The Effect of Inattentive Behaviours in the Classroom on Students' Progress in Literacy and Numeracy

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Abstract. An enduring concern of teachers, parents and mental health professionals is the extent to which externalizing behaviour problems in the classroom - presently called disruptive behavior disorders in DSM-III-R (APA, 1987) - (ie., attention deficit/overactivity and conduct disorders), adversely affect students' opportunities for learning and educational development. Students whose behaviours are regarded as inattentive, disruptive or maladjusted have been shown to be at risk of poor educational progress. In addition to the consequences for an individual, such behaviour problems in the classroom diminish educational opportunities for other students and contribute to teacher stress. A further concern is that externalizing behaviour disorders "...are quite refractory to typical interventions and, like severe underachievement, comprise a major psychological, economic and social problem" (Hinshaw, 1992, p. 894). Using illustrative data from the first two stages of a current three-year longitudinal study among 13,000 students (aged 5-16 years) drawn from 90 government, Catholic and independent primary and secondary schools, this paper provides estimates of the effects of externalizing, inattentive behaviours in the classroom on primary students' progress in literacy and numeracy.

Introduction

In educational theory, research and practice, the notion of student attentiveness in the classroom has long been associated with the key operational construct of active learning time or its equivalents: time on task, engaged learning time, or perseverance. This notion derives from the theoretical work of Carroll (1963, 1984), Cooley and Lohnes (1976) and Bloom (1976), who argued that although students may differ in their aptitude for learning, the different amounts of time needed to achieve a given level of proficiency are a direct function of the amounts of attention or effort invested by an individual in a learning task. Findings from research on student learning in classroom settings provide strong support for this view, indicating that attentive behaviours are directly related to achievement outcomes (eg., Fisher et al., 1980; Keeves, 1986, Lahaderne, 1986). This work suggests that attentiveness (defined as purposeful activity showing a sustained attention span, perseverance, and not easily distracted) is a crucial variable associated with student behaviour at school, through which the effects of learning experiences are mediated to influence learning outcomes.

Evidence from studies investigating the impact of maladaptive student behaviours provide growing support for the importance of inattentiveness as a major factor having negative effects on student achievement. These studies reflect an enduring concern of teachers,

parents and mental health professionals of the extent to which the major characteristics of externalizing behaviour problems in the classroom - presently called disruptive behavior disorders in DSM-III-R (APA, 1987) - (ie., attention deficit/overactivity and conduct disorders), adversely affect students' opportunities for learning and educational development. Students whose behaviours are regarded as inattentive, disruptive or maladjusted have been shown to be at risk of poor educational attainment (Cantwell & Baker, 1991; Davie, Butler & Goldstein, 1972; Elkins & Izard, 1992; Hinshaw, 1992a, 1992b; Keller et al., 1992; McGee & Share, 1988; Maughan, Gray & Rutter, 1985; Rowe & Rowe, 1992a, 1992b, 1993; Rutter, 1985; Silver, 1990). Moreover, in addition to the consequences for an individual, such behaviour problems in the classroom diminish educational opportunities for other students and contribute to teacher stress (Brenner, Sˆrbom & Wallius, 1985;

Otto, 1986; Wearing, 1989). Further, as noted by Hinshaw (1992a, p. 894), externalizing behaviour disorders "...are quite refractory to typical interventions and, like severe underachievement, comprise a major psychological, economic and social problem" (see also Kazdin, 1987; Loeber, 1990; Robins, 1991).

While students' classroom behaviours have been found to be partly dependent on factors such as ethnicity (Dunkin & Doenau, 1985), social background (Kahl, 1985), gender (Bank, 1985), as well as cognitive and affective characteristics (Debus, 1985; Sinclair, 1985), findings from a growing number of studies indicate stronger direct associations between poor attention and learning difficulties - both in general student populations and in identified learning-disabled groups (Day & Peters, 1989; Dykman & Ackerman, 1991; Hill, Holmes-Smith & Rowe, 1993; Levy, Horn & Dalglish, 1987; McGee, Williams & Silva, 1985, 1987, 1988). For example, in their longitudinal study in Dunedin, New Zealand, McGee and co-workers have consistently found poor reading achievement to be strongly related to high ratings of inattention. McGee and Share (1988) estimate that 80 per cent of their sample of 11-year old children identified with Attention Deficit Hyperactive Disorder (ADHD), as defined by DSM-III-R (APA, 1987), had learning disabilities in reading and written language skills. Due in part to both methodological and analytical limitations in these studies, however, the direction of `effect' relationships is not clear. Furthermore, researchers who have investigated the link between students' externalizing behaviour problems and academic underachievement have focused almost exclusively on underachievement in literacy (ie., reading and writing). With few exceptions (eg., Strang & Rourke, 1985), little is known about the link between behaviour problems and under-achievement in numeracy.

From interest in the relationship between students' reading difficulties and behaviour problems, however, Rutter, Tizzard and Whitmore (1970) have proposed four alternative `causal' hypotheses, namely: (1) problem behaviour leads to learning difficulties; (2) learning difficulties produce behaviour problems; (3) both problem

behaviour and learning difficulties are produced by some third factor; and (4) it may be that all of these hypotheses could be partly true. In a review of the related research, McGee et al. (1986) note: "All hypotheses have drawn support from the literature and the proposed mechanisms underlying the relationship between reading disability and behaviour disorder appear to be equally plausible" (p. 597).

On the basis of a detailed review of the literature concerned specifically with the relationship between ADHD and failure to acquire literacy skills, McGee and Share (1988) conclude: "The evidence that the authors have reviewed suggests that a substantial overlap exists between ADHD and learning difficulties and that, as yet, no unique pattern of cognitive or attentional deficits has been identified that can discriminate between these two types of disorder" (p. 322). Following Kinsbourne (1984), who argues that attentional problems are both "context" and "task" dependent, McGee and Share (1988) further conclude that: "ADHD behaviors might best be considered as a disorder of conduct in the classroom, because the child with learning difficulties is excluded from much of the normal classroom activity" (p. 322). This finding is consistent with the findings of Day and Peters (1989) who concluded that "...learning-disabled children seem to be better characterized as `inattentive in the classroom'" (p. 360).

Despite the apparent simplicity of the Rutter et al. (1970) hypotheses outlined above, the conclusions drawn from reviews of the related research highlight major methodological and analytical problems that have plagued empirical research in the field. This is especially the case for those attempts to address `causal' or `which comes first?' type hypotheses (eg., McGee & Share, 1988; McMichael, 1979). Since most of the evidence upon which such hypotheses are based derive from cross-sectional rather than longitudinal studies, it is difficult to determine both the nature and direction of the `causal' relationships. Moreover, findings from the few longitudinal studies that have been reported are not consistent (eg., Chazan, 1985; Ecob, 1987; Jorm et al., 1986; Maughan et al., 1985; McGee et al., 1986; Richman, Stevenson & Graham, 1982; Stott, 1981). On the basis of an extensive review of issues related to the comorbidity between externalizing behaviour problems and academic underachievement, Hinshaw (1992b) concludes:

The overriding conclusion from the investigations reviewed above is sobering. Despite avid theoretical and empirical interest in revealing the undepinings of overlap between externalizing behavior and underachievement, alternative causal models have rarely been tested with sufficient rigor (p. 149).

The challenge for the field is to derive explanatory models with sufficient rigor and complexity to handle the diversity of causal factors (p. 151).

Findings from a three-year longitudinal study reported by Ecob (1987),

however, raise several substantive and methodological issues that are of particular relevance to the present investigation. A brief review of this study is of value here.

Using data from the Inner London Education Authority's Junior School Project (Mortimore et al., 1986), Ecob (1987) investigated the relationship between learning difficulties (inattentive behaviours in the classroom) and reading attainment for a cohort of 1,317 students drawn from 49 elementary schools, over the first three years of schooling (year 1 to year 3). Within a conceptual framework that views low attainment as the product of learning difficulties, Ecob investigated conditions required for a reduction in learning difficulties over time. To this end, Ecob used a `three-wave' structural equation model to estimate the effects of learning difficulties on students' progress in reading attainment, and the effects of reading attainment on learning difficulties from year to year.

Adjusting for the effects of student gender and father's social class, the results indicated that for both reading attainment and learning difficulties, students' scores in year 3 were significantly influenced by their scores on these domains in year 1 and in year 2. The changes between years in reading attainment and learning difficulties were also related. Ecob concluded: "Such a result may be due to the common effect on both reading attainment and learning difficulties of experiences in the classroom over the previous year, an effective teacher raising a child's reading attainment while reducing the child's experience of learning difficulties" (p. 152).

Ecob noted several methodological and analytic caveats that need to be considered when interpreting the results of the longitudinal models fitted. First, the results showed that the effect estimates of learning difficulties at year 1 on reading attainment in year 2 and year 3 are crucially dependent on the reliabilities (and validities) of their respective measures in year 1. Second, the sample used for structural equation modelling of the data was a clustered sample at the student level that ignored the contextual effects of class/teacher and school groupings. Ecob notes that under such circumstances, "...the standard errors reported will therefore generally underestimate the true standard errors" (p. 156), increasing the likelihood of yielding Type I errors (see Aitkin, Anderson & Hinde, 1981; Rowe, 1992a).

Third, measures of students' behaviours in the classroom are affected by the characteristics of both students and teachers that constitute the normative or contextual environment of the classroom which may have effects over and above that operating at the individual student level. The need to account for variability in student-level variables due influences of contextual variables at the class/teacher level is not only of methodological importance, but may also be substantively illuminating. Ecob correctly notes that analyses of this type cannot be performed with the structural models fitted, "...although they can

if multilevel models are used" (p. 156). Ecob's (1987) study highlights only some of the methodological and analytic problems of research in this area; others related to the present investigation have been noted previously by Rowe & Rowe (1992a, 1993, 1994). However, there are several methodological issues that are of special relevance to research in classrooms and schools that require highlighting here.

Methodological Issues of Special Relevance to Research in Schools

Particularly in educational research, characteristics associated with individual students and those associated with groups of students (ie., classrooms and schools) are typically confounded. This occurs because student groups are typically not established according to random assignment. Students in naturally occurring groups are commonly more like one another than those in general or students in other groups. It has long been recognised that the existence of such clustering poses special problems related to levels of analysis and lead to several longstanding and troublesome obstacles to statistical conclusion validity. Such obstacles include: aggregation bias, undetected heterogeneity of regression, misestimated parameters and their standard errors, and associated problems of model mis-specification due to lack of independence between measurements at different levels (Aitkin & Longford, 1986; Bryk & Raudenbush, 1987, 1993; Burstein, 1980; Cheung et al., 1990; Goldstein, 1986, 1987; Raudenbush & Bryk, 1986, 1988; Raudenbush & Willms, 1991; Robinson, 1950; Rowe, 1989, 1990, 1992a, 1993). In fact, it is inappropriate to pool responses of students without regard to groups unless it can be shown that groups do not differ significantly from each other (see Pedhazur, 1982). Moreover, as a consequence of aggregation bias, it is widely recognised that relations observed at one level (eg., the student level) may not bear any straight-forward relation to relationships observed at another level (eg., the classroom or school).

In the context of the present investigation, class/teacher-level contextual effects and related aggregation bias, have important implications for data analyses. For example, Marsh (1987, 1991), Marsh & Rowe (in press) and Rowe (1992a) have shown that measures of academic achievement (or behaviour) at the student level take on different meanings, and consequently, have different effects at different levels. That is, while measures of behaviour and achievement at the student level provide indicators of student attributes, average indices of these measures at the classroom and school levels become proxy measures of a school's normative environment. Thus, the average behaviour or achievement of a class or school has an influence on students above and beyond effects operating at the individual student level. Multilevel modelling is designed to resolve the confounding of these effects by facilitating a decomposition of observed relationship among variables, such as behaviour and achievement, into separate within-class/teacher and between-school components. This decomposition may be critical to correct interpretations of empirical relationships and is a major focus of the present investigation.

There are further grounds for taking class/teacher contextual effects into account. Intuitively, it seems essential to conceptualise the link between student learning outcomes and behaviour in the classroom as both direct and indirect in terms of being mediated by teacher effects (see Lee, Dedrick & Smith, 1991). This is especially so given the strong relationships that have been demonstrated between student

achievement and teachers' levels of "efficacy" (Ashton & Webb, 1986), "energy/enthusiasm" (Rowe, 1990, 1991a) and "commitment" (Rosenholtz, 1985). Nevertheless, there have been few studies that have been designed to reflect such a conceptualisation, and even fewer that have employed analytic techniques that take into account the hierarchical relationships implied by such a conceptualisation (see Rowe, 1992a, 1993; Rowe & Hill, 1994). In the Preface to their recent book, Raudenbush & Willms (1991, p. xi) observe:

An irony in the history of quantitative studies of schooling has been the failure of researchers' analytic models to reflect adequately the social organisation of life in classrooms and schools. The experiences that children share within school settings and the effects of these experiences on their development might be seen as the basic material of educational research; yet until recently, few studies have explicitly taken account of the effects of particular classrooms and schools in which students and teachers share membership.

Educational and psychosocial research that ignores the inherent hierarchical sampling structure of the data typically obtained, and merely examines, for example, the simple bivariate relationship between behaviour and learning outcomes, is naive in the extreme.

This, in any analysis of the relationship between student learning outcomes and explanatory factors such as behaviour, two major issues need to be taken into account. First, factors affecting student learning outcomes are complex, multifaceted, multidimensional and multilevel. For example, in studies using structural equation modelling (Hill, Holmes-Smith & Rowe, 1993a, 1993b; Rowe, 1991a, 1991b; Rowe & Rowe, 1992b), students literacy and numeracy achievements have been found to be both directly and indirectly influenced by their attitudes towards learning, perceived usefulness of the curriculum, homework, attentiveness in the classroom, and home background factors including parent interest in monitoring their child's progress. Moreover, in the study reported by Rowe & Rowe (1992b), non-recursive structural equation modelling revealed significant interdependent effects (reciprocal) between students' reading achievements and inattentiveness in the classroom, suggesting the need for intervention strategies to focus on both domains simultaneously. Further, using multilevel modelling techniques (Prosser, Rasbash & Goldstein, 1991, 1993), Rowe and colleagues (Rowe, 1991a, 1993; Hill, Holmes-Smith & Rowe, 1993a; Rowe & Hill, 1994) have found that between 26 and 44 per cent of the variance in measures of students' literacy and numeracy

achievements are due to between class/teacher differences. Furthermore, high average levels of inattentiveness in the classroom had significant negative effects on students' individual and group achievements.

Second, a major criticism of research into schooling is that most studies have used cross-sectional designs or have employed, at most, two time points. Because such studies are usually non experimental, drawing 'causal' inferences is particularly problematic in the absence of longitudinal data, since measures of change based on only one or two time points are notoriously unreliable (Bryk & Raudenbush, 1987; Goldstein, 1979; Kessler & Greenberg, 1981; Raudenbush & Bryk, 1988; Rogosa & Willett, 1985; Willett, 1988). Nuttall et al. (1989, p. 775) provide:

...a note of caution about any study...that relies on measures of outcome in just a single year, or of just a single cohort of students. Long time series are essential for a proper study of stability over time.

To avoid these problems, the design of studies concerned with the effects of schooling should be longitudinal, with (1) repeated measures on multiple cohorts of students nested within classes and schools, to estimate their growth trajectories, and (2) repeated measures on schools - to evaluate the stability of contextual effects over time. The second design involves cross-sections of student cohorts nested within classes and teachers that are changing over time. In both cases, as noted by Rowe and Hill (1994), the fact that students are used as their own 'controls', obviates the need to rely merely on possible under-estimates in intake-adjusted measures, and solves the problem of the confounding effects due to student ability grouping or 'tracking' practices. Moreover, such designs allow for estimation of the effects of changing class/teacher contextual influences and organisational characteristics. The study reported here was designed to avoid these methodological and analytical problems.

Aims of the Study

For the purposes of this paper, the primary aim of the study was to extend Ecob's (1987) model to estimate the magnitudes of the effects of externalizing, inattentive behaviours in the classroom (what Ecob refers to as "learning difficulties") on primary students' literacy and numeracy development over two time periods (ie., two years). In the process of meeting this primary aim, a secondary aim was to address the methodological and analytical issues outlined above.

An Explanatory Model

Consistent with this aim, the basic two-wave explanatory model tested

in this study is schematically depicted in Figure 1. Estimation of the magnitudes of the effects among the latent constructs (manifest or composite variables), indicated by the unidirectional arrows, constituted the key objectives of the study.

Figure 1. Schematic representation of the basic explanatory model

Several features of this model are worth noting. First, in order to evaluate the stability of student behaviours and learning outcomes, the model provides for estimation of the autoregressive effects of inattentive behaviours and learning outcomes on themselves over time. Second, given the influence of mediating factors at each time period, the model allows for simultaneous estimation of the cross-sectional and longitudinal effects of externalizing behaviours on learning outcomes. Third, the model provides for the use of analytic methods to estimate the magnitude of effects among the factors at each level of analysis, as well as for estimation of the contextual effects on students' behaviours and learning outcomes, adjusting for initial behavioural and learning outcome levels.

Method

Study Design

The overall design of the study is presented schematically in Figure 1. The major feature of the longitudinal, ex post facto, survey design is the opportunity to explore inter-relationships among factors at three levels (student, class/teacher and school) over time. Hence, the analytic design entails repeated measures on students clustered with class/teacher groupings and schools. A special feature of the study design is the use of analytic methods that allow simultaneous estimation of the effects of factors at the student, class/teacher and school levels on the stability of inattentive behaviours in the classroom and learning outcomes using multilevel, path analytic techniques (see Goldstein, 1987; Prosser, Rasbash & Goldstein, 1993).

The Data and Sample Characteristics

The data set used in this investigation derives from a current three-year longitudinal study (1992-1994) of school and teacher effectiveness for a sample of students, their parents and teachers, initially in the year-level cohorts of Prep, 2 4 7 and 9, drawn from government, Catholic and independent primary and secondary schools in the State of Victoria, Australia. For this paper, however, data from only the primary student sample is reported. Full details of the

design, sampling, methodology and findings from Phase 1 of this study have been reported by Hill, Holmes-Smith and Rowe (1993a).

In brief, a two-stage, stratified, probability sample was drawn, with a conservative intraclass correlation estimate (roh - p = 0.2) and an average cluster size (a ~ 30), for Ú 95% confidence limits (see Ross, 1988a, 1988b). Within these constraints, schools were randomly selected at the first stage of sampling, but with probability proportional to their enrolment size (PPS sampling). At the second stage of sampling the total number of students enrolled in Prep, Year 2, Year 4, Year 7 and Year 9, in each selected school, were included in the sample.

Following written invitations to a designed sample of 96 schools in the first phase of the study (1992), useable data were received from 90 school sites, representing a response rate of 88.5 per cent. The achieved sample included 63 government schools (41 primary, 22 secondary); 15 Catholic schools (12 primary, 3 secondary) and 12 independent schools (6 primary, 6 secondary), for a total of 13,909 students and 931 teachers. Thus, the sampling structure of the data entailed three levels, with 13,909 students (level 1) clustered within 931 class/teacher groups (level 2) and 90 school sites (level 3). Repeated measures for those students remaining in the sampled schools were obtained in 1993 and will again be obtained in 1994, as shown below.

For the purposes of this paper data is presented for 1992 and 1993 sample of primary students only (see footnote 2).

Characteristics of Variables Measured

Among others, a set of three instruments was used between 1992 and 1994 to obtain information on the following:

Student-Level Mediating Variables: Year level; age; gender; ethnicity; residential location (metropolitan/rural), family socio-educational level (SEL); and English or Non-English speaking background. Student Attitudes: Attitudes to learning; liking for school; social acceptance (by peers); and teacher responsiveness.
Student Externalizing Behaviours: Teacher-rated behaviours on the Rowe Behavioural Rating Inventory (RBRI) - an inventory consisting of 16 bipolar items for the three domains: Social/Anti-Social, Attentive/Inattentive and Settled/Restless. Normative data on the RBRI for more than 25,000 school-age children is available (see Rowe & Rowe, 1993, 1994). For illustrative purposes here, however, only the Attentive/Inattentive scale is used.
Student Learning Outcomes: English (reading, writing and spoken

language) using the Victorian English Profiles (Victoria, 1991) and Mathematics using the Mathematics Profiles (Victoria, 1992). The rationale for using Profiles as frameworks for assessment, recording and reporting on student achievement is given by Rowe (1992b) and Rowe, Hill and Holmes-Smith (1994b)
Full details of these measures, including their measurement properites and the reliabilities of the related composite variables, are given in Hill, Holmes-Smth and Rowe (1993a).

Analytic Methods

1. Calculation of composite variables and estimating their reliabilities using one-factor congeneric models. To ensure that measurement error problems in observed indicator variables were minimised for fitting the multilevel path-analysis models to the data (see below), this investigation focuses on an approach to computing composite variables that has been developed for specific applications in explanatory research work of the present kind (see Holmes-Smith & Rowe, 1994). This approach is based on confirmatory factor analyses (CFA) of reponse scores on individual, observed variables or items (xi). using LISREL (Jîreskog & Sîrbom, 1989, 1993b). Two types of CFA were conducted. First, to obtain accurate estimates of the item-factor loadings (SYMBOL 108 \f "Symbol"xij's), their standard errors (SYMBOL 113 \f "Symbol"SYMBOL 100 \f "Symbol"'s), and the correlations among common factors or scales (SYMBOL 102 \f "Symbol"'s), CFA's were computed. The CFA measurement model for the observed xi item variables is given by

x = SYMBOL 76 \f "Symbol"xSYMBOL 120 \f "Symbol" + SYMBOL 100 \f "Symbol",(1)

and the variance-covariance matrix of x is

SYMBOL 83 \f "Symbol" = SYMBOL 76 \f "Symbol"xSYMBOL 70 \f "Symbol"SYMBOL 76 \f "Symbol"x' + SYMBOL 81 \f "Symbol"SYMBOL 100 \f "Symbol"(2)

From equation (1) x is a (n SYMBOL 180 \f "Symbol" 1) vector of measurements on observed item indicators, SYMBOL 76 \f "Symbol"x is a (n SYMBOL 180 \f "Symbol" 1) vector of fixed coefficients or loadings on the latent (scale) variables (SYMBOL 120 \f "Symbol") and SYMBOL 100 \f "Symbol" is a (n SYMBOL 180 \f "Symbol" 1) vector of unique (random) factors specifying the measurement errors in the x item indicators. From equation (2), SYMBOL 83 \f "Symbol" is the estimated variance-covariance matrix of the factor loadings (SYMBOL 108 \f "Symbol"x) for the vector of item measures (x), SYMBOL 70 \f "Symbol" is the correlation matrix among the factors, and SYMBOL 81 \f "Symbol"SYMBOL 100 \f "Symbol" a vector of unique variances. SYMBOL 76 \f "Symbol"x, SYMBOL 100 \f "Symbol", SYMBOL 83 \f "Symbol", SYMBOL 70 \f "Symbol" and SYMBOL 81 \f "Symbol"SYMBOL 100 \f "Symbol" are the

parameters to be estimated. To maximise the reliability of the parameter estimates, a listwise method for deleting missing data was employed, and a weighted least squares method of parameter estimation was used in a joint analysis of the polychoric/polyserial item-intercorrelation matrix and the asymptotic variance-covariance matrix of these correlations, computed from PRELIS (Jîreskog & Sîrbom, 1993a).

The second type of CFA employed was the calculation of composite scores for the relevant scales, obtained from fitting one-factor congeneric models to the constituent observed item data (using equations 1 and 2). Composite scores computed by this method are single indices of their component items, each of which is weighted for its relative

contribution to the composite. Unlike traditional unit-weighted methods for computing composites, the use of factor score regression weights obtained from CFA one-factor congeneric models, minimise measurement error in the contributing items, thus increasing the reliability (and validity) of the computed scale scores. In the interests of parsimony for explanatory research applications, the use of reliable composite scores (or variables) is crucial in fitting both single-level and multi-level regression models, as well as in fitting structural equation models (see Bock, 1989; Goldstein, 1987; Hill, Holmes-Smith & Rowe, 1993a; Holmes-Smith & Rowe, 1994).

From the parameters of equation (2), the reliability of a composite (rc) is given as

EMBED Equation ,(3)

where wc is a vector of factor score regression weights (w1 = SYMBOL 108 \f "Symbol"x1/SYMBOL 113 \f "Symbol"SYMBOL 100 \f "Symbol"1, w2 = SYMBOL 108 \f "Symbol"x2/SYMBOL 113 \f "Symbol"SYMBOL 100 \f "Symbol"2, ..) that maximise the reliability of the composite (see Alwin & Jackson, 1980; Brown, 1989; Holmes-Smith & Rowe, 1994; Jˆreskog, 1971; Munck, 1979; Werts et al., 1978).

2. Explanatory multilvel models

To estimate the proportion of variance in the response and explanatory variables of interest due to class/teacher contextual effects, multilevel models were fitted to the maximally-weighted composite variables, at each time period, as follows:

(a)Three-level variance-components models (hereinafter referred to as the "null models"), to estimate the variance due to the group effects of students (level 1) within classes/teachers (level 2) within schools (level 3), for each of the behavioural and achievement variables,

(b)Three-level, "intake-adjusted" regression models, with the student intake characteristics and mediating variables fitted as fixed, level 1

explanatory variables, and the contextual variables fitted as fixed, level 2 or level 3 explanatory variables. (For specifc details of these models, see Bryk & Raudenbush, 1993; Goldstein, 1989).

For convenience here, equations for the null models (a) are illustrated. Following Prosser, Rasbash & Goldstein (1993), this model can be written in three parts. First, for the ith student in class/teacher j within school k, scores on each of the externalizing behavioural domains, or for Literacy and Numeracy achievement (Yijk), can be modelled as

Yijk = SYMBOL 98 \f "Symbol"0jkX0 + eijk. (4)

Here, the slope is constant (0 - zero) but the intercept is random, varying across classes/ teachers and schools. The X0 term in equation (4) is a column vector of unities representing the constant slope for classes/teachers and schools, and eijk is a random residual term representing the contribution to the response variable Yijk of the ith student in the jth class/teacher within the kth school.
Second, the intercept for class/teacher (SYMBOL 98 \f "Symbol"0jk) can be expressed as a linear function of the average intercept for school k (SYMBOL 112 \f "Symbol"00k) and a class/teacher-level random term (u0jk):

SYMBOL 98 \f "Symbol"0jk = SYMBOL 112 \f "Symbol"00k + u0jk. (5)

Third, the average intercept for school k can be modelled in terms of an overall school average intercept (SYMBOL 103 \f "Symbol"000), and a school-level random term (v00k):

SYMBOL 112 \f "Symbol"00k = SYMBOL 103 \f "Symbol"000 + v00k.(6)

By combining equations (4), (5) and (6), a single equation version of the model can be written as follows:

Yijk = SYMBOL 103 \f "Symbol"000 + (v00k + u0jk + eijk),(7)

where SYMBOL 103 \f "Symbol"000 is the fixed part of the model and the three random terms are bracketed.

From equation (7), given the fixed part of the model (SYMBOL 103 \f "Symbol"000 - the grand mean of Yijk), the random parameters that are estimated for this model are the variances of the residual terms in brackets, namely:

SYMBOL 183 \f "Symbol" \s 10 \hthe between-school variance estimate of the residual term v00k (i.e., SYMBOL 115 \f "GreekMathSymbols"v2);
SYMBOL 183 \f "Symbol" \s 10 \hthe between-classes/teachers variance of the residual term u0jk (i.e., SYMBOL 115 \f "GreekMathSymbols"u2), and;

SYMBOL 183 \f "Symbol" \s 10 \hthe between-students, within classes/teachers and schools variance of the residual term eijk (i.e., SYMBOL 115 \f "GreekMathSymbols"e2).

The total variance due to random effects (SYMBOL 115 \f "GreekMathSymbols"(T)2= SYMBOL 115 \f "GreekMathSymbols"v2 + SYMBOL 115 \f "GreekMathSymbols"u2 + SYMBOL 115 \f "GreekMathSymbols"e2) may then be partititoned into that due to school, class/teacher and student effects as follows: Proportion of variance due to school effects = SYMBOL 115 \f "GreekMathSymbols"v2/SYMBOL 115 \f "GreekMathSymbols"(T)2; class/teacher effects = SYMBOL 115 \f "GreekMathSymbols"u2/SYMBOL 115 \f "GreekMathSymbols"(T)2; and student effects = SYMBOL 115 \f "GreekMathSymbols"e2/SYMBOL 115 \f "GreekMathSymbols"(T)2.

Under an iterative generalised least squares method of estimation (see Goldstein, 1986), models described by equation (8) will be fitted to the data using ML3-E (Prosser, Rasbash & Goldstein, 1993).
To estimate the effect magnitude of student-level mediating and explanatory variables, as well as the effects of contextual variables at the class/teacher-level, multilevel regression models were fitted. Specifications of these models are straight-forward extensions of the variance-components models given above (see Bryk and Raudenbush, 1993; Prosser, Rasbash & Goldstein, 1993; Woodhouse, 1993).

Results

The results are briefly summarised in Figures 2 and 3. (The related discussion is forthcoming).

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Figure 2. Two-wave multilevel, path analytic model for primary English showing standardized path regression coefficients
(4079 students in 311 classes, in 51 schools)

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Figure 3. Two-wave multilevel, path analytic model for primary Maths showing standardized path regression coefficients
(4072 students in 306 classes, in 51 schools)

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