQ: Fraser, 1990), the *Questionnaire on Teacher Interaction* (QTI (Wubbels & Levy, 1993) and the *What Is Happening In this Class* (WIHIC: Fraser, 2007). Additionally, a plethora of context-specific derivatives of these instruments have been used in research in specific settings, particularly by doctoral students. The number of instrument derivatives is high and, as Shavelson and Seidel (2006) remarked, there is a need for the learning environment community to engage in an instrument culling program.

It is also important to note the methodological advances in the development, validation and use of classroom environment instruments over the past decade. At the instrument development level, Cavanagh and Romanoski (2006) set out a case for Rasch modelling in the development of true measures of learning environments. This approach was illustrated with the development of a classroom learning culture scale.

Confirmatory factor analysis has been employed in recent studies. Dorman (2003) employed LISREL to establish the factorial invariance of the WIHIC according to country, gender and year of student. Den Brok, Fisher, Wubbels, Brekelmans, and Rickards (2006) performed multigroup confirmatory factor analysis on QTI data collected in Singapore,

Brunei and Australia. Dorman (in press) performed a multitrait-multimethod analysis of actual and preferred versions of the WIHIC. Structural equation modelling and multilevel modelling have advanced the data analysis techniques employed in the learning environment field (see den Brok, Brekelmans, & Wubbels, 2006; den Brok, Fisher, Rickards, & Bull, 2006; Dorman, Fisher, & Waldrip, 2006; Fisher, Waldrip, & den Brok, 2005).

Some areas of contemporary classroom environment research include monitoring interpersonal behavior and student outcomes in vocational classes (Henderson & Fisher, 2008), investigating parent and student perceptions of classroom environments (Allen & Fraser, 2007), studying the classroom climate and students' goal structures in secondary school biology classes in Kenya (Mucherah, 2008), and investigating the effect of extended instructional time on learning environment, achievement, and attitudes in middle schools algebra classes (Azimioara & Fraser, 2007). Recent edited volumes have documented the growth in learning environment research over the past decade (see Fisher & Khine, 2006; Goh & Khine, 2002; Khine & Fisher, 2003). Aldridge and Fraser's (2008) recent book describes the learning environment of a school with an outcomes-based focus. Classroom environment literature has significant overlap with aspects of the student engagement literature (see Fredricks, Blumenfeld, & Paris, 2004). Establishing cohesive classroom environments that have high quality relationships and active student participation are critical to student academic engagement.

Variance Partitioning

There are many research settings that involve nested data. That is, a data hierarchy exists in which lower level units exist within higher level units. In hospitals, patients might be nested in wards which are nested within specialist units which, in turn, are located in hospitals. Voters are located in electorates which could be located in states. The most obvious hierarchy in educational settings is a three level school hierarchy: students are nested within classes that are nested within schools. Students within a class experience the same classroom learning environment. In turn, classes within a school experience a different overall school environment compared to classes in other schools. Acceptance of this hierarchy suggests that students' responses to questionnaires will not reflect the idiosyncratic views of students alone. While two students in the same class may respond to a classroom environment questionnaire in different ways, the common classroom environment will have some influence on their perceptions. That is, group membership effects exist.

A fundamental issue concerning group effects is that even if individuals are assigned to groups on a random basis, they, as a group will become differentiated. Students influence, and are influenced by other students in the class (Goldstein 2003). It is also true that schools can create class effects by directing students to classes on biased bases (e.g., timetabling constraints, specialist teacher availability, subject choice, specialist classroom availability). In essence, variance in students' scores can be partitioned at the student, class and school levels. The intraclass correlation, ρ or variance partition coefficient (VPC) is the proportion of variance accounted for by higher level units and can be thought of as the "extent of clustering" (Goldstein, Browne, & Rasbash, 2002). Qualitatively, the VPC can be taken as a measure of the importance of the particular level. So the computed value for the VPC for classes provides an indication of how important class membership is to scores on the particular variable under consideration.

While the hierarchical/nested nature of clustered data is clear, this essential characteristic has often been ignored when analysing data. Analysts have used either the individual as the unit of analysis and ignored class membership or the class as the unit of analysis with aggregated data and thus ignored the individual student. In response to these criticisms, some researchers have reported parallel but essentially independent sets of analyses conducted with both the individual student and the class as units of analysis in the one study (e.g. Goh & Fraser 1998).

According to Snijders and Bosker (1993), intraclass correlations for most educational settings range typically from .05 to .20. However, parameter values are dependent on the

setting and variables under investigation. Lee (2000) asserted that a variance proportion above 10% at any level is non-trivial and needs to be taken into account in any analysis. Roberts (2007) was particularly critical of intraclass correlation thresholds as precursors to multilevel analysis. He cautioned that, even with intraclass correlations near zero, group dependence can exist when variables are added to the model.

One key assumption of statistical tests like analysis of variance and *t* tests is that subjects are statistically independent. This assumption is violated if non-trivial intraclass correlations exist. Dorman (2008a, 2008c) has demonstrated the dramatic effect on Type I error rates if clustering is ignored when conducting such statistical tests. For example, in a two-group comparison involving 20 classes per group and 25 students per class, a nominal *t* test Type 1 error rate of .05 is inflated to an actual Type I error rate of .418 if the intraclass correlation is .20. That is, the probability of rejecting the null hypothesis and concluding that statistically significant differences exist between the groups when, in fact they do not, has inflated over 8 times to a clearly unacceptable value. Murray, Hannan and Baker (1996) noted that investigators who employ an analysis at the level of the individual run a very real risk of overstating the statistical significance reported for the test.

Proponents of multilevel modelling have argued that the existence of grouping hierarchies in data is neither accidental nor ignorable (Rowe, 2007) and that data with a clear hierarchy should not be analysed as if they are all on the same level because it can lead to statistical and interpretational errors (Tabachnick & Fidell, 2007). Dorman (2008b) recently demonstrated the merits of multilevel analysis in learning environment research by comparing the results of analyses conducted with the individual and class as units of analysis with the results of multilevel analysis. Classroom environment research of the type described in the above section inevitably involves nested data. The hierarchical nature to these data is self-evident and the partitioning of variance across the levels in the hierarchy is a significant first step in the conduct of multilevel analyses.

The aim of this research was to investigate the extent to which scores on three classroom environment instruments assess aspects of the classroom environment as opposed to either the idiosyncratic assessments of individual students or the overall school environment. This aim requires the partitioning of variance in scales scores across three levels: the individual student, the class and the school. As described below, the present investigation analysed data from three separate Australian classroom environment studies which employed the What Is Happening In this Class (WIHIC) questionnaire, the Questionnaire on Teacher Interaction (QTI) and the Catholic School Classroom Environment Questionnaire (CSCEQ).

METHOD

Samples

Table 1 describes the samples in terms of student gender and year. These students were from primary and secondary schools mainly in Queensland and Western Australia. The respective class and school membership for these students were: WIHIC, 4,146 students from 286 classes in 21 schools; QTI, 2,167 students from 103 classes in 37 schools , and CSCEQ, 2,211 students from 104 classes in 32 schools.

Instrumentation

Three different instruments were used in the three independent studies described in this paper. The first instrument is the What Is Happening In this Class? (WIHIC) questionnaire which is a well-established and widely-used instrument in classroom environment research (see, e.g. Dorman, 2003). The WIHIC scales are: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation and equity. The WIHIC consists of 56 items assigned to 7 underlying scales (8 items per scale). Each item employs a 5-point Likert response format (viz. almost never = 1, seldom = 2, sometimes = 3, often = 4, almost always = 5) with items scores aggregated to form scale scores for each respondent. Table 2 shows descriptions of each WIHIC scale.

Table 1: Description of the three samples in this study.

Year	Sample Size					
	WIHIC		QTI		CSCEQ	
	Male	Female	Male	Female	Male	Female
5-7	-	-	1051	1112	-	-
8-10	206	247	-	-	584	598
11-12	1729	1964	-	-	489	540
Total	1935	2211	1051	1112	1073	1138

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 Australia and Taiwan (Aldridge, Fraser, & Huang, 1999), Canada (Zandvliet & Fraser, 2004), Australia (Dorman, 2001), Turkey (Telli, Cakiroglu, & den Brok, 2006), New Zealand (Saunders & Fisher, 2006), the United States (Allen & 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 secondary school science (Aldridge et al., 1999), mathematics (Margianti, Fraser, & Aldridge, 2004) and mathematics and science (Raaflaub & Fraser, 2002).

The second instrument, the Questionnaire on Teacher Interaction (QTI: Wubbels & Levy, 1993) was developed in The Netherlands to focus on one aspect of classroom environment: teacher communication style. Its conceptual basis is a model of interpersonal teacher behaviour which was developed from Leary's (1957) personality model of interpersonal behaviour. According to den Brok, Fisher, Wubbels, et al. (2006) various forms of the QTI have been employed in over 120 studies worldwide. For example, Waldrip, Reene, Fisher, and Dorman (2008) used the QTI to assist teachers to make changes to their teaching strategies. QTI scores are used to map teacher behaviour on two orthogonal dimensions, a proximity dimension (cooperation–opposition) and an influence dimension (dominance–submission). This leads to eight different behaviour types with eight corresponding scales: leadership, helpful/friendly, understanding, student responsibility/freedom, uncertain, dissatisfied, admonishing, and strict (see Table 2). The version of the QTI used in the present study has 48 items (6 items per scale) and each item used a 4-point response format with anchors of agree and disagree.

The third instrument is the Catholic School Classroom Environment Questionnaire (CSCEQ) which consists of 66 items assigned to 7 underlying scales: student affiliation, interactions, cooperation, task orientation, order and organization, individualization, and teacher control (see Table 2). It is noteworthy that the CSCEQ is an amalgam of existing scales and newly developed scales to assess catholic school classroom environments. Whereas the task orientation and teacher control scales are from Moos and Trickett's (1987) Classroom Environment Scale, the interactions scale was developed by Dorman (1994). CSCEQ scales have either 9 or 10 items. Each item employs a 5-point Likert response format (viz. strongly disagree = 1, disagree = 2, not sure = 3, agree = 4, strongly agree = 5) with items scores aggregated to form scale scores for each respondent. Different versions of the CSCEQ have been used in previous research. For example, Dorman, McRobbie, and Foster (2002) used a personalized form of the CSCEQ to study associations between classroom environment in religion classes and their attitudes to Christianity. The CSCEQ has been

shown to provide a valid assessment of classroom environment, especially in Australian Catholic schools.

Table 2: Descriptive information for scales from three classroom environment instruments.

Scale	Scale Description	*Cronbach α*	*M*	*SD*
WIHIC	*The extent to which:*			
Student Cohesiveness	students know, help and are supportive of one another.	0.89	4.55	0.80
Teacher Support	the teacher helps, befriends, trusts and is interested in students.	0.93	3.99	0.98
Involvement	students have attentive interest, participate in discussions, do additional work and enjoy the class.	0.91	3.72	0.93
Task Orientation	it is important to complete activities planned and to stay on the subject matter.	0.89	4.53	0.81
Investigation	skills and processes of inquiry and their use in problem solving and investigation are emphasised.	0.94	3.32	1.02
Cooperation	students cooperate rather than compete with one another on learning tasks.	0.92	4.26	0.88
Equity	students are treated equally by the teacher.	0.95	4.39	0.91
QTI	*The extent to which the teacher:*			
Leadership	notices what is happening, leads, organizes, gives orders, sets tasks and determines classroom procedures.	0.67	3.06	0.56
Helpful/friendly	assists, shows interest, behaves in a friendly or considerate manner and inspires confidence and trust.	0.81	3.24	0.65
Understanding	listens with interest, sympathizes, shows confidence and understanding, accepts apologies and is patient.	0.80	3.12	0.63
Student responsibility/ freedom	gives opportunity for independent work, waits for class to let off steam, gives freedom and responsibility.	0.72	2.74	0.58
Uncertain	keeps a low profile, apologizes, waits and sees how the wind blows, and admit one is wrong.	0.62	1.85	0.56
Dissatisfied	waits for silence, considers pros and cons, keeps quiet, shows dissatisfaction, looks glum and criticizes.	0.72	1.84	0.63
Admonishing	gets angry, takes pupils to task, express irritation, and anger, forbids, corrects and punishes.	0.77	2.04	0.70
Strict	keeps a tight rein, checks, gets class silent, maintains silence, is strict and has exact norms and rules.	0.65	2.42	0.61
CSCEQ	*The extent to which:*			
Student Affiliation	students know, help and are friendly towards each other.	0.69	3.49	0.54
Interactions	teacher-student interactions emphasize a concern for the personal welfare and social growth of the student.	0.90	3.76	0.74
Cooperation	students cooperate rather than compete with each other.	0.71	3.22	0.53
Task Orientation	Extent to which it is important to complete activities planned and to stay on the subject matter.	0.76	3.25	0.65
Order & Organization	students behaving in an orderly, quiet and polite manner, and on the overall organization of classroom activities.	0.84	2.75	0.69
Individualisation	students are allowed to make decisions and are treated differently according to ability, interest and rate of working.	0.54	2.64	0.46
Teacher Control	rules are enforced and how severely infractions are punished.	0.75	3.47	0.60

Data Analysis

All three data sets used in this investigation of variance at different levels involved students nested within classes within schools. That is, the data are hierarchical at three levels. As indicated above, these three instruments have been employed in substantial previous research and have very sound structural characteristics. Accordingly, confirmatory factor analyses are not reported here. However, factor score regressions derived from these factor analyses were used to weight items when computing scale scores. This approach minimizes measurement error variance for each scale (see Holmes-Smith & Rowe, 1994). Scores for all 22 scales employed in this study were normalized prior to regression analyses. This approach attenuated the effect of non-normal univariate and multivariate scale score distributions, especially with regard to departures from normality in scale kurtosis. These normal scores were employed in all analyses reported below. Three-level multilevel analyses were conducted using MLwiN (Rasbash, Steele, Browne, & Prosser, 2005) with a base variance components (i.e. null) model created for each scale.

RESULTS

Table 2 shows the Cronbach coefficient α for each of the 22 scales used in this investigation. These values range from 0.54 for the investigation scale of the CSCEQ to 0.95 for the equity scale of the WIHIC. Overall the scales have very sound internal consistency reliability. As a Cronbach coefficient α of .54 is only marginally acceptable, results for the investigation scale need to be treated with caution. Table 2 also reports means and standard deviations for each scale.

Results of the variance components models are shown in Table 3. The most striking observation from these results is that all between student and between class variances were statistically significant ($p<.05$). Apart from the cooperation scale of the CSCEQ, all school level variances were not statistically significant. As expected, most of the variance in scales scores was at the student level with the proportion of variance at this level ranging from the QTI's admonishing (69.40%) to the WIHIC's task orientation (92.52%). However, it is noteworthy that 8 of the 22 scales had intra class correlations (the proportion of variance at the class level) over 20%. The WIHIC's task orientation had the lowest intra class correlation (6.18%). The highest intraschool school correlation (the proportion of variance at the school level) was for the QTI's strict scale (7.89%). It is also noteworthy that the average intra class correlation was 12.59% for the WIHIC, 18.55% for the QTI and 19.08% for the CSCEQ.

DISCUSSION

This discussion falls into two areas. Issues arising from this research concerning the importance of multilevel analysis in classroom environment research are discussed. This discussion is followed by a comparison of the present study's results with the findings of previous similar classroom environments studies.

The important methodological finding of this paper is that the multilevel nature to classroom environment data is real and needs to be acknowledged in approaches to data analysis. There are very few classroom environment studies in which data are not collected from intact classes. According to Goldstein (2003), despite the fact that classes are often established on a random basis, they tend to become differentiated and that students influence and are influenced by other students in the class. That is, a class effect comes into being. It is also true that schools can create class effects by directing students to classes on a clearly biased basis (e.g. timetabling, specialist teacher availability, subject choice). If such class effects are ignored, statistical inferences may be invalid. As noted by Hox (1995), analysis of variance may overestimate the effects of variables at the student level if group effects are not

Table 3: Parameter estimates and variance components for null models for three classroom environment instruments.

Scale	Fixed	Random (Residual Variance)					
		Between Students		Between Classes		Between Schools	
	School Intercept	σ^2	%	σ^2	%	σ^2	%
WIHIC							
Student Cohesiveness	-0.107 (0.077)	0.843 (0.020) *	88.73	0.062 (0.011) *	6.53	0.045 (0.026)	4.74
Teacher Support	0.043 (0.059)	0.725 (0.017) *	79.32	0.173 (0.020) *	18.93	0.016 (0.014)	1.75
Involvement	-0.089 (0.080)	0.845 (0.020) *	87.56	0.070 (0.012) *	7.26	0.050 (0.028)	5.18
Task Orientation	0.010 (0.048)	0.853 (0.020) *	92.52	0.057 (0.010) *	6.18	0.012 (0.010)	1.30
Investigation	-0.027 (0.056)	0.878 (0.021) *	91.55	0.063 (0.011) *	6.57	0.018 (0.013)	1.88
Cooperation	-0.090 (0.072)	0.843 (0.020) *	87.90	0.079 (0.013) *	8.24	0.037 (0.023)	3.86
Equity	0.002 (0.034)	0.755 (0.018) *	87.18	0.109 (0.015) *	12.59	0.002 (0.004)	0.23
QTI							
Leadership	0.008 (0.046)	0.823 (0.026) *	84.85	0.138 (0.029) *	14.22	0.009 (0.017)	0.93
Helpful/friendly	-0.007 (0.050)	0.716 (0.022) *	78.68	0.186 (0.036) *	20.44	0.008 (0.019)	0.88
Understanding	-0.001 (0.049)	0.752 (0.024) *	80.17	0.178 (0.035) *	18.98	0.008 (0.019)	0.85
Student responsibility/ freedom	0.004 (0.051)	0.780 (0.024) *	80.33	0.181 (0.035) *	18.64	0.010 (0.020)	1.03
Uncertain	-0.020 (0.054)	0.797 (0.025)	83.55	0.121 (0.027)	12.68	0.036 (0.024)	3.77
Dissatisfied	0.005 (0.058)	0.698 (0.022)	75.38	0.199 (0.038)	21.49	0.029 (0.028)	3.13
Admonishing	0.012 (0.068)	0.651 (0.020)	69.40	0.230 (0.044)	24.52	0.057 (0.039)	6.08
Strict	-0.013 (0.069)	0.729 (0.023)	74.69	0.170 (0.035)	17.42	0.077 (0.040)	7.89
CSCEQ							
Student Affiliation	0.030 (0.054)	0.830 (0.026) *	82.84	0.134 (0.029) *	13.37	0.038 (0.025)	3.79
Interactions	0.028 (0.069)	0.722 (0.022) *	72.42	0.201 (0.039) *	20.16	0.074 (0.039)	7.42
Cooperation	0.013 (0.054)	0.862 (0.027) *	86.11	0.090 (0.022) *	8.99	0.049 (0.024) *	4.90
Task Orientation	-0.002 (0.053)	0.740 (0.023) *	74.22	0.257 (0.041) *	25.78	-	-
Order & Organization	0.030 (0.067)	0.718 (0.022) *	71.51	0.229 (0.044) *	22.81	0.057 (0.037)	5.68
Individualisation	0.030 (0.052)	0.781 (0.024) *	78.41	0.202 (0.039) *	20.28	0.013 (0.024)	1.31
Teacher Control	-0.018 (0.050)	0.775 (0.024) *	77.81	0.221 (0.036) *	22.19	-	-

* $p < .05$

taken into account. If, on the other hand, student data are aggregated to the class level, information and statistical power is lost. Additionally, the potential for making ecological fallacies in which inferences about students are based on data analyses performed at the class level is very real (see Alker, 1969).

In the present study, little variance in some scale scores was evident at the school level. Depending on the research questions it would not be unreasonable to remove the school level from some models in which classroom environment scales are explanatory or response variables. However, it is advisable to check for variance at all levels of the hierarchy before conducting subsequent analyses in a particular study. As such, multilevel analyses should start with variance components models for all explanatory and response variables with all appropriate levels before fitting conditional models. It should be noted that when school is removed in the present three level variance components models, all the between school variance is shifted to the between class variance. In general, ignoring or removing a level affects parameter estimates, standard errors and variance partitioning of the flanking levels (i.e. those levels above and below the ignored level) (see van den Noortgate, Opdenakker, & Onghena, 2005).

The magnitude of the effect of ignoring or removing a level will depend on the proportion of variance that would have been accounted for by the ignored level. For example in the present study, if school is removed as the third level variable in variance partitioning models for the CSCEQ's task orientation and teacher control scales, there would be no change in the proportion of variance in scale scores at the class level as there was no variance accounted for at the school level for these two scales (see Table 3). However, if school is removed as the third level variable in variance partitioning models for the QTI's strict scale, the shift in class level variance is from 17.42% to 25.31% - a sizeable increase. The effects on variance partitioning due to ignoring levels in variance components models can be appreciable (van den Noortgate, Opdenakker, & Onghena, 2005).

The second part of this discussion attempts to link the findings of the present study with previous classroom environment research. As noted earlier in this paper, despite the obvious nested nature to the data in almost all classroom environment studies, only a handful of reported studies have employed multilevel analysis. Nevertheless, several recent studies have used multilevel analysis and it is important to compare the findings of the present study of variance partitioning with these studies. It is noteworthy that some studies have modelled data at two levels (student and class), others at three levels (student, class and school) and one study at four levels (student, class, teacher and school).

In the only study to date that has reported variance partitioning of the WIHIC using multilevel analysis, den Brok, Fisher, Rickards, and Bull (2006) collected data from 655 students in 28 science classes in 11 Californian schools. Variance partitioning with a three-level model indicated that most of the variance was at the student level with some variance at the class level and only a very small amount at the school level. For example, variance in student cohesiveness was distributed as student, 98.60%; class, 1.12%; and school 0.28%. Overall, den Brok et al.'s results are very similar to the WIHIC results of the present study with teacher support and equity having appreciable amounts of variance at the class level (16.05% and 23.86% respectively). In the present study these same two scales had the largest proportions of class level variance: teacher support, 18.93% and equity, 12.59% (see Table 3). One cautionary note identified by den Brok et al. is the relatively small number of classes and schools in their sample. The present study employed a large sample of classes (286) but in a relatively small number of schools (21). The results of den Brok et al.'s study and the present study are consistent in that variances in WIHIC scale scores are overwhelmingly at the student level.

Two studies involving variance partitioning of scores on the Questionnaire on Teacher Interaction (QTI) were conducted by Levy, den Brok, Wubbels, and Brekelmans (2003) and den Brok, Brekelmans, and Wubbels (2006). In the present study, while most of the variance was at the student level, there were appreciable proportions of variance (ranging from 12.68% for uncertain to 24.52% for admonishing) for all eight QTI scales at the class level. In the Levy et al. study, variance was apportioned to four levels: student, class, teacher and school.

Student-level variance ranged from 69% for leadership to 77.3% for uncertain with class and teacher factors each accounting for 10-15%. There is a high level of consistency between the finding of Levy et al.'s study and the present study.

The study by den Brok, Brekelmans, and Wubbels (2006) involved data from both class and personal versions of the QTI collected in The Netherlands. Variances in QTI scale scores were partitioned at the student and class levels. Intra class correlations for the class and personal version were very similar and ranged from 0.23 for the personal form of the strict scaled to 0.51 for personal form of the leadership scale. All intra class correlations indicated that sizeable amounts of variance in scores were at the class level. There was significant consensus within classes on several scales, especially leadership, helpful/friendly, understanding, uncertain, dissatisfied and admonishing for both class and personal versions.

While no previous variance partitioning has been reported for the CSCEQ, it is instructive to consider other classroom environment studies in which variances at different levels have been reported. Fisher et al. (2005) reported the use of the equity, collaboration, and congruence scales of the *Cultural Learning Environment Questionnaire* (CLEQ) with 2,178 Australian primary school students in 103 classrooms. For these scales, over 90% of the variance in scores was at the student level. Interestingly, for the congruence scale, which refers to the level of similarity between the home and school environments, a greater proportion of variance was attributed to the school level (6.4%) compared to the class level (2.1%).

As three of the congruence scale's five items referred to the school and not the classroom, this result is entirely plausible.

Wheldall, Beaman and Mok (1999) used Fraser's (1990) *Individualized Classroom Environment Questionnaire* (ICEQ) in a study of variance partitioning at the student, class and school levels. While the sample involved 1,467 students in 81 classes, they were drawn from only four secondary schools in Sydney, Australia. Accordingly there must be a degree of uncertainty with regard to estimated variances and coefficients. Models with a small number of observations in higher levels typically lack statistical power. This study revealed significant proportions of variance at the class level for all five scales. Intra class correlations were above 16% for the personalization, participation, independence and differentiation scales. The intra school correlations ranged from 1.5% for the participation scale to 13.1% for the personalization scale.

Two final studies highlight previous research in which variance partitioning could have been reported. Goh and Fraser (1998) reported multilevel analyses of QTI and *My Class Inventory* (Fraser et al., 1982) scores and outcome scales. However they did not report variance partitioning from a multilevel perspective. Although eta^2 (the proportion of variance explained by class membership) was reported for each scale via individual one-way analysis of variance for class membership, this approach does not reflect the multilevel nature of the data. Similarly, Wong, Young, and Fraser (1997) did not report variance partitioning of scale scores in their multilevel study of chemistry classroom environment in Singapore.

Overall, the results of the present study are consistent with previous research on variance partitioning of scores on classroom environment scales. One noteworthy feature of the present results is that the proportions of variances in QTI scores at the class level are consistently high, especially when compared to the WIHIC's results and other research findings discussed above. As the QTI focuses explicitly on teacher interaction with students, these findings are not illogical. It is plausible that students in a class would hold a more collective view of the teacher's classroom interactions than say, personal growth dimensions. For example the cooperation scales of the WIHIC and CSCEQ probably assess students' idiosyncratic views rather than an overall classroom viewpoint.

One noteworthy issue concerning the results in the present study concerns the school types where the data were collected. The QTI data were from primary school students and the WIHIC and CSCEQ data were from secondary school students (see Table 1). Whereas students in primary schools largely experience one classroom environment, students in secondary schools experience several classroom environments. Accordingly, the proportions of variance at the classroom level with the QTI scores could be related to these students being

from primary schools compared to the other two studies which were conducted in secondary schools.

CONCLUSION

The present study assessed variance partitioning of scores on three classroom environment instruments: the What Is Happening In this Class (WIHIC), the Questionnaire on Teacher Interaction (QTI) and the Catholic School Classroom Environment Questionnaire (CSCEQ). Multilevel variance components models (i.e. null models) with three levels (viz. student, class and school) were used to separate variance into these three levels. By taking into account the hierarchical nature of these data, this study has shown that the class level accounted for significant amounts of variance in scores on all scales of all three instruments. As noted above, the proportion of variance at the class level varied considerably among these 22 scales. This suggests that, whereas some scales are more aligned with a summary classroom atmosphere, other scales assess the distinctive views of individual students within classes. It is an inevitable fact that almost all classroom environment data are nested. Students are taught in classes and classes remain the basic instructional unit of schools. The important conclusion from this study is that this multilevel nature to classroom environment data cannot be ignored. There is simply too much variance in scales scores at the class level to use the individual as the unit of analysis. However the potential for aggregation bias and ecological fallacies makes the use of the class as the unit of analysis problematic also. Neither using the individual nor the class as units of analysis is optimal and this paper recommends the use of multilevel modelling when analysing classroom environment data.

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