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EXPLORING THE EFFECTS OF DIFFERING LINGUISTIC ACCOMMODATION PROGRAMS AMONG BILINGUAL LATINX STUDENTS' MATHEMATICS SELF-EFFICACY AND ACHIEVEMENT

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Synopsis:

If there is one thing we can recall from our history classes is that the United States is a country founded by immigrants from various nationalities. Nonetheless, this diversification in our history, specifically linguistic, seems to be neglected by many as the decades have gone by. To make matters more complicated, research has shown that Latinx students, specifically bilinguals, experience this gap with their White and Asian American peers at all proficiency levels of mathematics throughout their K-12 schooling. This paper explores current efforts to close the linguistic and mathematics achievement gap among our Latinx ELLs and their mathematics achievement. Recommendations include the incorporation of K-12 language programs that validate Latinx ELLs' linguistic and cultural capabilities as key components to their mathematics achievement.

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Luis Fernández, PhD

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I. Introduction

If there is one thing we can recall from our history classes is that the United States is a country founded by immigrants from various nationalities. Nonetheless, this diversification in our history, specifically linguistic, seems to be neglected by many as the decades have gone by. Our current reality is that we live in a country where there is a rapid increment of minority groups, with Latinxs being the largest ethnic group and Spanish the 2nd most spoken language (Associated Press, 2005; National Latinx Statistics, 2008; U.S. Census, 2015). Not surprisingly, this rapid diversification is reflected in our schools across the nation where Latinx students, born inside and outside the U.S., compromise over 80% of the English Language Learner (ELL) population (Batalova, 2006). This have led many school districts to implement strategies with the intentions of helping Latinx ELLs become more successful both in the acquisition of the English language and content knowledge, but this process is usually difficult and time-consuming (Center for Education Policy, 2007). Some of the most popular efforts have been “transitional models” designed to shift the student into English-only classrooms as quick as possible but unfortunately end up discouraging the ELL student’s usage of their first language (L1) and with that a significant part of their culture and heritage (Garcia & Wei, 2013; Valenzuela, 1999). Models like these are referred to by Lambert (1975) as “subtractive bilinguism,” and according to Cummins (1981), they lead to a negative effect on students’ educational experience.

To make matters more complicated, research shows that Latinx students are behind their White and Asian American peers in mathematics (Strutchens & Silver 2000; Tate 1997). More specifically, research has shown that Latinx students, specifically bilinguals, experience this gap with their White and Asian American peers at all proficiency levels of mathematics throughout their K-12 schooling (Garcia & Jensen, 2007). This gap can also be seen on national and state assessments where Latinx and African American students scored significantly lower than White and Asian American students, with extreme gaps between Latinx and White students on mathematics tests (Fox, 2005). Latinx ELL students are also overrepresented in low-ability remedial mathematics classes designed as supplementary courses aimed to increase their content knowledge and not fall behind their non-Latinx peers (Abedi et al. 2006; Catsambis 1994; Pew Hispanics Center, 2009). Findings like these are crucial now more than ever as we enter an era in which the fields in Science, Technology, Engineering, and Mathematics (STEM) are believed to become vital in our country's future, and underrepresented minorities are highly encouraged to enroll in such fields (Honey et al., 2014).

Few have been the occasions where efforts to close the linguistic and mathematics achievement gap among our Latinx ELLs have encouraged school officials to implement more linguistic and culturally sensitive bilingual models that validate the child's diverse set of skills as essential to their learning. Most of these have been bilingual/bicultural or dual language enrichment (DLE) programs in which the student's first language is not only seen as crucial in their learning but it is also built upon to ultimately develop strong bilingual linguistic skills without the sacrifice of content knowledge (Del Valle, 2003; Roberts, 1995). For this reason, we will explore whether a bilingual Latinx's current or prior enrollment in a bilingual/bicultural or DLE program has any affects in their mathematics achievement and self-efficacy and if this depends on a previous enrollment in a remedial mathematics course. Before doing so, we will briefly discuss what research has to say about bilinguals in the classroom.

II. Literature Review

For many decades, traditionalists had opted for a definition of a bilingual as a person who is able to control two languages as if they were two monolinguals in one, allowing them to communicate in any language, in all contexts and with all individuals (Bloomfield, 1933). This later became to be known as a *balanced bilingual*, whereas the term *semilingual* was used to describe the opposite scenario (Silver & Lwin, 2013). Although they might have sounded harmless at first, careful examination of the term *balanced bilingual* gives the impression that a bilingual must have both languages balanced, implying that there exists a distinct dichotomy of the languages, something that is rarely seen in practice among bilinguals. Similarly, the term *semilingual* implies that a person who is not one-hundred percent competent in either or both languages lacks strong linguistic skills and is therefore seen through a deficit perspective. Grosjean (1985), on the other hand, proposed a more well-rounded definition for bilinguals that sees a bilingual individual, including the rare *balanced bilingual* and other "imperfect" forms of bilinguism, as one person with multicompetencies. García & Wei (2013) have also proposed a more holistic view of bilinguism as the act of *translanguaging*. Through this perspective, languages are not seen as autonomous nor closed linguistic systems but rather as "trans-semiotic systems" in which bilinguals, via the act of *translanguaging*, select "meaning-making features and combine them to potentialize meaning-making, cognitive engagement, creativity and criticality" (Garcia & Wei, 2013). The following studies demonstrate the positive effects that *translanguaging* could have in students' acquisition of the English language and content knowledge.

Probyn (2015) investigated the linguistic practices of a group of science teachers in rural schools located in South Africa. Despite English being the home language of a small percentage of students, she observed that most of the science classes were taught in English and claimed that is this lack of English proficiency that frequently restricts ELL students' access to English monolingual curriculums. From all the science teachers involved in the study, only one, Teacher B, went beyond code-switching in the classroom and actually used the students' home language, isiXhosa, for longer periods of time in ways that appear to be both substantively and functionally in line with the notion of *translanguaging*. Probyn argues that Teacher B's use of *translanguaging* in the science classrooms seemed to provide a more systematic and purposeful pedagogy using both languages in "an integrated and coherent way to organize and mediate mental processes in learning" as suggested by Baker (2011); and thus, improving the opportunity for the students to learn both English and science.

In a similar fashion, Mazak and Herbas-Donoso (2015) described the *translanguaging* practices performed by Javier, a science professor, in an upper-level science undergraduate course at an officially bilingual university in Puerto Rico. Regardless of the official bilingual status, Mazak and Herbas-Donoso found that there existed an obvious inclination in the institution towards the English language in the science department by having all science textbooks and materials in English, as well as having the science courses taught mostly in English. Nonetheless, their ethnography demonstrated that Javier was able to make multifaceted lessons by using Spanish, the home language of the students, in conjunction with English to make connections between both languages, therefore increasing their content and linguistic knowledge, and introduce the Spanish-speaking students to the English-dominant scientific field.

Research has also demonstrated the benefits of *translanguaging* practices in English Language Arts (ELA) classrooms. In his study, Ajayi (2015) observed two high school ELA teachers and how they used various strategies to build word consciousness in Mexican American bilingual students. Knowing that asking students to memorize word meanings and use them in sentences are methods that have shown little to no progress in leaning new words (Nation, 2013), these two teachers decided to implement an inquiry-based approach of teaching English, allowing students to build an honest interest in the subject and simultaneously exploit the linguistic resources and cultural knowledge that they already possessed (Genesee et al., 2008). Results demonstrated an increase in interest on learning English on behalf of the students as well as an increment in their overall self-esteem.

If we as educators want to promote an educational model that values the linguistic skills of our Latinx students, not only must we create teaching models based on what we know about bilinguism but also have clear goals and expectations that align with what is best for our future bilingual citizens, especially in their teaching of mathematics. Such is the reasoning behind the implementation of bilingual/bicultural and DLE models. In order to further explore the effects that these can have on a bilingual Latinx's mathematics achievement, the following research questions will be assessed:

RQ1. Does a Latinx bilingual student's enrollment in a language support program affect his/her levels of mathematics self-efficacy?

RQ2. Does having taken a remedial mathematics course affect the Latinx bilingual students' levels of mathematics self-efficacy?

RQ3. Is there a difference in Latinx bilingual students' mathematics achievement depending on their participation in a language support program and does this vary depending on their enrollment in a remedial mathematics course?

III. Research Methodology

3.1 Sample and Data Collection

This study was created using data obtained from the Education Longitudinal Study of 2002 (ELS:2002), a study designed to provide data about critical transitions experienced by students as they proceed through their education and into adulthood. In the original ELS:2002 the sample size was of 17,590 students who were 10th-graders in 2002 and the data collection processed was conducted by the National Center for Education Statistics (NCES). ELS:2002 used a two-stage sampling procedure. The first stage consisted of a sample of 750 high schools, both public and private, that were selected with probabilities proportional to their size. During the second stage, approximately 26 students were randomly sampled from each school on the condition that they were in the 10th grade in the spring term. Parents, teachers, principals, and librarians were surveyed as well. About 14,710 of the originally selected sample members were re-interviewed in the spring of 2004 and comprise the target population for this study: sophomores in the spring of 2002 who were respondents in both the base-year (BY) and first follow-up (F1) interviews. To be included in this analysis, sample members had to have been an in-school sophomore in 2001-02, participated in BY interviews, completed the mathematics assessment in the BY interview, selected Spanish as their home language, and selected "Hispanic, no race specified" or "Hispanics, race specified" as their ethnicity. The final analytic sample included between 600~800 respondents depending on the statistical analysis used, or about 4.5% of the 16,252 members who participated in the base-year interviews.

3.2 Statistical Analysis

IBM's Statistical Package for the Social Sciences (SPSS) was used for all statistical analysis. The dependent variables were *Mathematics Self-Efficacy* measured with the addition of items BYS89A, BYS89B, BYS89L, BYS89R, and BYS89U, and *Mathematics Achievement* measured by the variable *Mathematics IRT Estimated Number Right*. The independent variables were *Language Support Program Participation* and *Remedial Mathematics Enrollment*. Table 1 contains a more detailed description of all the previously mentioned variables. Descriptive statistics were reported for all of the variables. Next, we used Chi-square tests to assess if there existed an association between a student's participation in a language support program and his/her mathematics self-efficacy and between a student's participation in a language support program and his/her enrollment in a remedial mathematics course. A 2-way between-groups ANOVA was also implemented to assess differences in the students' mathematics achievement depending on their enrollment in a language support program and/or remedial mathematics course.

IV. Results

4.1 Descriptive Statistics

Descriptive statistics for the distribution of Mathematics Self-Efficacy, shown in detail in Table 2, showed that among the students who have participated in both ESL and Bilingual/Bicultural programs, only 16.3% reported Low Mathematics Self-Efficacy, making it the smallest proportion among the rest of the enrollment statuses. It also appears that the greatest proportion of the students lie within medium levels of Mathematics Self-Efficacy. Additionally, students who have never taken a remedial mathematics course reported the smallest proportion of low Mathematics Self-Efficacy levels. In terms of Mathematics Achievement scores, students who participated only in a bicultural/bilingual program scored an average mathematics achievement score of 43.60 (SD=10.31) whereas students who have participated in an ESL program scored an average of 31.22 (SD=11.37) in their mathematics achievement assessment. More information pertaining Mathematics Achievement mean scores can be found in Table 3.

4.2 Research Questions Results

4.2.1 Research Question 1

Research Question 1 investigated possible associations between a Latinx bilingual student's enrollment in language support programs (0=No Participation, 1=ESL Program Participation, 2=Bilingual/Bicultural Participation, 3=Both ESL and Bilingual/Bicultural Program Participation) and their levels of Mathematics Self-Efficacy (0=Low Mathematics Self-Efficacy, 1=Medium Mathematics Self-Efficacy, 2=High Mathematics Self-Efficacy). A Chi-square test for independence, as shown in Table 4, indicated a statistically significant association between them, $\chi^2(6, n=593) = 13.17$, $p=.04$; however, the size effect was small, Cramer's $V=0.11$. Within students' participation in a language support program, the highest proportion of students who reported high mathematics self-efficacy have participated in a bilingual/bicultural program (29.5%) compared to students who have participated in ESL programs (10%), have participated in none (20.4%), and have participated in both (22.2%). Additionally, students who participated in ESL programs reported the highest proportion of medium mathematics self-efficacy (75%) and the lowest proportion of low-self efficacy (15%).

4.2.2 Research Question 2

Research Question 2 investigated possible associations between a Latinx bilingual student's enrollment in a mathematics remedial course (0=Never enrolled in Remedial Mathematics, 1=Have Enrolled in Remedial Mathematics) and their levels of Mathematics Self-Efficacy (0=Low Mathematics Self-Efficacy, 1=Medium Mathematics Self-Efficacy, 2=High Mathematics Self-Efficacy). A Chi-square test for independence indicated a statistically significant association between them, χ^2 (3, n=923) =58.14, $p<.001$, with a moderate size effect, Cramer's $V=.25$. Within students' participation in a language support program, the highest proportion of students who have enrolled in remedial mathematics courses have participated in a bilingual/bicultural program (29.8%) compared to students who have never participated in any language support program (5.2%). More details can be found in Table 5.

4.2.3 Research Question 3

For *Research Question 3*, a two-way between-groups analysis of variance was conducted to explore the impact of students' participation in language support programs and enrollment in remedial mathematics courses on their mathematics achievement measured by their Math IRT scores, as shown in Table 6. The interaction between participation in language support programs and enrollment in mathematics courses on their mathematics achievement was not statistically significant, $F(3, 915) = .931$, $p = .425$. There was a statistically significant main effect for participation in language support programs and mathematics achievement, $F(3,918) = 31.747$, $p < .001$; however, the effect size was small, partial eta squared=.094. There was also a statistically significant main effect for participation in remedial mathematics and mathematics achievement, $F(1,918) = 9.198$, $p = .002$; however, the effect size was small, partial eta squared=.010. Post-hoc comparisons using Tukey HSD indicated that all mathematics achievement scores differed statistically significantly from each other (except for students who participated in both programs and in ESL only).

V. Discussion

Bilinguals need teaching approaches that acknowledge their identity, validate their linguist practices and exploit their bilinguism, and it seems that language support programs like DLE models or bilingual/bicultural programs might be worth further exploration. Results demonstrated that students who have participated in such models yielded the highest proportion of high levels of mathematics self-efficacy. It is possible that these models positively impact the self-esteem of many of its bilinguals by acknowledging their linguistic skills as important rather than through a deficit model, therefore also impacting their mathematics self-efficacy. Results also demonstrated that students who have participated in language support programs averagely scored the highest mathematics achievement score compared to the other students. A possibility can be that these programs build content knowledge from what students already know, like their first language, and this increases their mastery of content subjects like mathematics. These models can also encourage in-class discussions that encourage students from diverse linguistic skills to participate.

On the other hand, students who have enrolled in ESL programs reported the lowest proportion of high self-efficacy in mathematics. ESL programs have a goal of a student's rapid transition into English-only classrooms, and this could impact the student's language development and overall self-esteem, hence affecting their mathematics self-efficacy. These programs could also focus so much on the acquisition of the English language that content knowledge like mathematics is seen as expendable factors. These same group of students also scored the lowest mean mathematics achievement score compared with the rest of the groups. Part of it could be that tests given to them are not in a language that they can understand, or they are present in mathematics classes that are in English only. Despite mathematics teachers encouraging students to participate in classroom activities, "ESL students" could feel like outsiders, not able to participate because of a linguistic issue rather than a cognitive one.

Results like these show positive effects from students who have been in language support programs, but many of these models have questionable mandatory linguistic policies that contradict what research on bilinguals say. For that reason, future studies should focus on investigating the various types of language support programs in order to find the most suitable ones to cater to the needs of our Latinx bilingual students. Researchers should look for models that learning that respect and validate their bilinguals' pre-existing linguistic and cognitive skills and encourages teachers to provide learning environments that build upon these foundations, thus allowing students to construct their own knowledge and go from a passive to a more active learning role. This, in return, could allow students to have an honest interest in what they are learning and encourage them to be more active in their learning process.

VII. References

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VIII. Appendix

Table 1. Variables used in the study

Variables	Description	Values
Dependent Variables		
Mathematics Self-Efficacy	Self-efficacy in mathematics reported by the students	0=Low Mathematics Self-Efficacy 1=Medium Mathematics Self-Efficacy 2=High Mathematics Self-Efficacy
Mathematics Achievement	Math achievement score based on the students' IRT Estimated Number Right score	0~81
Independent Variables		
Language Support Program Participation	Previous or current participation in a language support program	0=No Participation 1=ESL Program Participation 2=Bilingual/Bicultural Program Participation 3=Both Bilingual/Bicultural and ESL Participation
Remedial Mathematics Enrollment	Previous or current participation in a mathematics remedial course	0=Never Enrolled in a Remedial Mathematics Course 1=Have Enrolled in a Remedial Mathematics Course

Table 2. Distribution of Mathematics Self-Efficacy Levels among all 2 factors

		Low Mathematics Self-Efficacy		Medium Mathematics Self-Efficacy		High Mathematics Self-Efficacy	
		N	(%)	N	(%)	N	(%)
Language Support Program Participation	No Participation	1332	20.5%	3613	55.6%	1559	24.0%
	ESL Program Participation	89	18.1%	301	61.2%	102	20.7%
	Bilingual/Bicultural Program Participation	544	18.4%	1536	61.2%	880	20.7%
	Both ESL and Bilingual/Bicultural Program Participation	41	16.3%	158	62.9%	52	20.7%
Remedial Mathematics Enrollment	Never Enrolled in Remedial Mathematics	1797	19.5%	5057	55.0%	2346	25.5%
	Have Enrolled in Remedial Mathematics	194	20.3%	541	56.7%	219	23.0%

Note: N = sample size. Numbers in parentheses indicate row percentages.

Table 3. Mean Mathematics Achievement scores measured by scores by all 2 factors

		N	MA Mean	SD
Language Support Program Participation	No Participation	9120	36.77	11.84
	ESL Program Participation	808	31.22	11.37
	Bilingual/Bicultural Program Participation	3882	43.60	10.32
	Both ESL and Bilingual/Bicultural Program Participation	390	32.88	12.00
Remedial Mathematics Enrollment	Never Enrolled in Remedial Mathematics	12741	38.58	11.87
	Have Enrolled in Remedial Mathematics	1417	33.99	12.09

Note: N = sample size; MA: Mathematics Achievement Score; SD = standard deviation

Table 4. Results of Chi-square Test for independence for Mathematics Self-Efficacy by Language Support Program Participation

Language Support Program Participation	Mathematics Self Efficacy: Low	Medium	High
No Participation	70 (19.1%)	222 (60.5%)	75 (20.4%)
ESL Program Participation	9 (15%)	45 (75%)	6 (10%)
Bilingual/Bicultural Program Participation	24 (21.4%)	55 (49.1%)	33 (29.5%)
Both Bilingual/Bicultural Program Participation	8 (14.8%)	34 (63%)	12 (22.2%)

Note: $\chi^2 = 13.17^*$, df = 6. Numbers in parentheses indicate row percentages.
$^*p < .05$

Table 5. Results of Chi-square Test for independence for Mathematics Self-Efficacy by Remedial Mathematics Enrollment

Language Support Program Participation	Mathematics Remedial Course Enrollment No	Yes
No Participation	525 (94.8%)	29 (10.4%)
ESL Program Participation	96 (86.5%)	15 (13.5%)
Bilingual/Bicultural Program Participation	147 (89.6%)	17 (10.4%)
Both Bilingual/Bicultural Program Participation	66 (70.2%)	28 (29.8%)

Note: $\chi^2 = 58.14$***, df = 3. Numbers in parentheses indicate row percentages.
***$p < .001$

Table 6. Summary of two-way between-groups ANOVA of the mathematics achievement mean scores by language support program enrollment and enrollment in remedial mathematics courses

Source of Variation	Sum of squares	*df*	Mean square	*F*
Language Support Program Enrollment	9841.937	3	3280.65	31.75***
Enrollment in Remedial Mathematics Course	950.56	1	950.56	9.20***
Language Support Program Enrollment × Enrollment in Remedial Mathematics Course	288.68	3	96.23	.931
Residual	94575.89	915		
Total	989093.2	923		

Note: *df* = degrees of freedom; *F* = F statistic; Sig. = Significance
*p<.05, **p<.01, ***p<.001.