PREDICTING THE MATHEMATICS PATHWAYS OF ENGLISH LANGUAGE LEARNERS: A MULTILEVEL ANALYSIS

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This study employed hierarchical linear modeling to investigate the student- and school-level factors associated with the secondary mathematics achievement of English language learners (ELLs) and non-ELL students among a nationally representative sample of ninth graders in the United States. While certain characteristics, such as socioeconomic status, attitudes and interest in mathematics, and school engagement and belonging were predictive of access to and achievement in mathematics for both student groups, the direction and relative magnitude of the predictors differed. School-level variables, such as whether the school was public or private and administrator perceptions of school climate, were only predictive of mathematics grade point average (GPA) for non-ELLs. Implications of the findings are discussed.

Keywords: Affect, Emotion, Beliefs, and Attitudes; Equity and Diversity; High School Education

English language learners (ELLs) are among one of the fastest growing groups of students in the United States. This group of students vary considerably in terms of English language proficiency, educational experiences, and many other factors (National Center for Education Statistics, 2004; Ryan, 2013). Adapting to these shifting demographics has proven challenging for educators, who must contend with difficulties in the fair identification of ELLs (Carlson & Knowles, 2016), simultaneous attention to language and content (Janzen, 2008), and development of appropriate assessments (Abedi et al., 2005; Bailey & Carroll, 2015).

These issues become increasingly urgent in the face of evidence that ELLs continue to face limitations in access to multiple educational outcomes. ELLs are less likely to graduate high school (National Center for Education Statistics, 2004) and some researchers have found that ELLs encountered more restricted access to college preparatory courses and postsecondary planning (Callahan & Shifrer, 2016; Kanno & Cromley, 2013, 2015). The lack of access to resources may lead ELL students to conclude that academic success is not be for them (Kanno & Kangas, 2014; Menken & Kleyn, 2010). Such beliefs are not reflective of the possibilities of public education, and as educators it remains our duty to address these discrepancies in opportunities to learn.

Note that the term "English language learner" or "ELL student" is used throughout the text to align with the phrasing used by the federal data analyzed in the study, and the language that continues to be used across many policy documents. The author more strongly recommends use of the term "emergent bilingual" to refer to linguistically diverse students, as it demonstrates a greater respect for the student, their existing knowledge of a home language, and their emergent language skills in other languages.

Purpose of the Study

Much past research has focused on general educational outcomes of ELL students, with more attention paid recently to ELL students' progress through secondary mathematics course-taking (e.g. Thompson, 2017). Special attention to ELL students progression through secondary mathematics is key for several reasons. Mathematics courses are required for graduation, and almost always serve as gatekeepers for postsecondary access (Adelman, 2006). While there remains a significant language factor involved in the study of mathematics (Schleppegrell, 2007), these courses retain an important

In: Sacristán, A.I., Cortés-Zavala, J.C. & Ruiz-Arias, P.M. (Eds.). (2020). *Mathematics Education Across Cultures: Proceedings of the 42nd Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, Mexico. Cinvestav / AMIUTEM / PME-NA. https:/doi.org/10.51272/pmena.42.2020

place in the majority of students' access to postsecondary access, secondary graduation, and future access to a wide range of STEM fields.

Given the disadvantages facing ELL students, as well as the importance of mathematics for future academic success and attainment, it is critical to understand how the mathematical progress of ELLs in high school differs from that of their English-proficient peers, and whether factors predictive of success differ between the two. The primary research question was the following: What student- and school-level factors are significantly related to the secondary mathematics attainment of ELL and non-ELL students, and to what extent do key factors differ between the two groups?

Theoretical Framework

The present study was framed using Bronfenbrenner's ecological model of human development (Bronfenbrenner, 1976, 1977). Bronfenbrenner proposed that human development evolved through increasingly complex interactions between the organism and its ecological environment. The environment was conceptualized as multiple nested levels of influence, where levels ranged from the environment surrounding the individual (microsystem), up to relationships with others inside and outside the environment (mesosystem, exosystem), and expanded to include how society impacts the individual (macrosystem) and how influences change over time (chronosystem). In education, this model posits that students' learning is closely connected to the learning environment (classroom,) and shaped by interactions with actors in the environment, such as students, teachers, and administrators (Bronfenbrenner, 1976).

The microsystem was of primary interest to the present research, defined as "the complex of relations between the developing person and environment in an immediate setting containing that person" (Bronfenbrenner, 1977, p. 514). This level reflects the initial point of interaction between the individual and the environment. Variables at this level include perceptions of the environment and roles adopted within that environment, as well as relationships between student, teachers, and peers. Bronfenbrenner's model was used to select variables likely to affect mathematics outcomes in secondary school. Students' development in the mathematics classroom may be impacted by factors at multiple levels, ranging from psychological or cognitive factors to social or cultural. The present research drew on the ecological model to select variables that may impact students' mathematics attainment primarily in the microsystem.

Method

This study used two-level hierarchical linear modeling (HLM) to analyze restricted-use from the High School Longitudinal Study of 2009 (HSLS: 09). The HSLS: 09 consisted of data from a nationally representative group of approximately 24,000 students from over 900 schools. The study collected data beginning in 2009, with follow-ups in 2011, 2012, 2013, and remains ongoing. Analyses in this study were restricted to students with data regarding their status as an ELL student prior to 9th grade, and weighted using NCES-provided weights to account for non-response bias in the sample from 2009 through 2013. This restriction resulted in an analytic weighted sample of 3,220,965 students, with 124,042 ELLs prior to 9th grade nested within 91 schools and 2,930,349 non-ELLs nested within 920 schools.

Variables

A total of 13 student-level variables and 9 school-level variables were selected for study. Student-level variables included factors such as socioeconomic status (SES), race/ethnicity, affective characteristics, and school engagement and belonging. School-level variables included factors such as whether the school was public or private, school climate, and percentage of ELL students enrolled. The outcomes of interest were the number of mathematics credits earned and mathematics grade point average (GPA). These two measures were chosen as a proxy for the number of mathematics courses completed, as well as an average success in those courses.

Data Analysis

Analysis began with the unconditional model containing only one outcome variable and no independent variables. The unconditional model allows for examination of whether the school grouping variable has a significant impact on student-level scores. Next, full models were developed that introduced both student- and school-level variables to the unconditional model. First, to examine the absolute effects of the independent variables, each student- and school-level variable was tested individually. Statistically significant variables ($p < 0.01$) were then introduced together to examine relative effects. To achieve parsimony, variables that were no longer statistically significant were removed one by one, beginning with the variable with the largest p value and proceeding until all remaining variables were statistically significant. The resulting models reduced the overall complexity of the final model, and allowed us to focus only on those variables that had both absolute and relative effects on the outcomes of interest. The same procedures were carried out separately for both ELL and non-ELL students.

Results

Descriptive Statistics

Examination of the descriptive statistics in Table 1 indicated that students who had been previously classified as ELL demonstrated lower number of mathematics credits earned and lower mathematics GPA. There was a significant difference in scores for both mathematics credits earned and mathematics GPA ($p<0.001$). Previously ELL students also had significantly lower SES and standardized mathematics assessment scores.

Table 1: Descriptive Statistics for the HSLS Student Sample

	ELL Previously		Never ELL	
	M	SD	M	SD
Mathematics credits earned	3.50	1.26	3.64	1.16
Mathematics GPA	2.12	0.92	2.38	0.94
Socioeconomic status	-0.58	0.73	0.03	0.79
9^{th} grade standardized score	-0.23	1.33	0.06	1.08
Gender				
Male	0.48	--	0.51	--
Female	0.52	--	0.49	--
Race/Ethnicity [a]				
Asian	0.06	--	0.03	--
Black/African-American	0.03	--	0.13	--
Hispanic	0.82	--	0.17	--
White	0.09	--	0.58	--
School-Level Variables				
Public	0.97	--	0.92	--
Catholic or Other Private	0.03	--	0.80	--
City	0.46	--	0.30	--
Suburb	0.33	--	0.34	--

Town	0.06	--	0.12	--
Rural	0.15	--	0.24	--

[a] Native Hawaiian/Pacific Islander, American Indian/Alaska Native, and More than one race categories are excluded due to low proportions relative to the entire sample size (<0.01)

Unconditional Models

Table 2 presents the unconditional models for both mathematics credits and mathematics GPA models for ELL and non-ELL students. Calculation of the ICC of each model proceeded by dividing the between-school variance by the total variance. The ICC ranged between 28% and 55%, suggesting that a significant proportion of variance of the outcome measure was at the school-level. This implied a multilevel nature of the data and justified further use of HLM.

Table 2: Comparison of Unconditional Models

	ELLs Credits		Non-ELLs Credits		ELLs GPA		Non-ELLs GPA	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Fixed Effects								
Intercept	3.485**	0.102	3.667**	0.023	2.147**	0.067	2.420**	0.016
Random Effects								
Intercept variance	0.950**	0.142	0.477**	0.022	0.403**	0.060	0.249**	0.012
Level-1 variance	0.778**	0.003	0.937**	0.001	0.421**	0.002	0.654**	0.001
ICC	0.550		0.337		0.489		0.276	
Deviance	321,455.480		7,909,070.128		245,291.578		6,847,178.614	
# Parameters	3		3		3		3	

* p < 0.01, ** p < 0.001

Predictors for ELL Students

Table 3 presents the final models for ELL students. At the student-level, 10 out of the 12 variables were significant. SES, mathematics utility, and school engagement were all strong predictors of increases in credits earned. Mathematics assessment score and school belonging were also positively related, although smaller in magnitude. Alternatively, both self-efficacy and interest in 2009 mathematics course were negatively related to credits earned.

Regarding mathematics GPA, 10 out of the 12 student-level variables were significant. Mathematics assessment score, SES, mathematics identity, self-efficacy, and school engagement were all positively related, while interest and school belonging were negatively related.

Of the 7 school-level variables examined, none were statistically significant predictors of either credits earned or GPA for ELL students.

Table 3: Final Model Predicting Outcomes of Interest for ELL Students

	Credits		GPA	
	Estimate	SE	Estimate	SE
Fixed Effects				
Intercept	3.043**	0.097	2.169**	0.059
Student Level				
Gender (0 = Male)	--	--	0.058**	0.009

Hispanic (0 = Yes)	0.545**	0.012	--	--
Black (0 = Yes)	1.088**	0.022	0.132**	0.013
Asian (0 = Yes)	0.912**	0.016	0.584**	0.009
Socioeconomic status	0.214**	0.005	0.152**	0.003
Mathematics assessment score	0.080**	0.004	0.219**	0.003
Mathematics identity	--	--	0.149**	0.003
Mathematics self-efficacy	-0.050**	0.004	0.162**	0.003
Mathematics utility	0.161**	0.004	--	--
Interest in 2009 math course	-0.047**	0.004	-0.051**	0.003
School engagement	0.184**	0.003	0.168**	0.002
School belonging	0.043**	0.004	-0.108**	0.003
Random Effects				
Intercept variance	0.824**	0.125	0.307**	0.047
Level-1 variance	0.589**	0.003	0.242**	0.001
Intraclass correlation	0.583		0.559	
Deviance	230,281.809		143,170.007	

* p < 0.01, ** p < 0.001

Predictors for Non-ELL Students

Table 4 presents the final models for non-ELL students. At the student-level, 10 out of the 12 variables were statistically significant. Specifically, increases in SES, assessment score, identity, self-efficacy, belonging, engagement, and interest were all significantly and positively related to mathematics credits earned.

Regarding mathematics GPA, 11 out of the 12 student-level variables were significant. Increases in SES, assessment score, identity, self-efficacy, engagement, interest, and belonging were positively related to GPA, while mathematical utility was negatively related.

Of the 7 school-level variables examined, none were significant predictors of credits earned for non-ELL students. However, 2 of the 7 school-level variables were significant for non-ELL students, with private schools and positive school climates related to increases in GPA.

Table 4: Final Model Predicting Outcomes of Interest for Non-ELL Students

	Credits		GPA	
	Estimate	*SE*	*Estimate*	*SE*
Fixed Effects				
Intercept	*3.598***	*0.023*	*2.232***	*0.018*
Student Level				
Gender (0 = Male)	*0.079***	*0.001*	*0.278***	*0.001*
Hispanic (0 = Yes)	*-0.071***	*0.002*	*-0.095***	*0.002*
Black (0 = Yes)	*0.130***	*0.001*	*-0.117***	*0.002*
Socioeconomic status	*0.162***	*0.001*	*0.155***	*0.001*
Mathematics assessment score	*0.138***	*0.001*	*0.371***	*0.001*
Mathematics identity	*0.043***	*0.001*	*0.105***	*0.001*
Mathematics self-efficacy	*0.058***	*0.001*	*0.108***	*0.001*
Mathematics utility	--	--	*-0.054***	*0.001*
Interest in 2009 math course	*0.016***	*0.001*	*0.021***	*0.001*
School engagement	*0.089***	*0.001*	*0.107***	*0.001*
School belonging	*0.052***	*0.001*	*0.032***	*0.001*
School Level				

School type (0 = Public)	--	--	*0.120**	*0.041*
School climate	--	--	*0.057***	*0.016*
Random Effects				
Intercept variance	*0.483***	*0.023*	*0.135***	*0.007*
Level-1 variance	*0.813***	*0.001*	*0.381***	*0.000*
Intraclass correlation	0.373		0.381	
Deviance	6,239,817.966		3,414,698.368	

* p < 0.01, ** p < 0.001

Discussion and Significance of the Study

The present study explored the associations between mathematics credits earned in high school, mathematics GPA, and student- and school-level factors for ELL and non-ELL students. While many variables were predictive of both outcomes for ELL and non-ELL students, effects differed between the two groups. Such differences highlight the need for educators to approach students who are or have been classified as ELL in ways that specifically target these differences, acknowledging that assistance which may be beneficial to non-ELL students may not be as effective or necessary for ELLs. Key differences are discussed below.

Perhaps one of the most concerning findings is that of the statistically significant negative relationship between interest in 9^{th} grade mathematics and both access and achievement in mathematics outcomes for ELL students. "Interest" in this survey was operationalized as a composite of students' responses to six survey questions, all of which addressed the extent to which the student enjoyed mathematics and spoke of it as a preferred subject. In both final models, interest was related to decreases in the outcome measure, indicating that ELLs who began with higher levels of interest were more likely to experience worse access and achievement. Such findings indicate the need for investigation into the experiences of ELL students who exhibit mathematics interest early on, but perhaps then struggle to pursue that interest. Early interest in mathematics is vital in encouraging future growth, and efforts must be made to turn ELLs' interest in 9^{th} grade mathematics into a positive predictor of future success.

While many of the relationships between attitudes, school perceptions, and the outcomes were significant, the effects of variables such mathematics identity, efficacy, and engagement were inconsistent between the two groups. For example, belonging was positively related to GPA for non-ELLs, but negatively related for ELLs. Mathematics identity was a significant positive predictor for non-ELLs' credits earned, but insignificant for ELLs. One potential reason for these contradictory findings is that while mathematics identity and sense of belonging in the classroom are representative of the role the student adopts in their learning environment, this role may not necessarily be recognized by others in that environment (e.g. teachers, administrators, counselors). ELL students may find themselves fighting inaccurate academic placements or reduced opportunities to learn, despite their own beliefs and self-perceptions. These findings indicate also that the relationships between student attitudes and feelings of belonging and engagement differ for ELLs compared to their English proficient peers, and these details are difficult to identify. As educators, it remains critical to attend to all students' feelings of belonging and engagement, self-efficacy, and views of mathematics. However, it is necessary to keep in mind that such efforts may not have the same effects on all students, and students who were previously classified as ELLs may require more positive focus on mathematics utility, self-efficacy, and feelings of school belonging.

Finally, the final models for both ELL and non-ELL students included few school-level variables, with many significant predictors entered at the student-level and much variance unaccounted for at the school-level. Such findings indicate that there are other unaccounted for school-level variables which contribute to the school-level variance, likely related to aspects of institutional climate or environmental issues beyond the control of the student. Further investigations should include other more school-level variables to account for these differences.

The mathematics pathways of ELLs and non-ELLs differed significantly. Students previously classified as ELL were significantly more likely to earn fewer mathematics credits and a lower mathematics GPA. Some factors, such as SES and mathematics assessment score, exhibited similar positive relationships with the outcomes for both groups. In these cases, educators may continue to address both student groups in similar ways. For other factors, such as a student's interest in their 9th grade mathematics course, school belonging and engagement, and other attitudes, it is necessary to proceed with caution. A student's linguistic background and prior classification may have long-lasting effects on their mathematics success, and it is critical to acknowledge the ways their school experiences differ. Careful attention should be paid to fostering and maintaining early interest in mathematics, as well as developing mathematics self-efficacy and utility for ELL students. While school-level factors did not appear as often as student-level factors, the two are often intertwined, and educators should seek to positively impact ELL students' experiences throughout their school experience.

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