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Multilevel Predictors Influencing Reading Achievement: Comparison of Teacher Effects in Elementary, Middle and High Schools

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ABSTRACT

This paper determined significant predictors of reading achievement at student and teacher levels employing a two-level hierarchical linear model (HLM). Teacher effects were computed for elementary, middle, and high schools. The study found significant effects of race, learning disability, participation in free and reduced lunch, proficiency in English language, attendance and suspension at student level. The predictors such as experience in teaching, academic degree, and the teachers' ratings based on student performance were significant at teacher level. The comparison of teacher effects showed the highest and lowest teacher effects in elementary and high schools, respectively.

Keywords: hierarchical linear model, reading achievement, teacher effects.

INTRODUCTION

There have been persistent efforts for years and decades to improve the education system. The school education system can be improved by managing important factors influencing student achievement. Such predictors could be equally important at student and teacher levels that can be determined by employing a multilevel modeling approach called hierarchical linear model (HLM). This type of model allows us to analyze the student and teacher level data (predictors) simultaneously at level-1 and level-2 models, respectively. This paper explores significant student and teacher level predictors of student reading achievement and determines teacher level effects for elementary, middle and high schools based on teacher-to-teacher variance as suggested by Rowan, Correnti, and Miller (2002). This research is conducted in a large urban school district in Florida. The findings of this study would be beneficial for evaluators and research practitioners in K-12 school system.

RESEARCH PERSPECTIVE

Modelling Student Level Predictors

Based on past literature and significance of the variables, appropriate predictors were selected in this study. Researchers in past incorporated several student level predictors in multilevel analyses. Such predictors include student's race, ELL (English Language Learner) status, socioeconomic background such as participation in free and reduced lunch, and exceptional student education (ESE) status to predict student achievement (Adderley, 2013; Bankston & Caldas, 1996; Kieffer, 2008; Levine & Eubanks, 1990; Ortiz, 1986; Rowan et al., 2002). Bankston and Caldas (1996) concede that the degree of minority concentration has a powerful

negative influence on achievement test results. Levine and Eubanks (1990) found lower achievement among minority students compared to White students. Using NAEP (National Assessment of Educational Progress) reading data, Ortiz (1986) found that Hispanic and Black children continue to read at significantly lower levels than Whites. In a research using elementary school data, Adderley (2013) found a negative effect of ELL on third grade student reading achievement. Based on a multilevel research with data of kindergarten to 5th grade students, Kieffer (2008) recommend that the emphasis be given to the need for academic interventions for language minority learners who enter school with limited English proficiency. Hampton and Mason (2003) found that the learning disability status of a student has indirect influence on self-efficacy which in turn the learning disability affected academic performance. Rowan et al. (2002) predicted student achievement using SES (socio-economic status), race and special education (ESE) status associated with a student.

In a study in California schools, Peslak (2004) found a significant negative effect of student free or reduced meal status in predicting reading scores. Caldas and Iii (1997) found significant negative effect of minority and free/reduced-price lunch (FRL) on 10th grade Louisiana Graduate Exit Examination (GEE) scores. Using the mother/child data set of the National Longitudinal Survey of Youth, Eamon (2002) measured the effect of poverty on reading achievement and found that poverty was related to the lower reading achievement.

In a research conducted in one of the largest school districts in the United States, Arica (2006) reported that increase in student suspensions is related to decrease in achievement. Gottfried (2009) reported that students with a higher proportion of unexcused absences places them at academic risk from as early as in elementary school.

Modeling Teacher Level Predictors

Several past studies used teacher level factors to predict student achievement (Harris and Sass, 2008; Hanushek, Kain, and Rivkin, 2004; Haycock, 1998; Rice, 2010). They concede that teacher experience plays effective role in improving student achievement (Harris & Sass, 2008; Rice, 2010). In a study measuring the effects of teacher level predictors, Croninger, Rathbun, and Nishio (2007) found positive effects for teachers' degree type and experience on reading achievement. Similarly, Goldhaber, and Brewer (1998) found positive impact of teacher degree and experience on student achievement.

Research Questions

The following research questions are addressed associated with three separate models for elementary, middle and high schools.

1. What are the significant predictors at student and teacher levels in elementary, middle, and high schools for predicting students' reading achievement?
2. What are the percentages of the variance explained and effect sizes at teacher levels for elementary, middle, and high schools models?

METHODS

Data

This study used total 88654 students and 653 teachers with 34599 students and 150 teachers in elementary schools (grades 3-5), 31077 students and 233 teachers in middle schools (grades 6-8), and 22978 students and 270 teachers in high schools (grades 9 and 10) in Fiscal Year (FY) 2016 from the School District of Palm Beach County (SDPBC), Florida. This urban public school district is the 12th largest among 16,000 school districts in the United States at the time of data collection. The distribution of male and female students in SDPBC during FY2016 was 51% and 49%, respectively. Student race composition included approximately

32% White, 27% African-American, 32% Hispanic, and 9% other races. The distribution of student participation in free or reduced lunch was 62%, 58%, and 55% for elementary, middle, and high schools, respectively. English language learner student distribution was 18%, 6%, and 7% for elementary, middle, and high schools, respectively. Exceptional student education distribution was 16%, 16%, and 14% for elementary, middle, and high schools, respectively.

The primary source of data was obtained from teacher and student records of SDPBC. This included FY2016 Florida Standards Assessments (FSA) English Language Arts (ELA) test score data published and provided by the Florida Department of Education (FDOE) and teacher level data provided by SDPBC, Human Resources Department. The test scores for analysis were used from grades 3 to 10. The reliability of FSA ELA test ranged from 0.89 to 0.92 depending on grade level (FDOE, 2015).

Variables

Outcome variable. The student (FSA) ELA test scores were used as outcome measures for separate models in elementary, middle, and high schools. The scale scores for students' ELA scores for FY2016 ranged from 240-385 in elementary, 259-403 in middle, and 259-412 in high schools.

Predictors

African-American. This is a dichotomous variable with 1 for African-American status and 0 for absence of African-American status for a student.

Hispanic. This is a dichotomous variable with 1 for Hispanic status and 0 for non-Hispanic status for a student.

Exceptional student education (ESE). This is a dichotomous variable with 1 for student's ESE status and 0 for non-ESE status.

Free or reduced price lunch (FRL). This is a dichotomous variable with 1 for student's FRL (participation) status and 0 for non-FRL status.

English Language Learners (ELL). This is a dichotomous variable with 1 for student's ELL status and 0 for non-ELL status.

Suspension. This is a continuous variable for a student with the total of in-school and out-of-school suspension events. This variable ranged from 0 to 51.

Absence. This is a continuous variable for a student with the total unexcused days absent. This variable ranged from 0 to 84.

Experience. This is a continuous predictor at teacher level providing teacher experience in the number of teaching years. This variable ranged from 0 to 45.

Education level. This is a continuous predictor at teacher level providing teacher's academic degree with bachelor (1), master (2), and doctoral (3).

Effectiveness. This is a continuous variable that gives teacher's ranking based on Student Performance Rating (SPR). This is a continuous variable that ranged from 1 through 4 (1 = unsatisfactory, 2 = Need improvement, 3 = effective, 4 = highly effective).

Note that the SPR evaluation is a state mandated teacher rating system in SDPBC and other districts in Florida. Only the predictors with significant effects were incorporated in level-1 and level-2 models. The results are presented in Table 1.

Developing Hierarchical Linear Model (HLM)

Employing a two-level HLM suggested by Raudenbush and Bryk (2002), this paper predicted students' ELA scores where student and teacher level data were incorporated in level-1 and level-2 models, respectively. The final models for elementary, middle and high schools included students' status as African-American, Hispanic, FRL, and ELL as well as total events of suspensions, and total unexcused days absent as level-1 predictors. At level-2, teacher's experience, teacher's education level and teacher effectiveness (based on teacher SPR evaluation) were used as significant predictors.

The level-1 final model for predicting ELA scores (ELASCORE) due to student level predictors can be expressed as follows.

$$(\text{ELASCORE})_{ij} = \beta_{0j} + \beta_{1j}\,(\text{AFRIAMER})_{ij} + \beta_{2j}\,(\text{HISP})_{ij} + \beta_{3j}\,(\text{ESE})_{ij} + \beta_{4j}\,(\text{FRL})_{ij} + \beta_{5j}\,(\text{ELL})_{ij} + \beta_{6j}\,(\text{SUSP})_{ij} + \beta_{7j}\,(\text{UNEXABS})_{ij} + r_{ij} \quad (1)$$

where β_{0j} is the intercept, β_{1j}, β_{2j}, β_{3j}, β_{4j}, β_{5j}, β_{6j}, and β_{7j} are slopes or effects of African-American, Hispanic, ESE, FRL, ELL, suspension and unexcused absence, respectively. The term r_{ij} is the random effect for student i nested in teacher j.

The level-2 final model at teacher level, with level-2 coefficients as outcomes, can be given as follows.

$$\beta_{0j} = \gamma_{00} + \gamma_{01}\,(\text{Experience})_j + \gamma_{02}\,(\text{EdLevel})_j + \gamma_{03}\,(\text{Effectiveness})_j + u_{0j}$$
$$\beta_{1j} = \gamma_{10} + \gamma_{11}\,(\text{Effectiveness})_j$$
$$\beta_{2j} = \gamma_{20}$$
$$\beta_{3j} = \gamma_{30} + \gamma_{31}\,(\text{Experience})_j \quad (2)$$
$$\beta_{4j} = \gamma_{40} + \gamma_{41}\,(\text{Effectiveness})_j$$
$$\beta_{5j} = \gamma_{50} + \gamma_{51}\,(\text{Experience})_j$$
$$\beta_{6j} = \gamma_{60} + \gamma_{61}\,(\text{Experience})_j + \gamma_{62}\,(\text{Effectiveness})_j$$
$$\beta_{7j} = \gamma_{70}$$

In Equation (2), the level-2 coefficient terms represent the following.

γ_{00} = average ELA achievement for teachers,
γ_{01} = effect of teacher experience,
γ_{02} = effect of teacher's education level,
γ_{03} = effect of teacher effectiveness,
γ_{10} = effect of African-American students relative to the effect of non-African-American students,
γ_{11} = interaction effect between teacher effectiveness and students' African-American status,
γ_{20} = effect of Hispanic students relative to the effect of non-Hispanic students,
γ_{30} = effect of ESE students relative to the effect of non-ESE students,
γ_{31} = interaction effect between teacher experience and students' ESE status,
γ_{40} = effect of FRL students relative to the effect of non-FRL students,
γ_{41} = interaction effect between teacher effectiveness and students' FRL status,
γ_{50} = effect of ELL students relative to the effect of non-ELL students,
γ_{51} = interaction effect between teacher experience and students' ELL status,
γ_{60} = effect of student suspension,
γ_{61} = interaction effect between teacher experience and student suspension,

γ_{62} = interaction effect between teacher effectiveness and student suspension,
γ_{70} = effect of student's unexcused days absent.

Teacher Effects

The teacher effects in this paper represent the d-type effect sizes for elementary, middle, and high schools as suggested by Rowan et al. (2002). Such effects are determined based on the teacher-to-teacher proportion of variance explained after incorporating significant predictors at student and teacher levels. Considering the level-2 units as teachers and student reading achievement as an outcome measure, the d-type effect size can be computed using the following formula as provided by Rowan et al. (2002).

$$d = \frac{\sqrt{(\text{Variance in reading achievement lying among teachers })}}{\sqrt{(\text{Total student } + \text{ teacher variance in student reading achievement})}} \qquad (3)$$

The HLM analysis used the SAS PROC MIXED procedure as suggested by Singer (1998) to compute teacher-to-teacher variance (i.e., random effects) and fixed effects in all models.

According to Rowan et al. (2002), the teacher effects are classified as small, medium and large depending on the magnitude of d-type effect size as given below.
Small: Below .39
Medium: 0.39 – 0.45
Large: 0.46 or higher

Teacher effects are computed and compared for elementary, middle, and high school in following section.

RESULTS

For predicting students' ELA scores, we identified several significant predictors at student and teacher levels. The first research question is addressed by estimating the predictors' effects in final models by analyzing three separate models for elementary, middle, and high schools which is provided in Table 1. At student level for all school types (elementary, middle, and high), African-American ($p<.0001$), Hispanic ($p<.0001$), ESE ($p<.0001$), FRL ($p<.0001$), ELL ($p<.0001$), and absence ($p<.0001$) are found significant. For elementary and high schools, suspension was significant with $p<.0001$ and for middle schools this predictor was significant with $p=.0022$. All these predictors showed negative effects on student ELA scores.

At teacher level, the elementary schools showed only two significant predictors that were experience ($p < .0001$) and effectiveness ($p = .0029$). For middle and high schools, all three teacher level predictors were significant but with different probability values (middle schools: experience with $p = .0012$, education level with $p<.0001$, and effectiveness with $p<.0001$; high schools: experience with $p = .0031$, education level with $p = 0088$, and effectiveness with $p<.0001$). All these predictors showed positive effects on student ELA achievement.

Table 1: Estimation of predictors' effects for predicting reading achievement

Predictors	Elementary Schools		Middle Schools		HighSchools	
	Effect Est.	p-values	Effect Est.	p-values	Effect Est.	p-values
Student level						
African-American	-9.348	<.0001	-8.259	<.0001	-6.648	<.0001
Hispanic	-2.451	<.0001	-3.520	<.0001	-4.569	<.0001
ESE	-16.056	<.0001	-20.735	<.0001	-20.857	<.0001
FRL	-11.870	<.0001	-8.041	<.0001	-8.161	<.0001
ELL	-16.227	<.0001	-24.951	<.0001	-32.063	<.0001
Suspension	-1.911	<.0001	-0.617	0.0022	-0.836	<.0001
Absence	-0.359	<.0001	-0.284	<.0001	-0.613	<.0001
Teacher level						
Experience	0.073	<.0001	0.045	0.0012	0.043	<.0031
Education level	-	-	0.876	<.0001	0.561	<.0088
Effectiveness	0.951	0.0029	3.815	<.0001	4.527	<.0001
Interaction effects						
Effectiveness*Afri.-Ameri.	-	-	-	-	-1.508	.0068
Experience*ESE	-0.065	0.0323	-	-	-	-
Effectiveness*FRL	-1.544	<.0001	-	-	-	-
Experience * ELL	-	-	-	-	-0.137	.0029
Experience * Suspension	-	-	-0.011	.0470	-	-
Effectiveness*Suspension	-	-	-0.189	.0341	-	-
Afri.-Ameri. = African-American						

Further, several significant interaction effects were detected, at alpha 0.05 level, between student and teacher level predictors. The findings showed the significant interaction effects of teacher effectiveness with student FRL (p <.0001), suspension (p = .0341), and African-American status (p = .0068) for elementary, middle and high schools, respectively. Similarly, the results revealed the significant interaction effects of teacher experience with student ESE (p = .0323), suspension (p = .0470), and ELL (p = .0029) for elementary, middle and high schools, respectively. All these interaction effects are found negative.

Table 2. Estimates of variance components, percent of variance explained, p-values, and effect sizes at teacher level for predicting reading achievement for different school types

School Type	Teacher Variance Component	p-value	Variance Explained	Effect Size (Teacher Effects*)
Elementary (EL)	94.7	<.0001	21.6%	0.46 (Large)
Middle (MS)	62.2	<.0001	14.9%	0.39 (Medium)
High (HS)	15.7	<.0001	4.4%	0.21 (Small)

*Teacher effects are based on d-type effect sizes; Number of teachers: EL = 150; MS = 233; HS = 270.

To address the research question 2, we computed the effect sizes at the teacher level models for elementary, middle and high schools. Table 2 provides the teacher variance components,

percentages of teacher variance explained, p-values and effect sizes (d-type) for elementary, middle and high schools. The results showed significant teacher-to-teacher variation (p <.0001) for all school types. At teacher level, the elementary schools accounted for 21.6% of variance with an effect size of 0.46 and the middle schools accounted for 14.9% of variance with an effect size of 0.39. However, the high schools accounted for only 4.4% of teacher variance with an effect size of 0.21. These categories of effect sizes are determined as large, medium and small for elementary, middle, and high schools, respectively.

DISCUSSION

This study investigated multilevel predictors of reading achievement based two-level HLM analysis where we identified several significant predictors at student and teacher levels for elementary, middle, and high schools. The findings of this study supported several past results. The significant negative effect of student's limited English language proficiency can be interpreted as an obstacle in improving reading scores which is analogous to the finding of Adderley (2013). This study found a negative effect of those students with limited parents' income, which is associated with students' free and/or reduced lunch (FRL) status, in reading achievement and this is result is supported by past studies (Eamon, 2002; Caldas and Iii, 1997; Peslak, 2004). We found lower achievements for African-American and Hispanic students than non-African-American and non-Hispanic students, respectively which is similar to past investigations (Bankston & Caldas, 1996; Levine & Eubanks, 19990; Ortiz, 1986).

The increases in the number of student's days absent and suspension events (disciplinary variables) showed decreases on reading achievement implying that the school system should control such predictors for students' improvement in reading scores. Past research explorations supported these results (Arica, 2006; Gottfried, 2009).

The positive impacts of teacher's degree level and teacher experience are analogous to past research findings (Goldhaber & Brewer, 1998; Croninger, Rathbun, & Nishio, 2007). Thus, teachers with higher academic degrees and more years of teaching experience play crucial role in boosting student reading achievement. However, researchers also argue that the impact of experience is strongest during the first few years of teaching, with subsequent experience yielding diminishing increases in teacher productivity (Harris and Sass, 2008; Rice, 2010). Further, the significant positive effect of SPR based teacher effectiveness implied that effective and highly effective teachers played more efficient role in improving student reading achievement.

It is worth discussing the comparison of effect sizes for elementary, middle, and high schools based on the findings of this study. The highest teacher effect (produced due to teacher level effect size) for elementary schools implies that teachers are found most effective in elementary schools in predicting student reading achievement. Unlikely, the high school teachers are found least effective in predicting student reading achievement given with a smallest effect size. It can be argued that high school teachers were least effective due to the fact that the proportion of teacher-to-teacher variance in average student reading achievement for high school teachers was smallest (among all three school types) due to the highest error (unexplained) variance (95.6%) among teachers.

CONCLUSIONS

This paper predicted student reading achievement in elementary, middle, and high schools employing a two-level HLM. The study identified the student and teacher level significant predictors (including interaction effects) of reading scores. We also computed the proportions

of variance explained and effect sizes at teacher level, interpreted as teacher effects, for elementary, middle, and high schools.

The study found significant effects of student level predictors such as race, poverty, learning disability, proficiency in English language and disciplinary factors. The results also showed significant effects of teacher's education level, teacher experience, and teacher effectiveness based on student performance. We found that the elementary school teachers produced largest effect size than those in middle and high schools.

The results of this study would be beneficial for schools and school districts in terms of improving student reading performance and reforming schools. More specifically, the significant predictors identified in this study can be controlled to improve student reading scores for school excellence. The methods of this paper could be beneficial for the research practitioners in districts and state education agencies for teacher evaluations.

The population of this study is limited within one of the largest urban school districts in Florida, U.S.A., therefore future researches are suggested to cover the broader population. From analysis perspective, the models used in this study are limited to two-level with specific number of predictors in the equations. Future studies are recommended to extend to three-level HLM with broader population.

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