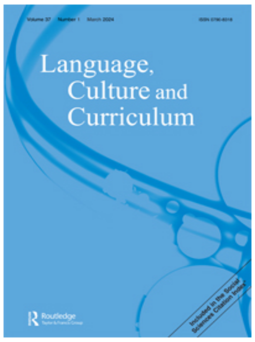

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When my teacher speaks Spanish, my math classroom experience changes: tracking attitudinal and achievement effects

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ABSTRACT

As the population of emergent bilingual students in the United States continues to grow, it has become increasingly important to ensure that content area instruction is linguistically and culturally inclusive and accessible. Longitudinal survey and state mathematics assessment data were used to examine how the use of students' home language in the English-medium mathematics classroom related to growth in student achievement and attitudes towards mathematics learning. Surveys from 1,274 students attending four middle schools in a Spanish-dominant community reported on teacher and student use of Spanish as well as attitudes towards learning strategies and mathematics. Structural equation modelling revealed that teachers' use of Spanish predicted students' use of Spanish, which was associated with growth in comfort participating in the mathematics classroom. Increased comfort, moreover, was related to growth in mathematics self-efficacy and, in turn, increased interest in mathematics as well as growth on the state mathematics assessment.

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In the United States, the population of speakers of languages other than English has grown substantially in recent decades, with over 52% growth since 2000 (Dietrich & Hernandez, 2022). Likewise, the number of students in U.S. schools who use languages other than English at home and who are classified as English learners – also described as emergent bilinguals, a term we use here to recognise such students' developing and expanding linguistic knowledge (García, 2009) – has grown to over 10% (NCES, 2023a). Meanwhile, monolingual English practices and policies generally remain dominant across educational contexts (Rafa et al., 2020), including in states such as Texas where the population of emergent bilingual students is more than double the national average and where English-only programme models prevail despite state-level support for multilingual programme implementation (TEA, 2023). As such, the linguistic environments of the schools where many emergent bilinguals learn often do not reflect the multilingual communities in which they are situated.

Academic achievement measures suggest these extant practices and policies have been ineffective for emergent bilingual students, notably in mathematics. In 2022, for

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instance, 95% of U.S. students classified as emergent bilingual scored either Basic or Below Basic on the Grade 8 Mathematics National Assessment of Educational Progress, in comparison to 68% of students not classified as emergent bilingual (NCES, 2023b). Further, students often feel excluded in classrooms that do not allow them to use their linguistic assets (Cavalcante et al., 2024), with implications for attitude and identity development. To better serve emergent bilingual students as they engage in content-area learning, advocates in the U.S. have called for a shift in educational language practices that, rather than pressure students to assimilate to English-only norms, instead recognise students' language backgrounds as assets in their learning and invite multilingualism into the classroom (García & Otheguy, 2020).

In this paper, we investigate the role that an asset-based orientation to students' home language may play in supporting academic and attitudinal outcomes in mathematics. Specifically, we examine the use of Spanish by students and teachers in middle school mathematics classes in a Spanish-speaking community in Texas where mathematics instruction occurred through the medium of English and used learning strategies that depended heavily upon spoken and written language. Using longitudinal survey and achievement data collected in four middle schools, we identify key affordances for using students' home language in mathematics for growth not only in achievement but in students' affective approach to mathematics learning, as well.

Literature review

Language in classroom communities

Among classroom characteristics that contribute to student learning are those that shape how students are positioned. That is, the ways students' identities are invoked in the classroom through their own articulations and through those defined by others serve to position them according to particular social discourses (Hall, 1996). Multilingual students who are formally designated as emergent bilingual, for example, have often been positioned in schools according to deficit-based discourses that link language knowledge with capacity and ability and which, in turn, have normalised practices and policies that inhibit access to academic opportunities, such as participation in advanced coursework and even in the core activities taking place in general education courses (Kibler & Valdes, 2016; Umansky, 2016). Therefore, students' language, notably that of emergent bilingual students, is a key element in shaping their positionality within the classroom community.

Indeed, language is deeply embedded in the ongoing processes whereby the classroom is established as a community of communicative practice (Lave & Wenger, 1991; Levinson et al., 2009). The linguistic choices made by members of the community contribute to the legitimisation of particular language practices within that community, and those legitimised practices carry meanings that inform how its various members are positioned. In classrooms where students are multilingual, legitimising the different varieties of language used by students in their homes and communities may serve as an impactful means for disrupting the deficit-based orientations that often characterise emergent bilingual students' learning environments and may instead support meaningful self-expression, recognition, and inclusion (García & Otheguy, 2020). Such affirmation, though, depends in large part on the positions taken up by teachers as they use language in their classrooms.

Teacher language use and classroom policy

Teachers play an important role in shaping and legitimising language use in the classroom as they set norms for communication through both explicit and implicit means. They may, for example, set expectations for language use that are overtly communicated to students by setting formal rules for how language may be used and when. Such explicit norm-setting has been observed in contexts where teachers implement official language policies (Hamman, 2018; Henderson & Palmer, 2015), where standardised assessments serve as *de facto* language policies and teachers encourage students to use the language of assessment (Sánchez et al., 2022), and in cases where teachers believe using only the language of instruction is necessary to prepare students for future success in school (Heineke & Cameron, 2013).

Similarly, teachers also influence classroom language use through their own modes of communication. Their position of power in relation to students situates them such that their language choices shape the linguistic norms of the class (Tai & Wei, 2021) and may constitute classroom language policy (Menken & García, 2010). Therefore, when teachers use multiple languages during instruction or provide materials written in students' home language, for instance, they establish the understanding that multilingual practices are welcomed in their classroom, including in settings where official monolingual policies are in place (Bonacina-Pugh, 2020; Bowden et al., 2024; Tai & Wei, 2023). Indeed,Skilton-Sylvester's (2003) comparative study showed that in classrooms where teachers were able to speak the home languages of their students, whether or not students used their home language depended on the teacher's multilingual practices. Similarly, when teachers acknowledge students' language practices as valid modes of participation in the classroom, students are likely to continue engaging in those legitimated practices (Menken & García, 2010; Tai & Wei, 2023). Teachers are thus crucial in determining how multilingual students, including emergent bilingual students, and their language(s) are positioned in the classroom and in turn how students might use language therein.

Multilingual practices and mathematics learning

In addition to their general norm-setting role, teachers' multilingual practices also shape content-specific learning opportunities for emergent bilingual students. For example, in effective mathematics classrooms there are extensive communicative tasks and language-based learning processes that could be shaped by multilingual practices. Students benefit from complex, open-ended tasks (Stein et al., 1996) and from describing and explaining their solution strategies (Wong et al., 2002) while working alone, from discussing different possible solution strategies (Star et al., 2016) during group work, and from participating in discussions about different solution strategies selected by the teacher at the whole-class level (Inagaki et al., 1998). Teachers' use of multilingual practices during instruction, moreover, may promote more meaningful participation among emergent bilingual students in such learning processes. Multilingual practices have been linked to emergent bilingual students' enhanced comprehension of content

(Avalos & Secada, 2019), reduced cognitive load (Prediger et al., 2016), increased conceptual understanding (Schüler-Meyer et al., 2019; Tai & Wei, 2023), and increased opportunities to clarify or explain reasoning and engage in mathematical discourse practices (Moschkovich, 2019). Multilingual practices, then, may serve as an instrumental academic resource for mathematics learning.

Establishing the mathematics classroom as a multilingual space can also contribute to learning by legitimising emergent bilingual students' membership in educational communities of practice. Linguistically responsive pedagogies that recognise home language knowledge as valid within English-medium schooling, for instance, may strengthen students' sense of connection within their learning environments and support self-empowerment (Le Pichon et al., 2023). Moreover, within linguistically inclusive classroom environments, students tend to feel comfortable taking academic risks during the communicative tasks that are necessary for meaningful mathematics learning (Cavalcante et al., 2024), particularly as they engage in conversations about mathematic concepts with peers (Barwell, 2018; Moschkovich, 2019; Planas, 2014). Teachers who are multilingual may further use multilingual practices to express solidarity with students (Setati, 2005). Even in classrooms where the teacher does not use multilingual practices themselves, validating emergent bilingual students' use of multiple languages has been shown to encourage continued engagement and deeper learning in mathematics (Barwell, 2016), as well as increased motivation (Tecedor & Pascual y Cabo, 2020). As such, along with its instrumental value, multilingualism also supports emergent bilingual students' affective stance in mathematics learning. This is especially important for middle school students, who overwhelmingly report decreased interest in school during early adolescence, which then contributes to declining achievement also seen during this developmental period (Gottfried et al., 2007).

Overall, then, recent research has provided substantial evidence of the practical and discursive functions of multilingual practices in emergent bilingual students' schooling experiences and specifically in their engagement in mathematics learning. However, the literature addressing the role of multilingualism has not yet thoroughly examined its relationship with outcomes beyond classroom learning processes. Notably limited in the existing body of literature is research investigating how multilingual practices are associated with outcomes related to mathematics achievement assessments. Though achievement measures are often problematic (Schochet & Chiang, 2010), especially for emergent bilingual students for whom standardised achievement assessments are not designed (Sánchez et al., 2022), they are important mechanisms in determining access to educational opportunities, such as coursework, college acceptance, and even graduation eligibility.

There is extensive research on the mechanisms by which classroom experiences shape attitudes and achievement, which is likely highly relevant to understanding the role of language in mathematics learning. A number of studies have found that self-efficacy in a domain often shapes interest in that domain (Rottinghaus et al., 2003), which then shapes identity development and later choices to participate in optional learning and later career pathways (Bodnar et al., 2020; Sha et al., 2016). In addition, self-efficacy also has been shown to shape achievement (above and beyond performance differences that shape self-efficacy judgements), and more so than does interest (Grigg et al., 2018). That is, when students feel capable, they often show higher levels of achievement, in part through reductions in distracting anxiety and worry during exams (Roick & Ringeisen, 2017) and in part through approach rather than avoidance reactions to initial challenges in tasks and exams (Sökmen, 2021). Further, supportive environments in which students are helped to feel comfortable are ones in which student self-efficacy grows (Usher, 2009). Thus, providing students with access to their home language during mathematics instruction should make them feel more comfortable engaging in mathematics learning routines, which should improve their self-efficacy, which should in turn improve their mathematics interest and mathematics achievement. However, it is an open research question whether this specific pathway provides a strong account for the mechanism by which access to home language use during instruction influences mathematics achievement.

Therefore, in this study we sought to understand the various affordances of multilingual practices for students' attitudes towards and engagement in mathematics learning, as well as for student achievement in mathematics. We approached multilingualism as an affective affordance in mathematics learning and hypothesised that the use of students' home language – Spanish – in mathematics would promote positive affective outcomes, including feelings of comfort, self-efficacy, and interest, in addition to promoting mathematics learning.

Methods

Context

The current study was part of a larger project supporting the implementation of a newly adopted mathematics curriculum in four middle schools serving grades 6, 7, and 8 in three small districts surrounding one U.S. city near the Texas-Mexico border. In the three participating districts – District A, District B, and District C – where 95% of all students identified as Hispanic (Texas Education Agency [TEA], 2022), Spanish played an important role in the schools' communities (e.g. between one third and three quarters of students reporting Spanish as the home language). Further, these districts also had between 50% and 150% higher rates of students identified as emergent bilingual compared with the state average, which was itself twice the national average of 10% (NCES, 2023a).

Across these three districts, new textbook mathematics curriculum was adopted for all 'on-grade-level' mathematics instruction (i.e. excluding honours courses). In-district educators adapted the curriculum with the aid of an outside support provider to ensure regular use of high cognitive demand tasks. Teachers participated in both between and within-district professional learning opportunities that supported the implementation of high-level tasks, focusing on increasing cognitive demand while enhancing students' collaborative engagement with mathematical tasks, which as discussed previously, may or may not be useful for emergent bilinguals depending upon the ways in which additional language use is supported in the classroom practices and policies (Moschkovich, 2019). In addition to an explicit emphasis on high-level tasks and collaborative engagement during professional development, in the second year of curriculum implementation, the use of Spanish during mathematics class was promoted among teachers and administrators as an effective practice in the English-medium mathematics classroom, particularly given the large populations of Spanish-speaking students in the participating schools.

Participants

Across all three districts, 1,274 middle school students participated in the study. School records indicated 51% of participants (n = 650) spoke Spanish at home and 45% (n = 573) were classified as emergent bilingual during the 2022–23 school year. Students were taught mathematics by 27 participating teachers, most of whom reported having at least intermediate knowledge of Spanish. Table 1 includes district-provided student demographic information, as well as teachers' self-reported demographic information.

Measures

Three sources of data were used. First, performance on the annual state mathematics test was used to examine change in mathematics achievement from the prior year. Second, the district provided demographic information about the students. Third, a survey was administered in the middle of the fall and spring semesters of the same year to measure changes in student attitudes towards mathematics and comfort engaging various mathematics learning practices. The spring administration also collected information about frequency of classroom mathematics practices and use of Spanish during

Table 1. Participant teacher and student information within each school.

	District A		District B	District C
	School 1	School 2	School 3	School 4
Teachers				
# of teachers	8	10	7	2
Average years teaching	8.3	8.8	21.3	10.5
%At least intermediate Spanish	86	75	100	100
%Female	88	60	71	50
Race/ethnicity				
%African American	0	11	0	0
%Asian	0	11	0	0
%Hispanic	100	67	83	50
%white	0	11	17	50
Students				
# of students	382	465	379	48
%Spanish home language	49	37	63	90
%Designated emergent bilinguals	46	30	59	71
%Female	46	48	50	46
Race/ethnicity				
%African American	2	2	0	0
%American Indian	0	<1	0	0
%Asian	0	<1	0	0
%Hispanic	94	92	100	100
%Pacific Islander	0	<1	0	0
%white	4	4	0	0
%Two or More Races	<1	<1	0	0

Note: Across all schools, families of 43 students (3%) reported neither Spanish nor English as their home language. Race/ethnicity categories reported are those used by the TEA. Race/ethnicity data are missing for 24 students, for ≤2% in Districts A and B, and for 10% of students in District C. All participants were included in analysis.

that year. All items were translated into Spanish, and students chose whether to answer the survey in English or Spanish. Because the surveys were relatively long, all items were closed-response, with a mixture of Likert and binary check-all-that-apply responses to limit burden on students / class time.

Mathematics achievement. We collected students' scores on the 2022 and 2023 administration of Texas's state-wide standardised achievement assessment of mathematics, the State of Texas Assessments of Academic Readiness (STAAR). STAAR mathematics assessments are administered annually to all students in grades 3–8 during the spring semester. We used students' 2023 percentile results as a measure of mathematics achievement and used 2022 percentile results to control for past achievement to thereby get an estimate of growth in mathematics achievement during the study year.

Attitudes towards mathematics. Mathematics *self-efficacy* was a latent variable comprised of five survey items using a six-point Likert scale (e.g. 'I believe that I can be successful in my math class'; Kosovich et al. 2015; $\alpha = .89$). Mathematics *interest* was a latent variable comprised of four survey items using a four-point Likert scale (e.g. 'I enjoy learning math'; Adelson & McCoach, 2017; Wang et al., 2016; $\alpha = .89$).

Comfort in engaging in mathematics learning practices. Comfort was a latent variable measured using four items created by the research team in collaboration with the team supporting teachers to align to the student learning practices targeted by the professional learning programme (e.g. 'I feel comfortable when I am asked to explain why my strategy for solving a problem makes sense'; Armor's $\theta = .72$). These items were binary check-all-that-apply items, making Armor's θ a more appropriate measure than Cronbach α for gauging reliability.

Use of Spanish during mathematics learning. Students' use of Spanish was measured using a four-item scale (e.g. 'In math class I have used Spanish to discuss math in small groups'; Armor's $\theta = .59$). Teachers' use of Spanish was measured using a three-item scale (e.g. 'My teacher speaks in Spanish to answer questions'; Armor's $\theta = .60$). These items were developed by the research team in collaboration with the team supporting teachers. Similar to comfort items, check-all-that-apply items were used for both student and teacher Spanish use items.

Data analysis

To identify latent constructs measured by the survey in the sample, we first conducted exploratory factor analysis of the spring 2023 student survey responses using principal-component factoring in Stata/IC 16.1. We selected oblique promax as the rotation method and applied Kaiser normalisation since we expected factors to be interrelated, and we used scree plots and eigenvalues > 1 to determine the number of factors to be retained; five factors were found to provide the best model. Through iterative cycles of principal-component factoring, we evaluated factor loadings and removed items that did not load onto theoretically sound constructs, items with standardised loadings $< .3$, and items with loadings $> .3$ for more than one factor. Together, the first three factors in the model represented constructs that research has previously determined play an important role in student achievement in math (Grigg et al., 2018; Roick & Ringeisen, 2017; Usher, 2009): *mathematics interest*, *mathematics self-efficacy*, and *comfort* engaging in mathematics learning as a social process. Additionally, two constructs related to the use of Spanish in mathematics emerged – *students' use of Spanish* and *teachers' use of Spanish*. None of the factors were correlated with one another above .55.

Using these criteria, we then conducted confirmatory factor analysis (CFA) to specify, modify, and validate the model, using the retained 20 survey items and a five-factor solution. This measurement model had acceptable although not excellent fit statistics, likely due to the larger number of binary items: The root mean square error of approximation (RMSEA) was 0.05 (< standard), the comparative fit index (CFI) was .93, the Tucker-Lewis index (TLI) was .91, and the standardised root mean square residual (SRMR) was .06.

Building on the measurement model confirmed with CFA, we then investigated the relationships between language use, growth in attitudes towards mathematics (by controlling for fall 2022 values of a given construct), and growth in mathematics achievement (by controlling for prior year achievement) using structural equation modelling (SEM). Given the substantial population of students whose home language was Spanish in the sample and the power of teachers to shape language use in schools (e.g. Henderson, 2017), we hypothesised that the use of Spanish by teachers would influence students' use of Spanish in mathematics learning. Similarly, we were also interested in the role of students' developmental linguistic progression on their use of Spanish in mathematics, but since we did not have access to measures of students' language proficiency, we were not able to deeply investigate this question. However, we used an analytic method in which we control for prior levels of attitudes and competencies in mathematics, and as a result, indirect effects of language proficiency as they relate to attitudes and mathematics performance were already controlled in the model. Likewise, indirect effects from language proficiency to likelihood of using Spanish or engaging in particular mathematics learning routines are controlled for even though they are not directly modelled.

Additionally, responding to research affirming the supportive role of the use of students' full linguistic repertoire in mathematics learning by teachers and students (Moschkovich, 2019), we also analyzed paths between both teachers' and students' use of Spanish and students' comfort, self-efficacy, and interest in mathematics, as well as their performance on the STAAR mathematics assessment. Further, we hypothesised that comfort in mathematics learning practices would shape self-efficacy in mathematics (Usher, 2009) and that self-efficacy in mathematics would shape interest (Rottinghaus et al., 2003) and achievement in mathematics (Grigg et al., 2018; Sökmen, 2021). We also tested alternate paths among the constructs. Figure 1 presents the theoretical model that was tested.

To address the substantial number of students who had some missing values in survey responses or test scores, we used maximum likelihood estimation for missing values. We iteratively adjusted the model to include significant paths by assessing residual matrices, parameter estimates, fit indices, and modification indices. The resulting SEM model, discussed below, had excellent fit statistics: RMSEA = .01, CFI = .97, and TLI = .97.

Results

Before testing the SEM model, we first explored whether teachers used Spanish only when many of their students were emergent bilinguals or whether they made this decision independent of student demographics. Figure 2 presents a scatter graph illustrating the relationship between the percent of each teacher's students designated as emergent

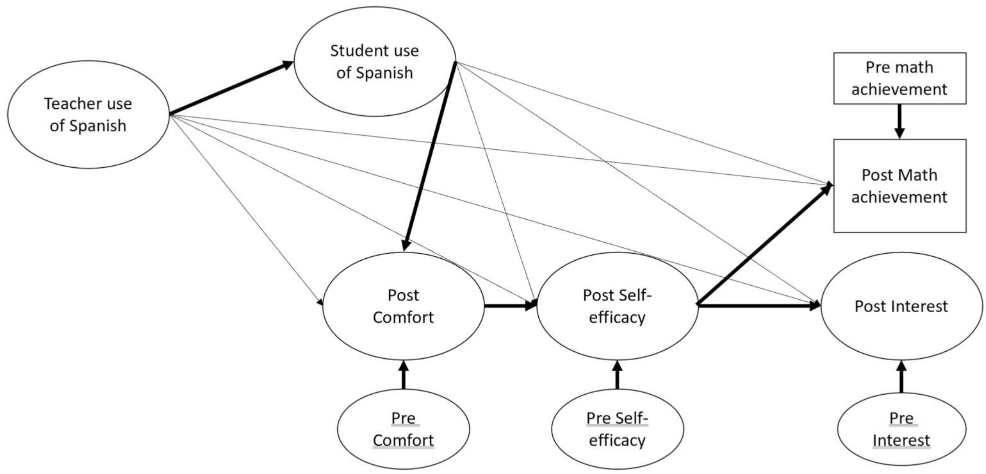

Figure 1. Theoretical model for the relationship between Spanish use during mathematics learning and student mathematics attitudes and achievement, controlling for prior attitudes and achievement.
Note: Thick lines represent the primary hypothesised connections and thin lines represent additional links that were also tested.

bilinguals and the teacher's average use of Spanish during mathematics. Although the percentage of students who were emergent bilinguals varied widely (from 13% for one teacher to 100% for another teacher), most teachers had enough emergent bilingual students such that regular use of Spanish would be warranted. Nonetheless, the teacher means on the Spanish use variable varied significantly from .11 to .67. The relationship between the two variables was only modest, $r = .36$. That is, some teachers made

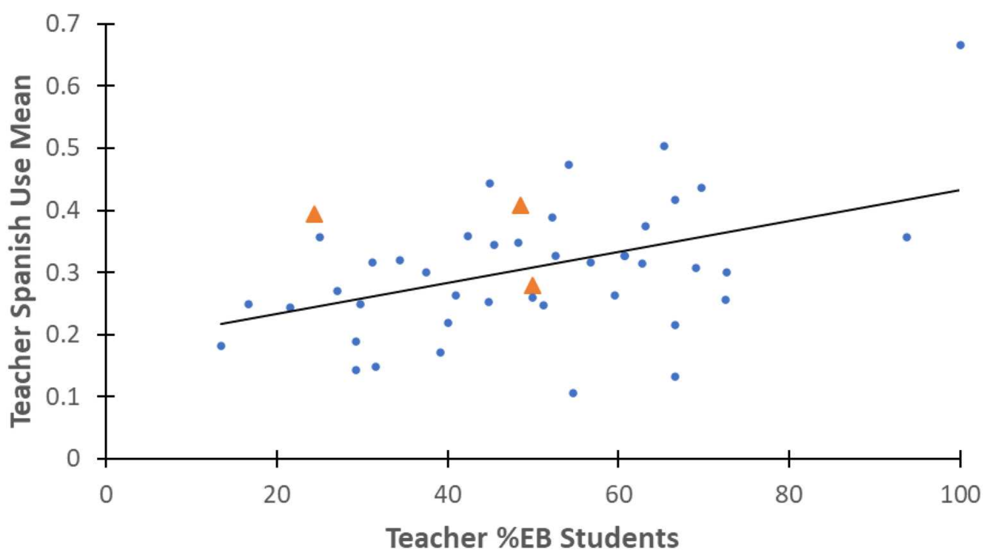

Figure 2. *Relationship between Spanish use and percent emergent bilingual students by teacher.*
Note: Dots indicate teachers who report at least intermediate knowledge of Spanish, and triangles indicate teachers who report basic knowledge of Spanish.

regular use of Spanish with only a low percentage of emergent bilingual students, whereas other teachers used little Spanish despite having a high percentage of emergent bilingual students. Moreover, though most teachers reported at least intermediate proficiency in Spanish, with three teachers indicated by triangles in Figure 2 below reporting knowledge of just basic words and phrases, only some used Spanish regularly.

Overall, the SEM confirmed both the measurement model identified by CFA and structural relationships between constructs hypothesised to be central to success in mathematics for all students – *mathematics interest*, *self-efficacy*, and *comfort* – and constructs hypothesised to be central to academic success among multilingual students specifically – *students'* and *teachers' use* of students' home language.

Focusing first on the measurement model, the items in each of the constructs are presented in Table 2. Standardised factor loadings in the measurement model for pre- and post- measures were all greater than .35 and statistically significant at the .001 level. Moreover, examination of the coefficient of determination (R^2) revealed that these variables explained 99% of variance in the final model. None of the item means were close to scale end-points at pre or post. Overall, there were nonsignificant gains in mathematics self-efficacy from pre to post, which is notable given that mathematics self-efficacy tends to decline during the middle school years (Gottfried et al., 2007), particularly among student populations historically excluded in STEM (Gutierrez, 2002).

Hypothesised relationships between these constructs were then tested in the structural model. As illustrated in Figure 3, the best fitting SEM model involved significant paths ultimately connecting teacher and student Spanish use in mathematics learning

Table 2. Retained survey items from each construct, their mean values, and the measurement model factor loadings at pre and post.

		Means		Factor loading	
Construct	Survey Item	Pre	Post	Pre	Post
Math Interest (1-4)	I like to solve math problems.	2.8	2.8	.86	.88
	I like math.	3.0	3.0	.69	.73
	I enjoy learning math.	2.6	2.6	.81	.81
	I learn many interesting things in math.	2.6	2.6	.89	.85
Math Self-efficacy (1-6)	I usually do well in math.	3.9	4.0	.70	.69
	I am good at working out difficult math problems.	3.3	3.6	.58	.60
	I believe that I can be successful in my math class.	4.5	4.5	.83	.86
	I am confident that I can understand the material in math class.	4.2	4.3	.85	.88
	I know I can learn the materials in my math class.	4.5	4.6	.77	.85
Comfort (0-1)	I feel comfortable when I am asked to explain why my strategy for solving a problem makes sense.	.45	.43	.60	.58
	I feel comfortable when I am asked to share my strategies with the whole class.	.28	.33	.63	.72
	I feel comfortable when I am asked to explain why other students' strategies make sense.	.18	.22	.60	.62
	I feel comfortable when I am asked to explain how I solved the problem.	.19	.21	.66	.62
Student use of Spanish (0-1)	In math class, I have used Spanish to answer questions.	-	.28	-	.59
	In math class, I have used Spanish to ask the teacher questions.	-	.37	-	.61
	In math class, I have used Spanish to discuss math in small groups.	-	.42	-	.35
	In math class I have used Spanish to share ideas with the whole class.	-	.14	-	.49
Teacher use of Spanish (0-1)	My teacher speaks in Spanish to answer questions.	-	.31	-	.50
	My teacher speaks in Spanish to explain what we should be doing.	-	.37	-	.54
	My teacher speaks in Spanish to explain math ideas.	-	.30	-	.70

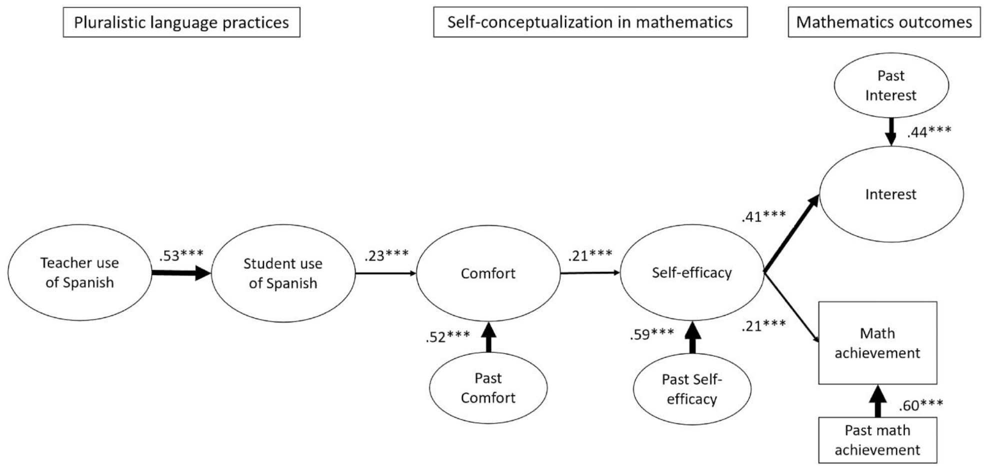

Figure 3. Final best-fitting structural equation model results connecting Spanish in mathematics learning with changes in mathematics attitudes and achievement.
Note: Arrow line thicknesses are proportional to standardised regression coefficients. *** = p < .001.

with growth in mathematics interest and achievement. As hypothesised, the connecting path was indirect via growing comfort with engaging in mathematical learning practices and growing mathematics self-efficacy. Focusing on the leftmost part of the model, we found that the use of Spanish in middle school mathematics classrooms by mathematics teachers was strongly and significantly associated with students' use of Spanish, with a regression coefficient of .53. Thus, confirming prior research (Henderson & Palmer, 2015; Menken & García, 2010; Skilton-Sylvester, 2003), the regular use of Spanish by a teacher was closely associated with more extensive use of Spanish among students.

Next, students' Spanish use was significantly associated with increased comfort engaging in social mathematics learning practices as expected, with a regression coefficient of .23 indicating a moderate effect. A model that explored the additional direct effect of teachers use on comfort found such a direct effect was small (-.16) and not statistically significant.

Next, increased comfort engaging in social mathematics learning practices was significantly associated with growth in students' mathematics self-efficacy, also with a moderate effect (.21 regression coefficient). Finally, growth in mathematics self-efficacy was then significantly associated with increases in both mathematics interest (a large effect) and improved mathematics achievement (a moderate effect size). For the additional direct links involving student's Spanish use within the tested full model (Figure 1), the relationships with self-efficacy ($b = -.12$), interest ($b = .08$), and achievement ($b = -.09$) were all small and not statistically significant. In other words, rather than directly being connected with mathematics attitudes and achievement, Spanish use was associated with those positive outcomes via the direct relationship with students' comfort in mathematics learning practices.

Discussion

For the studied middle schools, with their majority Spanish-speaking student populations, home language use in the mathematics classroom was shown to play a significant role in predicting changing attitudes and achievement in mathematics. Two related but distinct language use constructs linked to teachers' norm-generating influence and students' meaningful engagement and communication in learning were associated through specific pathways of changes in attitudes towards and achievement in middle-school mathematics.

Teachers' language practices

As hypothesised, the use of Spanish by teachers in mathematics classrooms predicted whether students used Spanish. The latent construct of *teacher use of Spanish* was indicated by whether or not they spoke in Spanish to answer questions or explain mathematics ideas or what students should be doing. Relative frequencies suggest the most common practice among these was teachers using Spanish to explain what students should be doing, with 37% of students reporting their teacher used Spanish as such, while 30% and 31% reported that teachers used Spanish to explain mathematics ideas and answer questions, respectively. By performing these procedural, practical, and conceptual tasks in students' home language alongside the language of instruction, teachers sanctioned multilingual practices in their mathematics classrooms. Indeed, the significant effects on student language use suggests teachers' language use functioned as an illustrative practice that discursively established the linguistic environment of the mathematics classroom as welcoming towards multilingualism. This pattern of outcomes affirms theoretical and descriptive studies that have shown linguistic practices of teachers may constitute informal language policy at the classroom level when they are understood as a norm (Bonacina-Pugh, 2020; Henderson, 2017; Levinson et al., 2009).

Note that the construct of student language use that was strongly correlated with teacher use of Spanish was not limited to student-teacher interaction (e.g. asking teacher questions or answering questions). Instead, it also included communication with peers through small-group and whole-class discussions. In fact, students most often reported using Spanish to discuss mathematics in small groups, with 42% having utilised this practice. Similar findings have been identified in other contexts where teachers' language practices have shaped those of students (Henderson & Palmer, 2015; Skilton-Sylvester, 2003). Likewise, our results illustrate how, despite the formal status of English as the medium of instruction, teachers' use of Spanish seemed to signify linguistic pluralism as a communicative norm, which supported students' own engagement in multilingual practices.

Language practices and changes in attitudes

Prior research has emphasised that a primary affordance of using students' home language in content area learning is its impact on student attitudes, which is of particular importance for adolescents (Gottfried et al., 2007; Gutierrez, 2002). This study extends that research by showing the ways in which changes in attitudes towards a content area are mediated by changes in learning practices. Specifically, students used Spanish to interpret, clarify, and convey understanding of mathematics content and concepts individually and collaboratively. Their use of Spanish was significantly associated with students' growth in comfort in a range of learning practices encouraged in their mathematics classrooms. The *comfort* items involved explaining mathematics processes, sense-making, and reasoning; these learning practices are all linguistically demanding and require extended production of language.

Interestingly, the use of Spanish did not have further direct effects on changing attitudes or learning, but rather those effects were mediated by changing comfort with mathematical learning practices that had high linguistic demands, which in turn was associated with increased self-efficacy in mathematics. In other words, as students felt more comfortable participating in conceptual and procedural mathematics talk, they also felt more capable as mathematicians. This effect might directly involve the ease in engaging in mathematics learning, which then students attribute to their own mathematical competency, or it might involve growth in mathematical understanding which then is directly reflected in increased self-efficacy (i.e. become better at mathematics learning vs. becoming better at mathematics).

While self-efficacy itself is an important attitudinal outcome, we also found that growth in self-efficacy was closely associated with increased interest in mathematics. *Mathematics interest* has been shown to be connected with investment in learning, including deep engagement in coursework and a desire to exceed requisite expectations (Fredricks et al., 2004), as well as continued interest in studying mathematics (Barwell, 2016). Although not measured, it is possible that changes in self-efficacy could also have shaped students' identity and sense of belonging. In many U.S. educational settings, restrictive language practices have disregarded multilingual students' assets, alienating them from their educational experiences and foreclosing space for feeling comfortable and capable (Cavalcante et al., 2024; Planas, 2014). Overall, our results highlight the supportive role pluralist language practices play in enhancing key student attitudes towards mathematics, which likely will have implications for students' overall approach to and future engagement in mathematics in high school and beyond.

Student attitudes and mathematics achievement

As has often been found in the literature (Grigg et al., 2018), self-efficacy was also positively and significantly related to growth in mathematics achievement. In addition, low self-efficacy can lead to worry while studying or completing exams, reduced engagement in class, or avoidance behaviours for out of class studying or homework completion, which can have negative effects on achievement (Roick & Ringeisen, 2017; Sökmen, 2021).

Importantly, the improved performance associated with growth in self-efficacy was on an English-only assessment. Although elementary students in Texas may opt to take state exams in Spanish, they must complete exams in English beginning in middle school. As discussed previously, the language used for standardised assessment has been shown to influence teachers' language use and serve as a *de facto* language policy in classrooms where high-stakes testing is central to accountability, including in multilingual classrooms (Sánchez et al., 2022). The current study showed that students' performance on English-only assessment is more likely to improve when use of their home-language during instruction is supported since it enables more productive learning processes.

Given that achievement was measured using a high stakes state assessment, it is important to also note the consequences for students in doing well on the test. In Texas, when a student's scores qualify as not meeting the tested grade level, accelerated instruction is required, which the TEA (2022) defines as 'supplemental instruction (i.e. tutoring) before or after school, or embedded during the school day' (p. 3). In practice, this is often implemented as after-school tutoring, which significantly extends the student's school day, reducing the time available for regenerative activities like sports or play. Test achievement also influences access to advanced course work in many Texas schools, which in turn has implications for college access and major choice.

Our results indicate that use of multilingual practices in mathematics class was indirectly associated with achievement on the state mathematics assessment. Logically, the use of Spanish *per se* should not guarantee mathematics learning; it should depend upon the Spanish being used for productive mathematics learning activities. As such, the limitations of this study include relying on survey methods without using observational data for triangulation. Future studies should use classroom observation in addition to survey data to better understand both the language practices of students and teachers – notably whether students' home languages are used for mathematical tasks – as well as students' attitudes during mathematics learning activities. Moreover, it is important to note that the data used were correlational and that the relationships identified in this study be interpreted as such.

Conclusions

Given confirmation of the hypothesised structural model, as well as the substantial benefits prior research has found for linguistic hybridity in mathematics learning (Avalos & Secada, 2019; Prediger et al., 2016; Schüler-Meyer et al., 2019), this research provides additional evidence in support of the value of multilingual practices in cognitively demanding, English-medium classrooms, notably those serving multilingual communities. The results illustrated how teachers' and students' use of Spanish reflected pluralistic language practices that were predictive of growth in students' comfort and self-efficacy – their self-conceptualization – in mathematics, which then predicted growth in their overall level of interest in mathematics and in their performance on Texas's standardised mathematics assessment.

Our study specifically highlights the centrality of teachers in promoting pluralistic language practices in English-medium mathematics classrooms and highlights the need to leverage teachers' norm-setting power to create classroom environments that promote students' linguistic flexibility in mathematics learning. For multilingual teachers, this might involve modelling the use of multiple languages, as teachers did in this study. For teachers who speak one language only, multilingual instructional practices might invoke the multilingual skills and knowledge of colleagues or other multilingual resources to provide written and oral materials in students' home language as well as the language of instruction, or they may simply encourage multilingual practices among students. By establishing the mathematics classroom as a multilingual space, teachers in English-medium schools may expand opportunities for students to develop as both multilingual individuals and as mathematicians.

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