The multilevel analysis of students’ achievement in learning the Chinese language

Ruilan Yuan
Flinders University of South Australia Ruian.Yuan@flinders.edu.au

John P. Keeves
Flinders University of South Australia john.keeves@flinders.edu.au

A three-level hierarchical or multilevel model is employed to examine the factors that influence students’ achievement in learning the Chinese language. The factors might be many or various, such as school factors, factors related to teachers, parents and peers. This study, however, only examines student level factors. The first level of the three-level multilevel model is the within-student level; the second level is between-student level; and the third level is between-class level. The results show that different factors at different levels of the model have effects on the students’ achievement. Interaction effects are also observed between some variables and the achievement.

Multilevel Analysis, Student Achievement, Chinese Language

INTRODUCTION

After the World War II, especially since the middle of 1960, when Australia’s involvement in business affairs with some Asian countries in the Asian region started to occur, more and more Australian school students started to learn Asian languages. The Chinese language is one of the four major Asian languages taught in Australian schools. The other three Asian languages are Indonesian, Japanese and Korean. In the last 30 years, like other school subjects, some of the students who learned the Chinese language in schools achieved high scores in learning the Chinese language, and others were poor achievers. Some students continued learning the language to Year 12, while most dropped out at different grade levels. Therefore, it is considered worth investigating what factors influence student achievement in the Chinese language. The factors might be many or various, such as school factors, factors related to teachers, classes and peers. This study, however, only examines student-level factors that influence achievement in learning the Chinese language.

DESIGN OF THE STUDY

The subjects for this study were 945 students who learned the Chinese language as a school subject in a private college of South Australia in 1999. The instruments employed for data collection were student background questionnaire and attitude questionnaire, four Chinese language tests, and three English word knowledge tests. All the data were collected during the period of one full school year in 1999.

THE THREE-LEVEL HLM ANALYSIS

It should be noted that one of the aims of this study is to examine the factors influencing students’ achievement in the Chinese language across school grades and over time. The factors to be examined are categorized into three types: (a) intra-student factors; (b) inter-student factors; and
(c) environmental factors of the school class group. The single-level PLS analysis is clearly insufficient to identify differences in the factors between students within year level groups and among the year level groups of students. Therefore, a three-level multilevel model is employed to undertake this task.

Bryk and Raudenbush (1992) have identified three general purposes of hierarchical or multilevel model applications: (a) to improve the estimation of effects for individual units; (b) to formulate and test hypotheses about across-level effects; and (c) to partition variance and covariance components among levels. The analyses undertaken in this study using a three-level multilevel linear model involves the investigation of student, as well as class factors influencing students who are learning the Chinese language. The data for the analyses are organized at the within- and between-student levels as well as at the between-class level. It is necessary to note that three different terms are used in the analyses and interpretation of the data. The first level of the three-level multilevel model is referred to as the micro level, or the within-student level, or Level 1; the second level is referred to as the meso level, or between-student level, or Level 2; and the third level is referred to as the macro level, or class level, or Level 3. Hence, the present paper discusses the results obtained from the analysis of the three-level multilevel model to show whether or not differences can be observed with respect to the within-student factors, the between-student factors and the between-class factors that are hypothesized to influence student achievement in learning the Chinese language. The outcome variable is $SCORE$ (see Figure 1).

Raudenbush and Bryk (1994) have stated that hierarchical linear models (HLM) enable the testing of hypotheses about effects that occur within and between each level of the variables and about the interrelations between them. In other words, hierarchical linear models allow for the analyses of data at different levels simultaneously.

Figure 1 presents the hypothesized three-level hierarchical or multilevel model of student level factors influencing the achievement in learning the Chinese language across year levels over time. Lietz (1995, p. 121) argued, “It is not possible to form latent variables in the actual HLM analysis and manifest variables are employed instead”. Hence, in the current hypothesized three-level multilevel model, some manifest or observed variables (see Table 1) were selected as variables for the HLM analyses.

The first level is the intra-student model, namely the within-student model (micro level model). Time is used as a predictor to estimate each individual student’s four scores and to explore the differences within each student at the four time points. The second level is the inter-student level model, that is the between-student model (meso level model) which is used to compare the differences in the achievement between students averaged over the four occasions. Level three is the macro level model or the between-class model, which allows for the effects of the average levels of student characteristics between classes. Therefore, the variables at the class level are aggregated from the between-student level, namely the second or meso level, to address the effects of differences in the composition of the class environment.

Figure 1 combines the intra-student, inter-student and environmental factors that are hypothesized to influence student achievement in learning the Chinese language. In the model, it is hypothesized that, at the within-student or micro level, the variable hypothesized to influence the achievement is referred to as time or occasion. At the between-student or meso level or Level 2, all the nine variables are hypothesized to influence directly student achievement in learning the Chinese language (cachment), namely, fathoc, gender, hmbooks, yearlev, wordknw, pareinfl, expwork, motiv, and attit.
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Figure 1 A Hypothesized Three-level Multilevel Model of Factors Influencing Student Achievement in Learning the Chinese Language

Notes:

Level 3  Level 3 effect
Level 2  Level 2 effect
Level 1  Level 1 effect
The variables at the between-class or macro level are averaged and aggregated from the second level, namely the between-student level. In addition to the nine variables aggregated from the second level, one more variable is created and used at the between-class level, namely, grade level (level).

At the micro level or Level 1, timeid is used as a predictor to examine the score differences within each student at the four time points. At the meso level, namely Level 2, the differences in the achievement between students on the four occasions are compared. Nine latent variables are hypothesized to influence the outcome variable score. These nine variables are fathoc, gender, hmbooks, yearlev, wordknw, pareinfl, expwork, motiv and attit. At the macro level or Level 3, the comparisons are made between the average levels of student achievement among classes. Ten variables are proposed to influence score, among which nine variables are aggregated and averaged from the variables at the meso level or Level 2 (i.e. fathoc-1, gender-1, hmbook-1, yearle-1, wordk-1, parein-1, expwo-1, motiv-1, and attit-1) with one additional variable (i.e. level) added to the model so that the effects of grade or year levels can be examined. In other words, with the class level model, it is also possible to investigate whether or not differences exist between the grade or year levels with respect to their achievement in learning the Chinese language. It should be noted that this analysis does not consider the relative performance of each individual class group, or the effects of the teachers on the performance of each class group.

Several preliminary steps of analysis are required prior to the conduct of the main analysis of the three level hierarchical or multilevel model. First, variables must be selected from the results of the PLS analyses to be included in the regression equations. Second, the data for analysis need to be prepared in an appropriate form for analysis at the three levels, and finally the models must be specified. The following sections describe these three steps respectively.

### Variable Selection

HLM analysis employed the observed or manifest variables. Therefore, all the 20 manifest variables that form the nine latent variables are selected as the variables in the three level HLM analysis. Consequently, the variables used in the equations in the fully unconditional model and the final model of the HLM analysis are the corresponding manifest variables of the latent variables used in the hypothesized three level HLM model.

It is important to point out that 12 items from the Student Background Questionnaire, and five items, namely chiease (ease of learning the Chinese language), chiefft (effort in learning the Chinese language), intrest (interest in learning the Chinese language), chiuse (usefulness of learning the Chinese language), and schefft (effort in schoolwork), which indicate the five attitude sub-scale scores obtained on both Occasions 1 and 2 are included in the analyses. The criterion variable in the three level HLM model is score which indicates the four separate scores from the Chinese language achievement tests. Table 1 provides the information on all the variables employed in the three level HLM model.

### Data Preparation

In order to separate out the variables for Level 1 or the micro level, a new file was built using SPSS for Windows Version 6.13 (Statistical Package for the Social Sciences, 1993). The first variable was timeid indicating Terms 1 to 4 for each individual student. The second was classid representing Classes 1 to 39. The third variable was studid representing each individual student. The final variable was the score for each of the four occasions which was the scaled Rasch scores for the four terms for each individual student. Hence, in general, each student had four Rasch scaled scores, with initially 945 students. However, four Year 4 classes (N=121) and 27 Year 12
students only completed two of the four tests (see Chapter 5). The scores for the other two terms were treated as missing data.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>The Variables Included in the HLM Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 1 Variable (Intra-student Level)</strong></td>
<td><strong>Coding</strong></td>
</tr>
<tr>
<td>timeid</td>
<td>Combined scale</td>
</tr>
<tr>
<td>(The 4 term points in the 1999 school year)</td>
<td></td>
</tr>
<tr>
<td><strong>Level 2 Variable (Inter-student Level)</strong></td>
<td></td>
</tr>
<tr>
<td>Fathoc</td>
<td>1 – Not in work force, 2 – Unskilled,</td>
</tr>
<tr>
<td></td>
<td>3 – Semiskilled, 4 – Skilled workers,</td>
</tr>
<tr>
<td></td>
<td>5 – Clerical workers, 6 – Managerial,</td>
</tr>
<tr>
<td></td>
<td>7 – Upper and lower professional.</td>
</tr>
<tr>
<td>focc (Father’s occupation)</td>
<td>1-Male; 2-Female</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>sex</td>
<td></td>
</tr>
<tr>
<td>Yearlev (Grade level)</td>
<td>Year 4 – Year 12</td>
</tr>
<tr>
<td>yearlevl</td>
<td></td>
</tr>
<tr>
<td>(No. of years learning the Chinese language)</td>
<td>1 – Just started, 2 – 1 to 2 years, 3 – 3 to 4 years, 4 – 5 to 6 years,</td>
</tr>
<tr>
<td></td>
<td>5 – 7 or more years.</td>
</tr>
<tr>
<td>Hmbbooks</td>
<td>1 – 0-10, 2 – 11-25, 3 – 26-100,</td>
</tr>
<tr>
<td>books (Books in general at home)</td>
<td>4 – 101-200, 5 – more than 200.</td>
</tr>
<tr>
<td></td>
<td>1 – None, 2 – 1 to 5, 3 – 6 to 10,</td>
</tr>
<tr>
<td>chibooks (Chinese language books at home)</td>
<td>4 – 11 –15, 5 – 16 or more.</td>
</tr>
<tr>
<td>Pareninf</td>
<td></td>
</tr>
<tr>
<td>encourag (Encouragement from parents)</td>
<td>1 – Hardly ever or never,</td>
</tr>
<tr>
<td></td>
<td>2 – Occasionally,</td>
</tr>
<tr>
<td></td>
<td>3 – Often.</td>
</tr>
<tr>
<td>parfeel (Parents’ feeling about their child’s learning the Chinese language.)</td>
<td>1 – I don’t know about their feelings.</td>
</tr>
<tr>
<td></td>
<td>2 – They are not in favour of it.</td>
</tr>
<tr>
<td></td>
<td>3 – They don’t care about it.</td>
</tr>
<tr>
<td></td>
<td>4 – They are in favour of it.</td>
</tr>
<tr>
<td>Wordknw</td>
<td>The average Rasch score on English word knowledge tests.</td>
</tr>
<tr>
<td>scorknw (The Rasch scores obtained from English Word Knowledge tests.)</td>
<td>1 – Not in work force, 2 – Unskilled, 3 – Semiskilled,</td>
</tr>
<tr>
<td></td>
<td>4 – Skilled workers, 5 – Clerical workers, 6 – Managerial,</td>
</tr>
<tr>
<td></td>
<td>7 – Upper and lower professional.</td>
</tr>
<tr>
<td>Motiv</td>
<td>Combined scale</td>
</tr>
<tr>
<td>schefft1, schefft2 (Effort into schoolwork on Occasions 1 &amp; 2)</td>
<td></td>
</tr>
<tr>
<td>homchin (The Chinese language homework)</td>
<td>1 – I do not do any Chinese home-work,</td>
</tr>
<tr>
<td></td>
<td>2 – About one hour, 3 – About two hours,</td>
</tr>
<tr>
<td></td>
<td>4 – About three hours, 5 – Four or more hours.</td>
</tr>
<tr>
<td>homewrk (Homework for all the subjects)</td>
<td>1 – I do not do home-work, 2 – Less than 2 hours,</td>
</tr>
<tr>
<td></td>
<td>3 – Less than 5 hours, 4 –5 to less than 10 hours,</td>
</tr>
<tr>
<td></td>
<td>5 –10 to less than 15 hours, 6 – 15 or more hours.</td>
</tr>
<tr>
<td>Attit</td>
<td></td>
</tr>
<tr>
<td>chiease1, chiease2 (Ease of learning Chinese Occasions 1 &amp; 2)</td>
<td>Rasch scaled scores</td>
</tr>
<tr>
<td>chieff1, chieff2 (Effort in learning Chinese Occasions 1 &amp; 2)</td>
<td></td>
</tr>
<tr>
<td>intrest1, intrest2 (Interest in learning Chinese on Occasions 1 and 2)</td>
<td></td>
</tr>
<tr>
<td>chiuse1, chiuse2 (Usefulness of learning Chinese on Occasions 1 and 2)</td>
<td></td>
</tr>
<tr>
<td><strong>Level 3 Variable (Class level)</strong></td>
<td></td>
</tr>
<tr>
<td>level-1 (Grade or year level)</td>
<td>1 to 8 grade or year level</td>
</tr>
<tr>
<td>and all Level 2 variables aggregated</td>
<td></td>
</tr>
<tr>
<td><strong>Outcome Variable</strong></td>
<td>The Rasch scaled scores for Terms 1, 2, 3, and 4 respectively.</td>
</tr>
</tbody>
</table>
Likewise, where data were missing for individual students or other class groups, the missing data code was assigned. As a result of these missing data, the four Year 4 classes and 27 Year 12 students had only two scores available for analysis but could be included in the analysis. However, another 12 students had inadequate data with scores for only one occasion, and were therefore deleted from the analysis. The scores available for the HLM analyses involved 3,109 cases at Level 1, 933 students at Level 2, and 39 classes in eight grade levels at Level 3. The Rasch scores at Level 1 formed the outcome variable (score). A second file was also created in SPSS for the between-student data at the meso level. Since students differed in the years that they had been learning the Chinese language, a variable level was formed that indicated years of learning Chinese. At Level 2 or the between-student level, all the manifest variables forming the nine latent variables used in the PLS analysis (i.e. fathoc, gender, hmbooks, yearlev, wordknw, pareinfl, expwork, motiv and attit) were also selected together with a new variable level for the HLM analysis. In addition, each student had a student-id and a class-id to identify the student and the class to which the student belonged. In should be noted that the attitude scores obtained from chiease, chieffi, intrest, and chiuse on Occasion 2 were also used in the HLM analysis.

At Level-3, or the between-class level, all the ten variables at Level-2 were aggregated and averaged to become Level-3 variables (see Figure 3) by running the command ‘Aggregate’ in the SPSS program. This was achieved by using the class identification number as a break variable. Moreover, there was a variable that indicated the class level at which the Chinese language was being studied.

In addition to the above steps, the following procedures were also taken to prepare data for three-level HLM analysis. First, all the files created were saved in SPSS as INTRASTU.sav for the Level 1 file, INTERSTU.sav for the Level 2 file, and CLASSLEV.sav for the Level 3 file. Secondly, TIMEID was used as the micro level identification variable, STUDEINTID was used as the Level 2 identification variable, and CLASSID was used as the Level 3 identification variable. Finally, a sufficient statistics matrix (SSM) was created and used as the data file for the three-level HLM analysis of the Chinese language achievement the data. A ‘Pair-wise’ procedure was used at Level 1 for the calculation of the SSM because it was identified as containing missing data.

Missing Data

It is worth noting that the HLM program accepts missing data at Level 1, namely the within-student level. The missing data were replaced with the grand mean at Level 2, that is at the between-student level. Consequently, the aggregated data at Level 3 had no missing data.

Model Specification

The analysis of a three-level multilevel model involves different steps. In general, the first step is to run a fully unconditional model in which no predictors are specified at either Level 1 or 2, nor at Level 3. The second step is to add into the equation the micro level or Level 1 variables. The third step is to add the meso level or Level 2 variables that are statistically significant. The fourth step is to add the macro level or Level 3 variables that are significant, and run a final model in which micro, meso and macro level variables are all entered into the equation. The sections that follow discuss the fully unconditional model and the final model.

The fully unconditional model

Bryk and Raudenbush (1992) have stated that the fully unconditional model is the simplest model among all multilevel models and contains no predictor variables from any level. The fully unconditional model is used to obtain the estimates of amount of variance explained at each level in the model. In this study the fully unconditional model for the three levels is written as
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Equations 1, 2 and 3. At Level 1, the achievement score in the Chinese language for each student is modelled as a function of the expected achievement plus a random error. The model is represented as:

\[ Y = P_0 + E \]  \[\text{[Equation 1]}\]

where

- \( Y \) = the Rasch test score for achievement in the Chinese language as outcome variable;
- \( P_0 \) = the intercept;
- \( E \) = a random within-student effect which is assumed to be randomly distributed with a mean of zero and a variance of \( \sigma^2 \).

The model at the meso level or Level 2 is given by equation:

\[ P_0 = B_{00} + R_0 \]  \[\text{[Equation 2]}\]

where

- \( P_0 \) = the intercept;
- \( B_{00} \) = the mean Rasch test score for achievement at Level 2;
- \( R_0 \) = a random between-student effect which is assumed to be randomly distributed with a mean of zero and a variance of \( \tau_x \).

The macro level or Level 3 model is specified as:

\[ B_{00} = G_{000} + U_{00} \]  \[\text{[Equation 3]}\]

where

- \( B_{00} \) = the mean Rasch test score for achievement at Level 3;
- \( G_{000} \) = the grand mean Rasch score across classes;
- \( U_{00} \) = a random effect associated with classes which is assumed to be randomly distributed with a mean of zero and a variance of \( \tau_\beta \).

The relevant results of the variance components generated by the fully unconditional model for the three-level HLM analysis are given in Table 2.

The fully unconditional model makes it possible to partition the total variability in the outcome measure \( Y \) into components at these levels, namely the within-students, \( \sigma^2 \); the between-students, \( \tau_x \); and the between-classes, \( \tau_\beta \). In addition, it also allows for estimations to be made of the proportions of variance analysed at each of the three levels. The following three equations were adapted from Bryk and Raudenbush (1992, p. 177).

<table>
<thead>
<tr>
<th>Random Effect</th>
<th>Standard Deviation</th>
<th>Variance Components</th>
<th>df</th>
<th>Chi-square</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level-1, INTRCPT1, INTRCPT1/INTRCPT2</td>
<td>( E )</td>
<td>1.303</td>
<td>1.698</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( R_0 )</td>
<td>0.931</td>
<td>0.867</td>
<td>893</td>
<td>1359.95</td>
<td>0.000</td>
</tr>
<tr>
<td>( U_{00} )</td>
<td>0.992</td>
<td>0.984</td>
<td>38</td>
<td>588.79</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Notes: \( E = \sigma^2 \), \( R_0 = \tau_x \), \( U_{00} = \tau_\beta \)

Deviance = 11489.25 with 4 parameters
At Level 1, or micro level, the proportion of the variance in the Chinese language achievement that exists between students in classes and within students is given by:

\[
\frac{\sigma^2}{\sigma^2 + \tau_x + \tau_\beta} = \frac{1.698}{1.698 + 0.867 + 0.984} = 0.479 \quad (n=3,109)
\]

At Level 2, or meso level, the proportion of the variance in the Chinese language achievement that exists between students and classes is represented by:

\[
\frac{\tau_x}{\sigma^2 + \tau_x + \tau_\beta} = \frac{0.867}{1.698 + 0.867 + 0.984} = 0.244 \quad (n=933)
\]

At Level 3, or macro level, the proportion of the variance in the Chinese achievement that exists between classes is given by:

\[
\frac{\tau_\beta}{\sigma^2 + \tau_x + \tau_\beta} = \frac{0.9840}{1.698 + 0.867 + 0.984} = 0.277 \quad (n=39)
\]

The above estimations have shown that the Level 1 or micro level model accounts for 48 per cent of the variance, the Level 2 or meso level model accounts for 24 per cent of the variance, and the Level 3 or macro model accounts for 28 per cent of the variance in the outcome measure of the Chinese language achievement under examination in this study. It is then possible to conclude that most of the variance exists within students (48%), followed by between-class variance (28%). A slightly smaller proportion of variance (24%) exists between students. Furthermore, the \( \chi^2 \) statistics associated with these variance components recorded in Table 10.2 indicate highly significant variation between students, and between classes.

The three-level fully unconditional model also estimates the reliabilities at the between-student or meso level, and the between-class or macro level under investigation in this study. The reliabilities calculated are for the estimates of random Level 1 and Level 2 coefficients. Table 3 shows the reliabilities of the coefficients and indicates that the average reliability of the between-student sample mean for use in discrimination among students within the same class, \( P_0 \) is 0.616 at Level 2, and the reliability of the class sample mean as an estimate of the class mean, \( B_{00} \) is 0.928 at Level 3.

The final estimation of the fixed effects for the fully unconditional model is shown in Table 4. It should be noted that there is only one fixed effect in the fully unconditional model. In the present example, the fixed effect of \( G_{000} \) which indicates the grand mean test score in the Chinese language achievement was estimated to be 1.370 with a standard error of 0.165. This value is tested for a difference from zero with a \( t \)-value of 8.31. The above estimates obtained from the fully unconditional model are then used to determine the amount of variance explained by the final three-level model.

**Table 3  Reliabilities of Random Level-1 and Level-2 Coefficients**

<table>
<thead>
<tr>
<th>Random Coefficient</th>
<th>Reliability Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRCPT1, ( P_0 ) (Level 1 coefficient)</td>
<td>0.616</td>
</tr>
<tr>
<td>INTRCPT1/INTRCPT2, ( B_{00} ) (Level 2 coefficient)</td>
<td>0.928</td>
</tr>
</tbody>
</table>
The final model

The final model for the three levels is written as Equations 4 to 15. The within-student equation in the three-level model is given as:

\[ Y = \beta_0 + \beta_1 \times (TIMEID) + E \]  

[Equation 4]

where

- \( Y \) = the Rasch test score or outcome variable score;
- \( \beta_0 \) = the intercept for the expected outcome variable score;
- \( \beta_1 \) = the regression slope, namely the expected change in the Chinese language achievement associated with \( TIMEID \); and
- \( E \) = the random error at the micro or within-student level.

In words, Equation 4 states that the expected achievement in the Chinese language of a particular student depends upon the different points of time, namely Term 1, Term 2, Term 3 and Term 4.

For the Level 2 model, or meso level, there are seven hypothesised explanatory variables that are employed to investigate the variation in growth parameters between students. Equation 5 indicates that the predicted achievement of a student in learning the Chinese language depends on the gender, the amount of homework, the encouragement from parents, English word knowledge, effort in school work, perception of ease or difficulty of the Chinese language, and interest in learning the Chinese language. The Level 2 model is specified as:

\[
\begin{align*}
\beta_0 &= B_{00} + B_{01} \times (SEX) + B_{02} \times (HOMEWRK1) + B_{03} \times (ENCOURAG) \\
&\quad + B_{04} \times (SCOKWN) + B_{05} \times (SCHEFFT1) + B_{06} \times (CHIEASE1) \\
&\quad + B_{07} \times (INTREST2) + R_0 \\
\beta_1 &= B_{10} + R_1
\end{align*}
\]  

[Equation 5]

where

- \( \beta_0 \) = the intercept, namely the expected outcome for each individual student;
- \( B_{00} \) = the level-2 intercept;
- \( B_{01} \) = the regression slope associated with \( SEX \);
- \( B_{02} \) = the regression slope associated with \( HOMEWRK1 \);
- \( B_{03} \) = the regression slope associated with \( ENCourAG \) (i.e. the encouragement from parents);
- \( B_{04} \) = the regression slope associated with \( SCOKWN \) (i.e. English word knowledge test scores);
- \( B_{05} \) = the regression slope with \( SCHEFFT1 \) (i.e. attitude towards and effort in school work);
- \( B_{06} \) = the regression slope with \( CHIEASE1 \) (i.e. ease or difficulty of the Chinese language);
- \( B_{07} \) = the regression slope with \( INTREST2 \) (i.e. interest in learning the Chinese language expressed in the second Attitude Questionnaire);
At Level 3, namely between-class level in the final model, there are three hypothesised variables which are aggregated and averaged from Level 2 to examine the variation between classes. These three variables are \( LEVEL_1 \), \( FOCC_1 \) and \( EXPECT_1 \). The Level 3 regression equations are described as follows:

\[
\begin{align*}
B_{00} &= G_{000} + G_{001} (LEVEL_1) + U_{00} \quad \text{[Equation 7]} \\
B_{01} &= G_{010} + U_{01} \quad \text{[Equation 8]} \\
B_{02} &= G_{020} + G_{021} (FOCC_1) + U_{02} \quad \text{[Equation 9]} \\
B_{03} &= G_{030} + U_{03} \quad \text{[Equation 10]} \\
B_{04} &= G_{040} + U_{04} \quad \text{[Equation 11]} \\
B_{05} &= G_{050} + U_{05} \quad \text{[Equation 12]} \\
B_{06} &= G_{060} + G_{061} (EXPECT_1) + U_{06} \quad \text{[Equation 13]} \\
B_{07} &= G_{070} + U_{07} \quad \text{[Equation 14]} \\
B_{10} &= G_{100} + U_{10} \quad \text{[Equation 15]} \\
\end{align*}
\]

where

\( B_{00} \) = the mean initial status;
\( G_{000} \) = the overall mean initial status;
\( G_{010} \) = the regression slope with \( LEVEL_1 \) (the class level);
\( U_{00} \) = the class random effect associated with class;
\( B_{01} \) \( \ldots \) \( B_{07} \) = the regression slopes associated with \( SEX \), \( HOMEWRK1 \), \( ENCOIRAG \), \( SCOKNW \), \( SCHEFFT1 \), \( CHIEASE1 \) and \( INTREST2 \) respectively;
\( B_{10} \) = the effect of occasion or time on the outcome variable \( SCORE \);
\( G_{020} \) \( \ldots \) \( G_{070} \) = the Level 3 intercepts;
\( G_{021} \) = the regression slope associated with \( FOCC_1 \) (fathers’ average occupation at the class level);
\( G_{061} \) = the regression slope associated with \( EXPECT_1 \) (students’ average expected occupation at the class level);
\( U_{01} \) \( \ldots \) \( U_{07} \) = the Level 3 random effects;
\( U_{10} \) = the class \( SCORE \) random effect;
\( G_{100} \) = the overall mean \( SCORE \) effect.

Table 5 presents the results obtained from the final model of the three-level HLM analysis for the estimates of the variance components. As a result of addition of predictors of the Chinese language achievement at all three levels, it can be seen that the estimates of variance components of three levels in the final model have decreased in comparison with those in the fully unconditional model. The proportion of variance explained by the final model at each level are computed by using the following three formulae:
The multilevel analysis of students’ achievement in learning the Chinese language

\[
\text{within-students } \frac{\sigma^2_{\text{fully uncon.}} - \sigma^2_{\text{(final)}}}{\sigma^2_{\text{fully uncon.}}} = \frac{1.698 - 1.118}{1.698} = 0.34
\]

\[
\text{between-students } \frac{\tau_{\pi(\text{fully uncon.})} - \tau_{\pi(\text{final})}}{\tau_{\pi(\text{fully uncon.})}} = \frac{0.867 - 0.661}{0.867} = 0.24
\]

\[
\text{between-classes } \frac{\tau_{\beta(\text{fully uncon.})} - \tau_{\beta(\text{final})}}{\tau_{\beta(\text{fully uncon.})}} = \frac{0.984 - 0.195}{0.984} = 0.80
\]

Table 5 Final Estimation of Variance Components by Final Model
(a) Final estimation of Level 1 and Level 2 variance components

<table>
<thead>
<tr>
<th>Random Effect</th>
<th>Standard Deviation</th>
<th>Variance Component</th>
<th>df</th>
<th>Chi-square</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRCPT1, (R_0)</td>
<td>0.813</td>
<td>0.661</td>
<td>588</td>
<td>1828.328</td>
<td>0.000</td>
</tr>
<tr>
<td>TIMEID slope, (R_1)</td>
<td>0.050</td>
<td>0.003</td>
<td>861</td>
<td>755.451</td>
<td>&gt;.500</td>
</tr>
<tr>
<td>Level-1, (E)</td>
<td>1.057</td>
<td>1.118</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(b) Final estimation of level-3 variance components

<table>
<thead>
<tr>
<th>Random Effect</th>
<th>Standard Deviation</th>
<th>Variance Component</th>
<th>df</th>
<th>Chi-square</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRCPT1/INTRCPT2, (U_{00})</td>
<td>0.442</td>
<td>0.195</td>
<td>29</td>
<td>71.263</td>
<td>0.000</td>
</tr>
<tr>
<td>INTRCPT1/SEX, (U_{01})</td>
<td>0.118</td>
<td>0.014</td>
<td>30</td>
<td>39.425</td>
<td>0.116</td>
</tr>
<tr>
<td>INTRCPT1/HOMERWK1, (U_{02})</td>
<td>0.200</td>
<td>0.040</td>
<td>29</td>
<td>33.764</td>
<td>0.248</td>
</tr>
<tr>
<td>INTRCPT1/ENCOURAF, (U_{03})</td>
<td>0.144</td>
<td>0.021</td>
<td>30</td>
<td>30.256</td>
<td>0.453</td>
</tr>
<tr>
<td>INTRCPT1/SCOKNW, (U_{04})</td>
<td>0.126</td>
<td>0.016</td>
<td>30</td>
<td>31.956</td>
<td>0.369</td>
</tr>
<tr>
<td>INTRCPT1/SCHEFFT1, (U_{05})</td>
<td>0.050</td>
<td>0.003</td>
<td>30</td>
<td>22.801</td>
<td>&gt;.500</td>
</tr>
<tr>
<td>INTRCPT1/CHIEASE1, (U_{06})</td>
<td>0.086</td>
<td>0.007</td>
<td>29</td>
<td>25.563</td>
<td>&gt;.500</td>
</tr>
<tr>
<td>INTRCPT1/INTREST2, (U_{07})</td>
<td>0.160</td>
<td>0.026</td>
<td>30</td>
<td>32.254</td>
<td>0.356</td>
</tr>
<tr>
<td>TIMEID/INTRCPT2, (U_{10})</td>
<td>0.429</td>
<td>0.184</td>
<td>30</td>
<td>426.860</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Notes: \(E = \sigma^2\) \(R_0 = \tau_{\pi}\) \(U_{00} = \tau_{\beta}\)

The model explains variance at all the three levels. The variance explained at Level 1 or the within-students level is 34 per cent. Only 24 per cent of the variance is explained at Level 2 or the between-students level. It is of interest to note that the variance explained at Level 3 or the between-classes level is 80 per cent. Once variance is calculated for each level, the calculation of total amount of variance explained by the model is possible. The total variance explained by the model is calculated by adding the total variance of each level obtained by multiplying variance explained by the final model and that predicted by the fully unconditional model. Thus, the proportion of total variance explained by the model is 44 per cent. The estimates employed in the calculation are given by:

within-students = 0.34(final) x 0.48(fully uncon.) = 0.16 (n=3,109)

between-students = 0.24(final) x 0.24(fully uncon.) = 0.06 (n=933)

between-classes = 0.80(final) x 0.28(fully uncon.) = 0.22 (n=39)

Total variance explained by the model = 0.16 + 0.06 + 0.22 = 0.44
Table 6 records the reliabilities at the between-students and the between-classes levels for the final model. The figures indicate that the average reliability of the between-students intercept is approximately 0.60, and the reliability of the between-classes intercept is 0.52. The low level of reliability of `TIMEID` (0.008) should be noted, since it indicates marked variability in student performance overtime.

**Final Estimation of Fixed Effects**

The above sections address the estimates of variance components for the three levels and reliabilities for between-students and between-classes in the final model. The section that follows discusses the final estimation of fixed effects for the three levels in the final HLM model. Table 7 below presents the details.

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Reliabilities of Random Level 1 and Level 2 Coefficients by Final Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Random Level 1 and Level 2 coefficient</strong></td>
<td><strong>Reliability estimate</strong></td>
</tr>
<tr>
<td>INTRCPT1, $P_0$</td>
<td>0.595</td>
</tr>
<tr>
<td>TIMEID, $P_1$</td>
<td>0.008</td>
</tr>
<tr>
<td>INTRCPT1/INTRCPT2, $B_{00}$</td>
<td>0.519</td>
</tr>
<tr>
<td>INTRCPT1/SEX, $B_{01}$</td>
<td>0.052</td>
</tr>
<tr>
<td>INTRCPT1/HOMEWRK1, $B_{02}$</td>
<td>0.284</td>
</tr>
<tr>
<td>INTRCPT1/ENCOURAG, $B_{03}$</td>
<td>0.136</td>
</tr>
<tr>
<td>INTRCPT1/SCOKNW, $B_{04}$</td>
<td>0.144</td>
</tr>
<tr>
<td>INTRCPT1/SCHEFFT1, $B_{05}$</td>
<td>0.061</td>
</tr>
<tr>
<td>INTRCPT1/CHIEASE1, $B_{06}$</td>
<td>0.073</td>
</tr>
<tr>
<td>INTRCPT1/INTREST2, $B_{07}$</td>
<td>0.249</td>
</tr>
<tr>
<td>TIMEID/INTRCPT2, $B_{10}$</td>
<td>0.911</td>
</tr>
</tbody>
</table>

**Level 3 Predictors**

The first panel in Table 7 shows that the positive coefficient of the Level 3 predictor `level-1` is 0.17. This indicates that students in classes at higher year levels in learning the Chinese language are higher-level achievers in the Chinese language tests, with an increment of 0.17 logits for each year of learning after other factors have been taken into account.

**Level 2 Predictors**

At Level 2, namely the between-student level, a number of variables are observed to contribute to the Chinese language achievement scores across year levels and across occasions. First, sex of students (`sex`) shows a significant influence on achievement scores in the Chinese language tests with a coefficient of 0.25 logits. This indicates that girls are likely to be higher achievers than are boys on the Chinese language tests. The strongest predictor at this level is the score obtained on the English word knowledge tests (`scoknw`) with a coefficient of 0.46. This large positive coefficient indicates that students who score at a high level on the English word knowledge tests also achieve a higher score on the Chinese achievement tests. In other words, students’ average English word knowledge proficiency has a direct effect on their achievement in the Chinese language: the better students are on the English word knowledge tests, the higher level they achieve on the Chinese language tests.
The multilevel analysis of students’ achievement in learning the Chinese language

### Table 7  Final Estimation of Fixed Effects by Final HLM Model (with robust standard errors)

<table>
<thead>
<tr>
<th>Fixed Effect</th>
<th>Coefficient</th>
<th>StError</th>
<th>T-ratio</th>
<th>d.f.</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>For INTRCPT1, $P_0$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For INTRCPT2, $B_{00}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT3, $G_{000}$</td>
<td>1.222316</td>
<td>0.075527</td>
<td>16.184</td>
<td>37</td>
<td>0.000</td>
</tr>
<tr>
<td>LEVEL 1, $G_{001}$</td>
<td>0.166922</td>
<td>0.041641</td>
<td>4.009</td>
<td>37</td>
<td>0.000</td>
</tr>
<tr>
<td>For SEX, $B_{01}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT 3, $G_{010}$</td>
<td>0.246229</td>
<td>0.069081</td>
<td>3.564</td>
<td>38</td>
<td>0.001</td>
</tr>
<tr>
<td>For HOMEWK1, $B_{02}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT3, $G_{020}$</td>
<td>0.110409</td>
<td>0.049273</td>
<td>2.241</td>
<td>37</td>
<td>0.031</td>
</tr>
<tr>
<td>FOCC_1, $G_{021}$</td>
<td>0.268258</td>
<td>0.084660</td>
<td>3.169</td>
<td>37</td>
<td>0.003</td>
</tr>
<tr>
<td>For ENCOGRA, $B_{03}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT3, $G_{030}$</td>
<td>0.099839</td>
<td>0.050835</td>
<td>1.964</td>
<td>38</td>
<td>0.056</td>
</tr>
<tr>
<td>For SCOKWN, $B_{04}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT3, $G_{040}$</td>
<td>0.464115</td>
<td>0.047205</td>
<td>9.832</td>
<td>38</td>
<td>0.000</td>
</tr>
<tr>
<td>For SChEFFT1, $B_{05}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT3, $G_{050}$</td>
<td>0.039159</td>
<td>0.019493</td>
<td>2.009</td>
<td>38</td>
<td>0.051</td>
</tr>
<tr>
<td>For CHIEASE1, $B_{06}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT3, $G_{060}$</td>
<td>0.103101</td>
<td>0.051777</td>
<td>1.991</td>
<td>37</td>
<td>0.053</td>
</tr>
<tr>
<td>EXPECT_1, $G_{061}$</td>
<td>0.255907</td>
<td>0.083102</td>
<td>3.079</td>
<td>37</td>
<td>0.004</td>
</tr>
<tr>
<td>For INTREST2, $B_{07}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT3, $G_{070}$</td>
<td>0.171162</td>
<td>0.042181</td>
<td>4.058</td>
<td>38</td>
<td>0.000</td>
</tr>
<tr>
<td>For TIMEID slope, $P_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For INTRCPT2, $B_{10}$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INTRCPT3, $G_{100}$</td>
<td>0.486559</td>
<td>0.072509</td>
<td>6.710</td>
<td>38</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Note:  Deviance = 10367.80 with 62 parameters

A third predictor is students’ average interest in learning the Chinese language expressed in responding to the attitude questionnaire on the second occasion (Intrest2) with a positive coefficient of 0.17. This indicates that the more interested students are in learning the Chinese language at Term 4, the better they perform on the Chinese language tests. Thus, interest in learning the Chinese language is associated with the level of achievement on the tests.

Another variable that has an effect on score at Level 2 is encouragement from parents (encourag) with a coefficient of 0.10. This significant result shows that the more encouragement students receive from parents in learning the Chinese language, the higher score they are likely to achieve on the Chinese language tests. The positive coefficients of 0.11 for predictor homewrkl (homework in all school subjects) and 0.10 for predictor chieasel (ease or difficulty of learning the Chinese language at Term 1) indicate that those students who do more homework are likely to achieve higher scores on the Chinese language tests, and those students who achieve high scores consider the Chinese language easier to learn.

The small but significant positive coefficient ($y=0.04$) associated with schefft1 (effort in the schoolwork) indicates there is a relationship between students’ effort in schoolwork as a whole...
and their score in the Chinese language tests. The more effort a student puts into schoolwork, the higher score he or she is likely to achieve on the Chinese language tests.

**Level 1 Predictors**

The Level 1 predictor timeid is found to have an impact on score. The large coefficient of 0.49 indicates that the performance of students improves markedly across the terms of a school year. Students gain approximately 0.5 logits in the interval from Term 1 to Terms 2, and from Term 2 to Term 3, and from Term 3 to Term 4. There is clearly, in general, very effective learning occurring during the four terms of the 1999 school year, particularly at the lower grades where there are large numbers of students.

Furthermore, the sizeable magnitude of the Level 1 predictor coefficient (0.49) of nearly half a logit per term on average compared with the low magnitude of the Level 3 effect of variable level_1 (0.17) warrants careful consideration. This growth in learning the Chinese language occurs mainly between terms while the gain between levels may merely reflect the dropout of lower performing students between grade levels. It should be noted that these effects are estimated after the substantial effects of growth in English word knowledge are taken into account. There is no interaction effect observed between Level 2 variables and Level 1 variable timeid, namely between the between-student and the within-student levels.

In addition, from the null model (Deviance = 11489.25 with 4 parameters) there is a significant reduction in deviance for the final model (Deviance = 10367.80 with 61 parameters), indicating that the final model is a much better model than the null model in fitting the data.

The final three-level HLM model for the Chinese language achievement is presented diagrammatically in Figure 1 using the information in Table 7, where the robust regression effects are recorded. The interaction effects are best shown by calculating the co-ordinates for a graphical representation, and the procedures for the calculations are described below.

It should be noted that in the presentation of results, the robust regression solution has been presented because there is clearly heterogeneity of variance in the criterion measure across grades and the possible presence of some outliers in the data. Consequently, the robust regression results would seem to provide a more stable and meaningful analysis of the data collected.

**Interaction Effects**

In addition to the predictors that show direct influence on the scores of the Chinese language tests, Table 7 also reports two interaction effects between Level 3 and Level 2 predictors of the outcome variable score. The two interaction effects involve class average occupation of fathers (focc-l) on homework in all school subjects (homewrk1), and class average expected occupation of students (expect-l) on students’ perception of ease or difficulty of the Chinese language (chiease1). The coefficient of focc-l (Level 3 variable) on homewrk1 (Level 2 predictor) (y=0.27, t=2.6) indicates a positive relationship between class average of father’s occupation and the effect that amount of homework has on the outcome variable score. This result indicates that students in those classes where fathers have a higher level of occupation and who do more homework than students in classes whose fathers have a lower level occupation achieve higher scores on the Chinese language achievement tests.

The other interaction effect is found between expect_l (Level 3 variable) and chiease1 (Level 2 predictor) (y=0.26). This result indicates that the interactive effect of class average expected occupation between high- and low-viewers of the ease of learning the Chinese language has an impact on scores on the Chinese language tests. Those students who are in classes that have a
higher level of expected occupation in the future and who find it easy to learn the Chinese language achieve higher scores on the Chinese language tests than those students in classes where there is a lower level of expected occupation. The nature of these interaction effects is examined more thoroughly in later sections.

**Calculation of Co-ordinates for Interaction Effects**

The calculations are based on the results of the final estimation of the fixed effects from the three-level HLM analysis presented in Table 6. The calculation for the co-ordinates of the graphs follows the procedures that Lietz (1995) employed for a two-level HLM analysis of reading achievement. Mohandas (1999) used the same procedures for a two-level HLM analysis of mathematics and science achievement.

**Interaction Effects between Father’s Occupation (focc-1) and Homework (homewrk1)**

First, consideration is given to the interaction effect of the Level 3 variable focc-1 with the Level 2 predictor homewrk1 on achievement in learning the Chinese language. Figure 1 shows that focc-1 as a Level 3 predictor has an interaction effect on the path between homewrk1 as a Level 2 predictor and the outcome variable score. The equation for the Level 2 (i.e. between-student) predictor homewrk1 to influence the outcome variable score is given below based on Equation 5 for the Level 2 model in the final model specification.

\[ P_0 = B_{00} + B_{02} \times (\text{HOMEWRK1}) + R_0 \]  

[Equation 16]

where

- \( P_0 \) = the intercept for the expected outcome variable \( \text{SCORE} \);
- \( B_{00} \) = the Level 2 intercept;
- \( B_{02} \) = regression slope associated with \( \text{HOMEWRK1} \) (i.e. homework for all school subjects);
- \( R_0 \) = the Level 2 random effect.

The equation for the Level 3 (between classes) variable focc-1 to have an interaction effect with the variable homewrk1 on score is given in Equation 17 that is based on Equation 9 in the final model specification. It should be noted that at this level the variable focc-1 involves the average occupational status of the fathers of students within a class.

\[ B_{02} = G_{020} + G_{021} \times (\text{FOCC-1}) + U_{02} \]  

[Equation 17]

where

- \( B_{02} \) = the regression slope associated with \( \text{HOMEWRK1} \);
- \( G_{020} \) = the Level 3 intercept;
- \( G_{021} \) = the regression slope with \( \text{FOCC-1} \) (i.e. father’s occupation);
- \( U_{02} \) = the Level 3 random effect.

When \( B_{02} \) in Equation 17 is substituted in Equation 16, Equation 18 is obtained:

\[ P_0 = B_{00} + G_{020} \times (\text{HOMEWRK1}) + G_{021} \times (\text{FOCC-1}) \times (\text{HOMEWRK1}) + R_0 \]  

[Equation 18]

where (see Table 6)

- \( B_{00} \) = \( G_{000} \) (as the overall mean of Chinese achievement across classes) = 1.22;
When the coefficients of $G_{000}$, $G_{020}$, and $G_{021}$, namely, 1.22, 0.11, and 0.27 respectively, are substituted in Equation 18, Equation 19 is obtained:

$$P_0 = 1.22 + 0.11 * (HOMEWRK1) + 0.27 * (FOCC-1) * (HOMEWRK1) + R_0$$  \[\text{[Equation 19]}\]
Co-ordinates are calculated for points, one score point above and below the variable means and at the mean value.

1. Higher father’s occupation and more homework ($FOCC-1=1; HOMEWRK1=1$)
   
   \[ P_0 (SCORE) = 1.22 + 0.11 \times 1 + 0.27 \times 1 \times 1 = 1.60 \]

2. Higher father’s occupation and less homework ($FOCC-1=1; HOMEWRK1=-1$)
   
   \[ P_0 (SCORE) = 1.22 + 0.11 \times (-1) + 0.27 \times 1 \times (-1) = 0.84 \]

3. Lower father’s occupation and more homework ($FOCC-1=-1; HOMEWRK1=1$)
   
   \[ P_0 (SCORE) = 1.22 + 0.11 \times 1 + 0.27 \times (-1) \times 1 = 1.06 \]

4. Lower father’s occupation and less homework ($FOCC-1=-1; HOMEWRK1=-1$)
   
   \[ P_0 (SCORE) = 1.22 + 0.11 \times (-1) + 0.27 \times (-1) \times (-1) = 1.38 \]

5. Average father’s occupation and more homework ($FOCC=0; HOMEWRK1=1$)
   
   \[ P_0 (SCORE) = 1.22 + 0.11 \times 1 + 0.27 \times 0 \times 1 = 1.33 \]

6. Average father’s occupation and less homework ($FOCC=0; HOMEWRK1=-1$)
   
   \[ P_0 (SCORE) = 1.22 + 0.11 \times (-1) + 0.27 \times 0 \times (-1) = 1.11 \]

The coordinates obtained from the above calculations are used to produce Figure 3 which shows the interaction effect of class average father’s occupation with the amount of school homework on achievement in learning the Chinese language. The regression lines indicate that:

(a). those students in classes whose fathers on average have higher level occupations and who do more homework, achieve higher scores on the Chinese language tests which is shown in Figure 2,

(b). those students in classes whose fathers on average have higher level occupations and who do less homework achieve lower scores on the Chinese language tests,

(c). those students in classes whose fathers on average have lower level occupations and who do less homework are relatively high achievers on the Chinese language tests, and

(d). those students in classes whose fathers on average have lower occupations and who do more homework are relatively low achievers on the Chinese language tests.

The result indicates that those students whose fathers have a higher level occupation are likely to gain a higher level of achievement in learning the Chinese language than do the students whose fathers work in a lower level of occupation (see Figure 3).

**Interaction Effects between Students’ Expected Occupation (expect-1) and Ease of Learning the Chinese Language (chiease1)**

The same procedures can be employed to show the interaction effect between the average level within a class of a student’s expected occupation (expect-1) and the student’s perception about ease of learning the Chinese language (chiease1) on achievement in learning the Chinese language (score) based on Equation 5 for the Level 2 model in the final model specification.

\[ P_0 = B_{00} + B_{06} \times (CHIEASE1) + R_0 \]  \hspace{1cm} [Equation 20]

where

- $P_0$ = the intercept for the expected outcome variable $SCORE$;
- $B_{00}$ = the Level 2 intercept;
- $B_{06}$ = the regression slope associated with $CHIEASE1$ (i.e. student’s perception about ease of learning the Chinese language);
$R_0$ = the Level 2 random effect.

![Graph showing the impact of the interaction effect of father’s occupation with the amount of homework on Chinese achievement.](image)

Figure 3 Impact of the Interaction Effect of Father’s Occupation with the Amount of Homework on Chinese Achievement

The equation for the Level 3 (between classes) variable expect-1 to have an interaction effect with the Level 2 variable chiease1 on score is given below based on Equation 13 in the final model specification.

$$B_{06} = G_{060} + G_{061}(\text{EXPECT-1}) + U_{06} \quad \text{[Equation 21]}$$

where

- $B_{06}$ = regression slope associated with CHIEASE1;
- $G_{060}$ = level 3 intercept;
- $G_{061}$ = regression slope with EXPECT-1 (i.e. average level of student’s expectations in class);
- $U_{06}$ = Level 3 random effect.

When $B_{06}$ in Equation 21 is substituted in Equation 20, Equation 22 is obtained:

$$P_0 = B_{00} + G_{060}*(\text{CHIEASE1}) + G_{061}*(\text{EXPECT-1})*(\text{CHIEASE1}) + R_0 \quad \text{[Equation 22]}$$

where (see Table 6)

- $B_{00} = G_{000} = 1.22$;
- $G_{060} = 0.10$; and
- $G_{061} = 0.26$

When these values (1.22, 0.10, and 0.26) are substituted in Equation 22:

$$P_0 = 1.22 + 0.10*(\text{CHIEASE1}) + 0.26*(\text{EXPECT-1})*(\text{CHIEASE1}) + R_0 \quad \text{[Equation 23]}$$

The coordinates for the graphical representation are calculated for points one score point above and below the variable means and at the mean value.
The multilevel analysis of students’ achievement in learning the Chinese language

(1). High expected occupations and high ease of learning the Chinese language (EXPECT-1=1; CHIEASE1=1)
\[ P_0 (SCORE) = 1.22 + 0.10*(1) +0.26*(1)*(1) = 1.58 \]

(2). High expected occupations and low ease of learning the Chinese language (EXPECT-1=1; CHIEASE1=-1)
\[ P_0 (SCORE) = 1.22 + 0.10*(-1) +0.26*(1)*(-1) = 0.86 \]

(3). Low expected occupations and high ease of learning the Chinese language (EXPECT-1=-1; CHIEASE1=1)
\[ P_0 (SCORE) = 1.22 + 0.10*(1) +0.26*(-1)*(1) = 1.06 \]

(4). Low expected occupations and low ease of learning the Chinese language (EXPECT-1=-1; CHIEASE1=-1)
\[ P_0 (SCORE) = 1.22 + 0.10*(-1) +0.26*(-1)*(-1) = 1.38 \]

(5). Average expected occupation and high ease of learning the Chinese language (EXPECT-1=0; CHIEASE1=1)
\[ P_0 (SCORE) = 1.22 + 0.10*(1) +0.26*(0)*(1) = 1.32 \]

(6). Average expected occupation and low ease of learning the Chinese language (EXPECT-1=0; CHIEASE1=-1)
\[ P_0 (SCORE) = 1.22 + 0.10*(-1) +0.26*(0)*(-1) = 1.12 \]

The coordinates obtained from the above calculations are used to produce Figure 4 which shows the interaction effect of the average level of a student’s expected occupations with the student’s perception about the ease or difficulty of learning the Chinese language on the student’s Chinese language test scores. The regression lines indicate, as shown in Figure 4, that:

(a). those students in classes which who have on average a higher level of expected occupation and who find that it is easy to learn the Chinese language achieve higher scores on the Chinese language tests,

(b). those students in classes which have on average a lower level of expected occupation and who have more difficulty in learning the Chinese language achieve relatively high scores on the Chinese language tests,

(c). those students in classes which have on average a higher level of expected occupation and who have more difficulty in learning the Chinese language achieve lower scores on the Chinese language tests, and

(d). those students in classes which have on average a lower level of expected occupation and who find the Chinese language easy to learn achieve relatively low scores on the Chinese language tests.

CONCLUSION

The findings of the three-level HLM analysis of factors influencing achievement score on the Chinese language tests are discussed in the above sections. At the within-student level, timeid is found to have an influence on the score. Seven variables at Level 2, namely the between-student level, have significant influences on score on the Chinese language tests. These seven variables are sex of students (sex), score for English Word Knowledge (scoknw), interest expressed in learning the Chinese language on the second occasion (intrest2), encouragement from parents (encourag), homework for all school subjects (homewrk1), effort given to school work indicated on Occasion 1 (schefft1), and perception about ease or difficulty of learning the Chinese language indicated on Occasion 1 (chiease1). At Level 3, namely the between-class level, grade level (Level
1) is observed to have an influence on achievement score. The positive effect indicates that the higher the grade level, the greater the scores the students achieved on the Chinese language tests.

![Graph showing the impact of interaction effect of students’ expected occupation on ease of learning the Chinese language on Chinese achievement](image)

**Figure 4** Impact of the Interaction Effect of Students’ Expected Occupation on Ease of Learning the Chinese Language on Chinese Achievement

Apart from these effects, two Level 3 variables, that is, class average of students’ expected occupations (expect-1) and class average of father’s occupation (focc-1) show interaction effects with Level 2 predictors chiease1 and homewrk1 respectively on the outcome variable score on the Chinese language tests.

In summary, an examination has been made of factors that influence student achievement in learning the Chinese language as a school subject by employing a three-level HLM analysis. These findings, particularly those involving homework and attitudes have important implications for the learning of the Chinese language in Australian schools.

REFERENCES


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