

Hierarchical Linear Models: Applications to cross-cultural comparisons of school culture

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Some commonly used Hierarchical Linear Models (Multilevel models) for comparing school culture, including variance component models, slope as outcome models, and hierarchical structural models were discussed in this paper. Illustrative data came from a study on a group of Year 11 students in Australia and their counterparts in Hong Kong. The application of these models in studying organisational culture using two computer software packages, namely, ML3 (Prosser, Rashbash, & Goldstein, 1992) and BIRAM (McDonald, in preparation) are presented. As well as comparing Hierarchical Linear Models with conventional approaches, the authors examined the limitations of the former in cross-cultural studies.

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In the study of school culture, data were often collected from the perceptions of actors within schools. For example, data concerning student-teacher relationships were gathered from individual students. One conventional approach was to aggregate these individual data into group-level measures. Researchers adopting this approach argued that studies on school culture should be analysed at the school-level. Various authors have written on the possible analytical problems arising from the use of school aggregates. They pointed out that the process of aggregation eliminates the within school variations which might be of genuine interest to the researchers. On the other hand, other researchers have argued that conducting the analysis at the student-level means that between-school differences were ignored, and as a result, the standard error of the estimates were underestimated which might in turn exaggerate the significance level of the results (see for example discussions by Burstein, 1980; Mason, Wong & Entwistle, 1983; Goldstein, 1987; Bryk & Raudenbush, 1992). These problems related to the unit of analysis in ordinary linear regression are expected to be more serious in studies related to cross-cultural studies because the homogeneity of schools varies across culture. The cultural differences in terms of how far a school can be taken as a social unit are likely to exacerbate any error in selecting the unit of analysis in the conventional approaches.

The advancement in technology in the 80's has enabled the development of a set of approaches known collectively as hierarchical linear models (also known as multilevel models; Mason, Wong & Entwistle, 1983; Goldstein, 1987; Goldstein & McDonald, 1988; Bock, 1989; Bryk & Raudenbush, 1992), which takes into account simultaneously variances at both the student- and the school-levels. This approach has therefore overcome the problems related to the choice of the unit of analysis. This paper illustrates how some commonly used hierarchical linear models can be applied to the study of school culture across different cultural settings. In the discussion that follows, student morale and student-teacher relationships were chosen as two aspects of school culture for students from two regions: Sydney and Hong Kong. However, the methods discussed here can be easily generalised to more than two variables, or to research situations where more than two cultures were involved.

Theoretical Framework

(a) Bilevel Confirmatory Factor Model

The models discussed in this paper were special cases of the general models discussed in Goldstein and McDonald (1988), and in McDonald and Goldstein (1989). Within the framework of this conceptualisation and in the Spearman case, the observed data vector was decomposed into a between-school component, and a within-school component.

The covariance matrix was decomposed into the corresponding between- and within- components. The negative log likelihood was minimised using a standard Davidson-Fletcher-Powell quasi-Newton search method involving finite-difference approximations to the first and second derivatives, from guessed parameter values.

(b) Variance Component Model

Scales constructed using the results of the bilevel factor analysis were then fitted into various hierarchical linear

models. The first model considered was the variance components model (Goldstein, 1987; Bryk & Raudenbush, 1992). This is a "null" model with no explanatory variables other than region (Australia versus Hong Kong), and implicitly: schools. In this model, the total variance of morale was decomposed into a between-school and a within-school components. This model stated that Australian and Hong Kong students differed in their morale on the average by a fixed amount which was to be estimated, and school means were modelled as random deviations from the grand mean. In addition to a test on the regional differences, this model provided an estimate of the intraclass correlation which was the proportion of variance in morale between schools.

(c) Random-Intercept Model

Although the fully unconditional variance component model was useful in testing whether school-level variation was large enough to warrant multilevel analysis, no explanatory variables were included. If in addition, morale was taken as dependent on student-teacher relationships, two additional multilevel models could be considered. The first of these was the random-intercept model. In this model, the effect of student-teacher relationship on morale after controlling for migrant/non migrant status, was taken to be constant across schools.

(d) Random-Slope Model

In the random-slope model, the effect of student-teacher relationship on morale was allowed to randomly vary between schools.

(e) Hierarchical Structural Equation Models

Other explanatory variables can be included in models (c) and (d) above. However, in all models discussed in (b), (c), and (d), the explanatory variables were either fixed or the estimates were calculated conditioning on the explanatory variable. It is possible to fit bilevel structural equation models where both the explanatory and outcome variables are random (McDonald & Goldstein, 1989; McDonald, 1993). For example, the two-group (Australian/Hong Kong) bilevel structural equation model with morale, which was measured by 6 manifest variables, regressing on

student-teacher relationship, which was in turn measured by 12 manifest variables.

Sources of Data

Illustrative data consists of responses to a questionnaire from 2,615 Year 11 Australian and 1011 Hong Kong students studying at an equivalent grade. The questionnaires used in the two regions were identical other than translation. The Australian data were collected between July 21 and September 1993. The Hong Kong data were collected between September 1, 1993 and the time of writing. Thirty Australians and ten Hong Kong schools were involved. The questionnaire contains nine scales constructed to measure school culture, expectations, parental press, and student academic aspiration. These scales were developed by Flynn (1993), and were shown to have high validity and reliability (Cronbach's Alpha was greater than 0.8 for all scales).

Methods

The analysis has adopted the following strategies:

Step 1. Scale construction.

As discussed in Mok & McDonald (1993), various bilevel factor models are possible for scale construction, depending on the research question and the information available to the researcher. They further pointed out that each model offered some information regarding the two level factor structures. In their sample, no significant loss in terms of goodness of fit by constraining the loadings to be equal across levels was found, but they recommended that if the manifest variables were not comparable in spread, scaling is important. Because the data for the current study came from two different cultures, it was envisaged that the spreads of the data were different, a constrained-equal-with-scaling bilevel factor model was fitted for each of the scales.

Step 2. Computing Multilevel Descriptive Statistics

The distributions of the scales within and between schools for each region were obtained using ML3 (Rasbash, Prosser, & Goldstein;1990). This step provided insight into the amount of between school and within school variations, identification of outliers and other abnormalities.

Step 3. Establishing Cross-cultural differences in student morale

This step involved fitting the variance component model, the random intercept model and the random slope model to the data. For each of these models, region was represented by a "0-or-1" dummy variable. This step provided information regarding the proportion of variance between schools after controlling for region, the fixed- and the random-effect of student-teacher

relationship on morale within each region. The goodness-of-fit of these models can be estimated using a modified version of McDonald's Goodness-of-Fit Index whereby an effective sample size was used instead of the actual sample size. The effective sample size was calculated using an adjustment for cluster sampling effect.

Step 4. Building a bilevel structural equation model

This step was conducted using a BIRAM model (McDonald, Parker & Ishizuka, in press). Analogous to the arguments against comparing raw regression coefficients, there was an argument against using the unscaled path coefficients. In this study, the variables were scaled first thus producing standardised path coefficients.

Results

It must be stressed from the outset that the results presented here are only preliminary. The research is ongoing. Data collections have just finished in Australia at the time of writing. More returns from the Hong Kong sample were expected.

A full report of the findings will be available in form of a journal paper. Preliminary findings include:

1. Bilevel confirmatory factor analysis showed that the scales had construct validity for both regions. It is therefore meaningful to discuss any cultural differences in terms of these scales.
2. There were wide between- and within- school variations in student-teacher relationship and in student morale for both regions. Intraclass correlation was in the order of 16%.
3. Multilevel analysis showed that there was significant difference between the regions in student morale. Morale in Hong Kong was lower than in Australia. A variance component model fitted to the data conditioning on region showed that there were significant differences between school average morale.
4. Student-teacher relationship had a positive effect on morale. However, there was no significant random slope effect, nor was there any significant slope-intercept interaction effect.

Discussion

This paper discussed some commonly used hierarchical linear models and their applications to cross-cultural studies. Different path coefficients can be estimated simultaneously for

the two regions while taking into account the hierarchical nature of the data within each region. The method can be easily generalised to more than two regions or more than two latent variables. If used appropriately, hierarchical linear models can be a potentially very powerful research tool.

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