Translanguaging to Persevere: Supporting and Recognizing the Meaning-Making Process for Latinx Bilingual Students of Mathematics

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Abstract

This paper describes the translanguaging and perseverance practices of Latinx bilingual students and the careful preparation of their English-speaking, monolingual teacher to establish a supportive classroom environment. Drawing on the constructs of translanguaging mathematical practice and perseverance in problem-solving, we share our observations of a group of four Latinx bilingual students as they leverage their bilingualism to productively struggle to make sense of an exponential function. We discuss this vignette to reveal the pedagogical decisions that helped support these students to dialogically leverage their communicative resources to help persevere with in-the-moment mathematical obstacles. Such decisions included selecting and enacting a challenging mathematical task conducive for perseverance, encouraging a linguistically sensitive learning environment, and providing access to mathematical tools as learning resources.

Discussion And Reflection Enhancement (DARE) Pre-Reading Questions

1. What does translanguaging and perseverance look like for secondary bilingual students?
2. In what ways could a monolingual English-speaking teacher encourage translanguaging and perseverance in their bilingual students, for the purpose of learning mathematics with understanding?
3. What challenges might a monolingual English-speaking teacher face when enacting a task that invites collaboration and bilingualism? How might this teacher be supported?

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Joseph DiNapoli and Hector Morales, Jr.

There is a growing call for teachers to implement equitable, rigorous, and coherent mathematics instruction for their bilingual students (TODOS, 2019). However, dehumanizing school practices continue to marginalize bilingual students' linguistic, social, and cultural capital, especially those in the Latinx community (García, 2017; Gutiérrez, 2017; Langer-Osuna et al., 2016). Monolingual English-speaking teachers especially need support with authentically supporting their bilingual students' mathematical meaning-making (Wickstrom & Gregson, 2017). As authors, we position ourselves with a rehumanizing perspective (Gutiérrez, 2017) through which bilingual learners, when positioned in supportive learning environments, can act as agents of their own translanguaging use and are capable of collaboratively persevering toward authentic conceptual learning (Morales, Jr. & DiNapoli, 2018). In this paper, we describe, discuss, and reflect on a group of Latinx bilingual students' translanguaging and perseverance practice as they collaborated to make meaning in a supportive classroom environment. We detail the bilingual students' learning progression with mathematical functions as well as the classroom environment established by the monolingual English-speaking teacher that helped facilitate it.

Translanguaging to Persevere with Mathematics

Powerful classroom practice in a bilingual setting must encourage both translanguaging and perseverance with Latinx bilingual students. Recognizing and employing these lenses is paramount for mathematics teachers. Avalos, Medina, and Secada (2018) argue that the best way to support bilingual learners in mathematics is to explicitly teach and model mathematical semiotics (language, symbols, visuals) while students are engaged in challenging meaning-making interactions. We draw on the concept of translanguaging to reconceptualize bilingualism as a liberating and empowering communicative practice, and a resource capable of transforming learning that goes beyond the transition to a dominant school language (Maldonado, Krause, & Adams, 2018).

Translanguaging is an interrelated communicative practice that makes up bilinguals' linguistic repertoire (Cenoz, 2017). To make meaning, speakers can use their languaging, bodies, multimodal resources, tools, and artifacts in dynamically coordinated, interconnected, and entangled ways (García, 2017). For learning mathematics, effective teaching must support translanguaging mathematical practice (TMP, see Figure 1) by encouraging fluid movement between mathematical and everyday speaking across languages (Morales, Jr. & DiNapoli, 2019). This includes using everyday linguistic features and mathematics register resources in dialogically entangled ways with the intention to make meaning (García -Mateus & Palmer, 2017). Classroom teachers supportive of TMP provide opportunities for bilingual students to use their linguistic, multimodal, and mathematical repertoire to make meaning as they persevere with challenging ideas.

Perseverance in the classroom is a cycle of initiating and sustaining in-the-moment productive struggle in the face of one or more obstacles, setbacks, or discouragements (DiNapoli, 2018). Because productive struggle can help develop mathematical meaning (Hiebert & Grouws, 2007; Middleton, Hatfield, Tallman, & Davis, 2015), we draw on the Three-Phase Perseverance Framework (3PP, see Figure 2) (DiNapoli, 2018) to help illuminate the ways in which students first wrestle with an uncertain mathematical situation, and, if necessary, how they amend their first effort to continue to make mathematical progress. Paramount for supporting student perseverance is selecting and enacting a mathematical task that supports student uncertainty (Bass & Ball, 2015; DiNapoli, 2018). Specific to Latinx bilingual learners, mathematical tasks necessitating perseverance should be complex enough such that students engage at all levels of language proficiency to help make their own connections (Driscol, Heck, & Malzhan, 2012), yet invite engagement

with multiple entry points and resources (Aguirre et al., 2012). For monolingual teachers of bilingual students, the enactment of these tasks must carefully preserve students' opportunities to translanguage to persevere.

Figure 1

Translanguaging Mathematical Practice

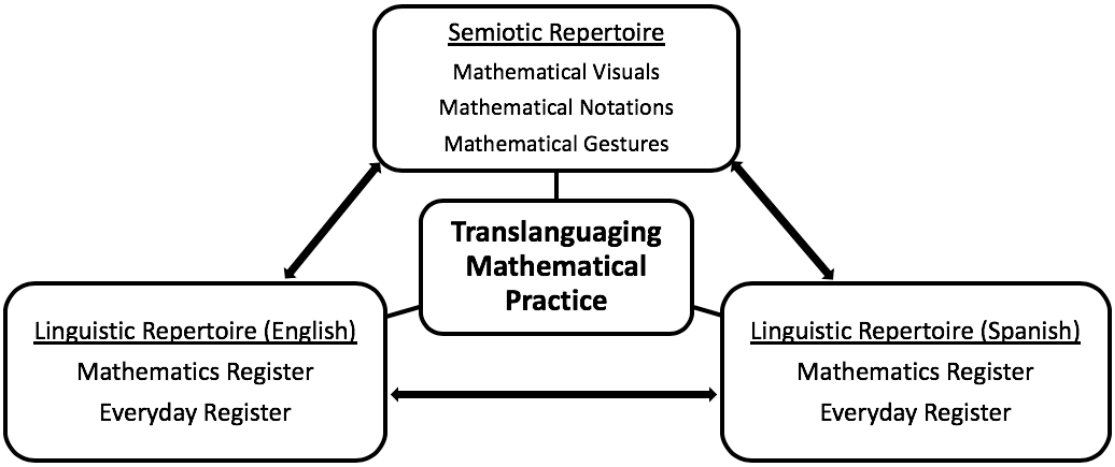


Figure 2

Three-Phase Perseverance Framework

Entrance Phase	
Clarity	Objectives were understood
Initial Obstacle	Expressed or implied that a solution pathway was not immediately apparent
Initial Attempt Phase	
Initiated Effort	Expressed intent to engage with task
Sustained Effort	Used problem-solving heuristics to explore task
Outcome of Effort	Made mathematical progress toward a solution
Additional Attempt Phase (after perceived setback(s))	
Re-initiated Effort	Expressed intent to re-engage with task
Re-sustained Effort	Used problem-solving heuristics to explore task
Outcome of Effort	Made additional mathematical progress toward a solution

Context, Participants, and Task

This study took place in an urban 12th-grade classroom (Morales, Jr., 2004). For this paper, we focus on one group of four Latinx bilingual students and their monolingual, English-speaking teacher. The students, Carina, Jessica, Elena, and Ines (all pseudonyms), were chosen because they had worked in the same small group for much of the school year and often leveraged their bilingualism when collaborating. Carina, Elena, and Jessica were born in the United States, but their parents were from Mexico. These three students had been enrolled in bilingual programs during their elementary grades and had transitioned into mainstream classrooms by the time they were in middle school. Each of them grew up speaking both Spanish and English at home, and they all stated that they felt comfortable speaking Spanish but not comfortable reading or writing in Spanish. Ines

was born in Mexico to Mexican parents, immigrated to the United States at age 12, returned to Mexico for 9th grade, and then returned to the United States to complete her high school education. Ines' formal educational experiences included speaking, reading, and writing in Spanish. These students represent typical students in the school with a history of average achievement in their mathematics courses. For all four of these students, Spanish has always played a major role in their meaning making process for mathematics.

The teacher, Ms. O (pseudonym), was a monolingual English-speaker with 20 years of mathematics teaching experience. Ms. O was trained by her school district to use the *Interactive Mathematics Program* (Fendel et al., 2015) curriculum and thus was a proponent of student-centered mathematical activities and problem-solving. Ms. O's pedagogy incorporated many aspects of Smith and Stein's (2011) *5 Practices for Orchestrating Productive Mathematical Discussions* and she often explicitly encouraged her students to collaborate with challenging mathematics in any language and use mathematical tools to explore multiple resources and representations while doing so. Ms. O was not formally trained to support translanguaging in her teaching.

The mathematical task with which Carina, Jessica, Elena, and Ines engaged was a multi-day activity necessitating perseverance. The Function Analysis Task was introduced by Ms. O and invited students to revisit a function (couched as a story) they had explored in a past unit. With this function, students were prompted to (1) describe the mathematical context and define the independent and dependent variables, (2) describe the utility of the function, and (3) describe the family of function mathematically (e.g., linear, quadratic, exponential, etc.). The group chose a function presented as a magical story in which a character's height is doubled by eating a special cake. From this story comes the basic principles for working with exponents and an introduction to exponential growth and decay.

The design and facilitation of this task supports Latinx bilingual students' perseverance by (a) encouraging collaboration with other Latinx bilingual peers, (b) involving the exploration of a familiar mathematical idea that was not yet well-formed, and (c) affording the autonomy to choose a past function and to describe its characteristics in their own way. Also, Ms. O explicitly stated that the students should work in any language with which they were comfortable.

Classroom Vignettes and Findings

Here we describe observations from Carina, Jessica, Elena, and Ines' engagement with the *Function Analysis Task*. This group exemplified translanguaging and perseverance practices while conceptually exploring exponential growth.

Translanguaging to Persevere on the *Function Analysis Task*

Consider the following vignettes from Carina, Jessica, Elena, and Ines' three-day collaboration around the *Function Analysis Task*. With Ms. O's help, this group demonstrated evidence of understanding the goal of the task during the last five minutes of class on Day 1. They read the task together and agreed on a past function to revisit, but they did not exactly know how to complete it. Beginning in Table 1, we share observations and analysis from this group's collaboration during the last 20 minutes of class on Day 2, as they made their Initial Attempt at solving without interaction with Ms. O.

The students made their Initial Attempt with the Function Analysis Task by coordinating their meaning making actions and deploying their linguistic repertoires. After reading, the students began to interpret the problem context and the nature of doubling. In dialogically entangled ways, they expressed linguistically across Spanish and English what doubling meant to them (e.g., double, two, dos, grows twice, sumando el mismo número, multiplicas por dos, times it). They also questioned how to represent their ideas symbolically, which demonstrates their productive struggle regarding understanding the nature of doubling. This translanguaging exchange is an example of students moving between everyday and mathematics registers across both languages, as well as drawing on mathematical gestures, notations, and visuals. Drawing on such resources is also evidence of the careful classroom culture Ms. O had cultivated, one that was supportive in students spending diligent effort using linguistic repertoires and multiple representations to explore the nature of the function. They did not,

Table 1

The Group's Translanguaging Practice in the Initial Attempt Phase of Perseverance

Transcript *(English Translation)*
JESSICA: ¿Qué era la primera, se hace así? *(What was the first one, do you do it like this?)* If [she] eats one ounce, that means that she grows twice, dos ¿qué? *(two, what?)* Double, no double, two…See, so when two is four, and then three is six, and four is eight, y así, y así vamos hacer la graph *(like this, and this is how we are going to make the graph).* Going like that [gesturing], para arriba *(up)*. You get it? **ELENA**: Um hmm. Pero *(But)*, how to times it?
JESSICA: Porque mira *(look)*, two, times two. Well no…Double it by, nomas *(just)* double the number of ounces, so if she takes… **ELENA**: Two times two, y luego *(and then)* four times two, y luego *(and then)* six times two, is that what you are saying?
JESSICA: Más o menos como sumando el mismo número. *(More or less like adding the same number.)* **CARINA**: Pero es lo mismo de sumando si lo multiplicas por dos. *(But it is the same as adding if you multiply by two.)*
INES: Lo que parece escomo hicimos un in/out table y ya lo sacamos. *(It looks like we just did an in/out table and that's it).* (See Figure 2, left) **CARINA**: Yeah. In times two equal out… ¿Ya no tenemos que hacer su altura? *(We don't have to use her height?)*

Table 2

The Group's Translanguaging Practice in the Additional Attempt Phase of Perseverance

Transcript *(English Translation)*
INES: Empezamos de cuatro pies. Si toma si come un pedacito son ocho, si come un pedacito son dieciseis, el tercer pedazo dieciseis y dieciseis. Treintaidos ¿no? *(We start at four feet. If she drinks, if she eats one piece it becomes eight, if she eats one piece it becomes sixteen, the third piece, sixteen and sixteen, thirty-two, no?)* **JESSICA**: Pero, ¿cómo sacastes eso? *(But how did you get that?)*
INES: Porque si empezamos con cuatro pies, como yo les digo, si come un pedacito y sale, aumenta de altura de doble [gesturing up]. *(Because, if we start at four feet, like I'm telling you, if she eats one piece and it comes out to, her height grows double (gesturing up)*). **JESSICA**: Ohh, her height doubles!
ELENA: You know it's the same thing mira *(look).* Dos *(two)*, you multiply one times two is two, two times four is eight, y si pones *(and if you put)* two times two is four, four times four is sixteen. **CARINA**: In squared times 2 equals your out.

however, immediately realize they were multiplying the number of ounces of cake by two, instead of the character's height. Their equation correctly spanned the table of values, yet these representations did not model an exponential function.

Not completely agreeing with the other students' mathematical representation, Ines' metacognition during their Initial Attempt helped collectively move the discussion in a direction that considered the character's initial height. The entire group collaborated around this new idea and persevered together as a learning community. Near the end of class on Day 2, Ines recalled her prior experience with this problem from her sophomore year and raised the issue of starting with an initial height. This helped the others rethink about the mathematics, cross out their first In/Out table (Figure 3, left), and they worked for about 10 minutes during class on Day 3 to think about starting a new one (see Table 2).

Ines tried to help the group understand that the character's initial height is necessary to compute subsequent heights. The task was written in English, yet Ines leveraged her native language to re-voice the problem. She modeled the concept of doubling using her mathematics register in Spanish, and she also mathematically gestured to demonstrate how the character's height doubles for each ounce of cake she eats.

This incited Jessica to have her moment of clarity, in which she realized the character's height needed to double, not the number of ounces of cake.

This translanguaging exchange exemplified further perseverance by exploring what it means to double and illustrated how this group became aware about the flaws in their first attempt to make sense of the function. What makes this so significant is the students' commitment to collaboratively and fluidly draw on their mathematical and everyday registers in English and Spanish as they continue to try to grapple with the concept of doubling. The combination of these interactions affords Jessica her liberating moment of understanding, which leads these students to amend their plan and adapt their thinking to continue to persevere.

Following this discussion, the students created a new In/Out table (Figure 3, center) that correctly modeled the character's exponential growth. This new approach demonstrated the end of their Initial Attempt and the start of their Additional Attempt by the group amending their plan and making a second attempt to make sense of the function. This new approach also demonstrated the interaction within TMP as they drew dialogically on their full semiotic repertoire by considering their mathematical visuals, notations, and gestures. Unfortunately, their equation was not correct and did not span all of their entries. Again, this is an important opportunity for the group to recognize more mistakes and continue to persevere.

Near the end of their time working on Day 3, the students used a graphing calculator to make a table of values for $y=2x^2$ (Figure 3, right) and discovered that it did not match their current table. Consequently, they were ready to continue to explore ways to change their equation and make another Additional Attempt, but time was up and Ms. O needed to move on to a discussion of solution processes. Although this group did not yet find the proper equation to span their In/Out table in this episode, they were agents of their own translanguaging repertoire and leveraged this practice to help persevere and think more deeply about exponential functions.

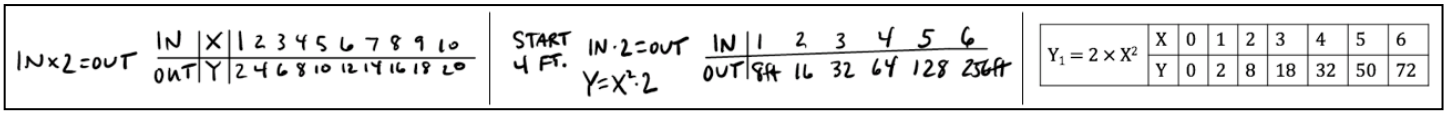
Discussion

Reflecting on these classroom episodes, we use Ramirez and Celedón-Pattichis' (2012) five guiding principles for teaching mathematics to Latinx bilinguals to help reveal the specific ways Ms. O fostered a classroom environment supportive of mathematics learning for her bilingual students. Consider the Five Principles: *challenging mathematical tasks, linguistically sensitive social environment*, *support for learning English while learning mathematics*, *mathematical tools and modeling as a resource*, and *cultural and linguistic differences as intellectual resources*. These principles articulate effective ways to engage Latinx bilinguals to persevere with rigorous mathematics while engaging in TMP. In the vignette we shared, Ms. O's careful efforts were mostly in preparation with intent to build a classroom culture that aligned with Ramirez and Celedón-Pattichis' (2012) principles and supported Carina, Jessica, Elena, and Ines' translanguaging to persevere. We believe it was the building of this classroom culture that helped lay the foundation for the mathematics learning of this group of Latinx bilingual students.

Carina, Jessica, Elena, and Ines' meaning-making trajectory was one filled with rich translanguaging practice and authentic productive struggle. The thoughtful selection of a challenging mathematical task designed with several supports for bilingual learners demonstrates Ms. O's commitment to nurturing her bilingual students toward mathematical understanding, as well as her commitment to gain knowledge and training, since nurturing alone may not always be enough. Assigning the Function Analysis Task was an important decision because it allowed students to access mathematical ideas through their prior work and created an environment conducive for productive struggle. When introducing the task, Ms. O insisted her students use their native language to engage with the mathematics, which suggests that she genuinely intended to create a productive, inclusive, and linguistically sensitive learning environment. It was

Figure 3

Progression of the Group's In/Out Tables (recreated by authors)



within this environment that Carina, Jessica, Elena, and Ines spontaneously leveraged each other's linguistic repertoire and viewed their linguistic resources as assets to help persevere past obstacles and make progress toward a solution. Ines' strong academic discourse in Spanish was particularly celebrated and played a crucial role in the meaning making process for the group.

Ms. O also encouraged collaborative learning to allow her students to communicate with each other in their groups. Such emphasis on student-to-student communication in any language suggests Ms. O believes that cultural and linguistic differences are intellectual resources and valuable to the meaning-making process when learning mathematics. Additionally, Ms. O encouraged her students to first read their textbook in English and then discuss the mathematical meaning in both English and Spanish. This supported their language and literacy development by helping make the mathematical content more comprehensible. Further, Ms. O intended to create a classroom environment where using mathematical tools was the norm. Students' understandings were mediated by the use of the graphing calculator, In/Out tables, and other multimodal visual and symbolic representations. Access to these mathematical tools proved to be instrumental in the ways in which the group persevered past their mathematical obstacles.

Carina, Jessica, Elena, and Ines' engagement within Ms. O's classroom illustrates how an effective learning environment can be established by a monolingual teacher of bilingual students. In our view, Ms. O thoughtfully established her classroom culture with strategies aligned to Ramirez and Celedón-Pattichis' (2012) five guiding principles for teaching mathematics to Latinx bilinguals to ensure that her bilingual students had the time and space to productively struggle with a well-designed task. It was the careful planning of the classroom environment that helped nurture the group's evolving mathematical understanding of exponential functions. Although Ms. O advocated for native language use, we recognize it can be difficult for monolingual teachers to view bilingualism as an asset and not yet truly understand the advantages of translanguaging practice for learning with understanding (Maldonado, Krause-Rueda, & Adams, 2018; Mazzanti & Allexsaht-Snider, 2018). We encourage future scholarship to help connect research to practice in ways that help monolingual teachers recognize examples of powerful classroom practices to support the meaning-making process for Latinx bilinguals, as well as to develop a belief in the educational value of bilingualism.

Conclusion

This paper offered a description and discussion of a group of Latinx bilingual students' translanguaging and perseverance practice as they collaborated to make meaning of an exponential relationship in a supportive classroom environment. We hope the reader appreciates the intentions of the monolingual, English-speaking teacher, Ms. O, and learns from her effective practices that informed task selection, design, and enactment. The students' engagement within Ms. O's classroom environment demonstrates inspiring collaborative activity and is a true example of translanguaging to persevere within the context of learning mathematics with understanding. We also hope the reader appreciates that more work is needed to support teachers like Ms. O to recognize what the process of meaningful learning looks like, especially for bilingual students. Bilingual learners need explicit support to encourage translanguaging and perseverant practice, and this study shows that teachers also need ample support to consistently facilitate such student engagement.

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Discussion And Reflection Enhancement (DARE) Post-Reading Questions

1. What methods would you suggest for encouraging bilingual learners' translanguaging to persevere?
2. What advice would you give Ms. O (or teachers like her) when she enacts the Function Analysis Task next time? Is there a way to root your advice to mathematics education research?
3. Is it enough for teachers to just allow their bilingual students to work in their native language? What do you think were some of the challenges Ms. O faced supporting her bilingual learners? Identify and talk through the challenges posed by having bilingual students work in their native language.