

Modeling in Languages, Languages of Modeling: Integrating Science Practices and Translanguaging Practices

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Abstract: Contemporary research demonstrates that students can leverage hybrid resources for complex and rigorous disciplinary thinking (e.g., Moschkovich, 2015) and that linguistic and disciplinary practices can be integrated to support meaningful classroom science practices (e.g., Hudicourt-Barnes, 2003). We extend this research by leveraging a syncretic approach (Gutiérrez & Jurow, 2016) to blend scientific modeling practices with everyday translanguaging practices in a generative way that leverages linguistic diversity in service of inquiry. In a design study conducted in a 6th grade STEM classroom as part of a 9-week ecology unit, we explore the ways that students appropriated and transformed modeling and translanguaging practices. We focus on two syncretic practices that capitalize on parallels between modeling and translanguaging: (a) translating as a part of modeling and (b) using language and conversation as metaphors for interpreting and creating multimodal models. In this context, syncretic modeling and translanguaging practices contributed to productive science discourse by helping students (a) to understand complex phenomena, (b) to express ideas, and (c) to legitimize diverse linguistic and representational practices.

Objectives and significance

This paper addresses two forces shaping science education. First, a new wave of reform emphasizes engaging students in science practices (e.g., Duschl, Schweingruber & Shouse, 2007; NGSS Lead States, 2013; Östman & Wickman, 2014). Second, broadening participation in science to include bilingual students is increasingly urgent. Students classified as English Learners (EL) are the fastest growing subset of the U.S. student population (National Center for Education Statistics, 2018), and over 21% of school-age children speak a language other than English at home (U.S. Census Bureau, 2012). Science education with bilingual learners has historically emphasized English learning as a pre-requisite for engaging in disciplinary practices. Yet, academic English is neither necessary nor sufficient for learning (Lee, Miller, & Januszyk, 2014). Instead, contemporary research promotes engaging students in language-intensive science practices (e.g., Pearson, Moje, & Greenleaf, 2010), finding that students can leverage and integrate hybrid resources (e.g., language, drawing, and gesture) to engage in rigorous disciplinary thinking (Moschkovich, 2015). Moreover, research demonstrates that similarities between linguistic practices and disciplinary practices can be integrated to support the development of meaningful classroom science practices (e.g., Hudicourt-Barnes, 2003). Gutiérrez and Jurow (2016) propose an approach for linking and leveraging everyday and professional practices in service of equitable and consequential learning. Within Gutiérrez and Jurow's framing, a *syncretic* approach to design aims to connect and reorganize everyday and disciplinary practices to create new forms of knowledge and expertise. They illustrate this approach with a design intended to help high school students from migrant farmworker backgrounds develop sociocritical literacies. Their design included the creation of syncretic texts, which reorganized everyday and school-based genres including: *testimonios* (a form of historicizing narrative), expository essays, and extended definitions. These syncretic texts were valued in formal settings and by the students and their communities (Gutiérrez & Jurow, 2016). Following this syncretic approach, we aim to help bilingual students and their monolingual peers (1) blend aspects of everyday translanguaging practices with disciplinary modeling practices, supporting students in appropriating and transforming these practices in a generative way that leverages rather than suppresses linguistic diversity.

Theoretical framework

We focus on scientific *modeling* and everyday *translanguaging* practices because they are used for similar purposes: creating representations that bridge boundaries across discourses. Modeling allows scientists to generatively collaborate across areas of expertise (Galison, 1997), and translanguaging allows bilinguals to communicate across the political and social boundaries of languages (García & Kleyn, 2016). This similarity in purpose results in parallels between practices; both practices involve (a) multimodal representations (Bialystok & Barac, 2012; Blackledge & Creese, 2017; diSessa et al., 1991; Gouvea & Passmore, 2017; Moschkovich, 2015) and (b) mapping across representations with attention to correspondence and salience (Canagarajah, 2013;

Jiménez et al., 2015; Latour, 1999; Nersessian, 2008). We propose that the structural similarities between modeling and translanguaging could be leveraged to position these practices as complementary. Modeling and translanguaging are both difficult to support in K-12 contexts. Helping students see these practices as connected could contribute to their engagement in both modeling and translanguaging practices (Blikstein, Fuhrmann, & Salehi, 2016; Cole et al., 2016; Schwarz et al., 2012; Sengupta, Dickes, & Farris, 2018).

In this study, we explore the potential of linking modeling and translanguaging as complementary practices. The high-level conjecture guiding our work is that integrating scientific modeling practices and everyday translanguaging practices could support productive science discourse. We explore this conjecture in the context of our design by creating opportunities for students to: (a) engage in translation as a part of modeling and (b) use language as a metaphor for making sense of multimodal models and the phenomena they represent. Drawing on parallels of multimodality and mapping, we have identified mediating processes (italicized and elaborated below) that could link syncretic practices to outcomes of productive science discourse.

We conjecture that translating across modes and languages could help students *see phenomena from new perspectives*, because meaning shifts in translation (Bezemer & Kress, 2008), and because students' linguistic resources are connected to unique experiences and understandings (e.g., Pacheco & Smith, 2015). Shifts in perspective could help students understand complex phenomena (like ecosystems and population dynamics) in increasingly nuanced ways as they *compare representations*. The new understandings that arise from translation could help legitimize diverse representational and linguistic resources for science. Legitimizing multimodal and multilingual resources could, in turn, help students leverage their full representational and linguistic repertoires in science, supporting them in building understanding and expressing ideas (e.g., Moschkovich; 2015).

Attending to language could highlight for students that there are some ideas they do not know how to describe with language. Encouraging students to *create or appropriate language* to describe these ideas could help them develop new understandings of phenomena, because naming an idea requires identifying and capturing salient features (diSessa et al., 1991). Creating and appropriating language could also add to students' repertoires for expression. As students' resources for expression increase, so do their opportunities for *selecting among representations*, which could help them build understanding as they shift among perspectives (Pacheco & Smith, 2015) and consider correspondence and salience between representations and phenomena (e.g., Nersessian, 2017).

Comparing representations could also help students *consider the affordances of representations* for understanding and expression, a practice valued in scientific modeling (Nersessian, 2017) that could contribute to students' capacity for expression (diSessa et al., 1991). In terms of language, Bialystok and Barac (2012) find that bilingual individuals demonstrate increased awareness of the structural features of languages. They attribute this difference to bilingual individuals' frequent need to differentiate between representations of an object or idea as they choose among potential translations. We conjecture that during modeling activities, translating between languages and modes could help students consider the affordances of representations for building understanding and expressing ideas. The metaphor of modes and models as languages and as speakers in conversation could help students: (a) differentiate between modes, model types, and languages; (b) compare the content foregrounded by different representations; and (c) consider the affordances of different representations for understanding and expression. Recognizing that modes, model types, and languages have unique affordances for understanding and expression could help legitimize diverse languages and representations as resources for science.

Because this design is still evolving, in this paper, we do not focus on evaluating specific features of our design. Instead, we use the design as a context in which we explore the promise of integrating modeling and translanguaging for supporting productive science discourse. We ask, in this context: (a) How do students engage in translation as a part of modeling? and (b) How do students use language as a metaphor for making sense of multimodal models and the phenomena they represent?

Research context and methods

The current design study (Cobb et al., 2003) was conducted in a public middle school in the southeastern United States. According to the state report card, 18% of the school's students qualify for free or reduced lunch. The students are culturally and linguistically diverse: 55% of students identify as White, 34% as Hispanic or Latino, 7% as Black or African American, and 4% as Asian. In addition, 8% are classified as English Learners. The study was conducted in collaboration with a STEM teacher, Ms. S, who was in her 26th year of teaching. Ms. S's 6th grade STEM class participated in the project (20 students). Five students were classified as English Learners (all speak Spanish at home). Ms. S and the first author, Ashlyn, codesigned and cotaught the lessons for the project. Lessons took place three times a week during the students' 56-minute STEM class over the course of 9 weeks for a total of 23 class sessions. The unit was designed to support state and NGSS ecology standards.

This study is part of the larger SAIL+CTM project (NSF DRL-1742138). This paper analyzes data from the fourth cycle of the design, which occurred January-March 2019, because that cycle focused specifically on

syncretic modeling and translanguaging practices. All iterations of the design foreground modeling, a practice that affords students opportunities to reason and express ideas across multimodal tangible and testable representations, facilitating argumentation and explanation (Lehrer & Schauble, 2015). The unit is framed by two challenges: students design (a) a biosphere – a closed-system physical model that includes plants, snails, and guppies and (b) a computational model that represents a larger ecosystem of plants, guppies, and guppies' competitors and predators. Throughout the unit, the students gather information and re-represent the guppies' environment with increasing complexity. In this iteration of the design, opportunities for (a) translating as a part of modeling and (b) using language as a metaphor for modeling were embedded within learning activities.

Data sources include whole class data and data from focal students. Focal students were selected with input from the 6th grade teachers to represent a range of backgrounds, academic performance, and engagement. To understand the resources and experiences of bilingual students participating in the study, we selected three bilingual focal students classified as EL (Jennifer, Carlos, and Luis). To understand how practices were valued, appropriated, and transformed by monolingual students, we also selected three monolingual focal students (Nora, Alexis, and Sam). We collected all student work to trace the multiple modes, including languages, used by students in modeling. Two cameras positioned on opposite sides of the classroom captured classroom discourse. For focal students, we used computer screen recordings to follow the ways that students engaged in modeling. Each focal student used a laptop with Camtasia, which records students interacting with their computers. We conducted interviews with focal students to triangulate their enactments of classroom practices with their experiences.

Our analysis uses methods of inductive coding and constant-comparative analysis (Charmaz, 2006; Strauss & Corbin, 1990). Using whole class and focal student videos and interviews, we began by identifying instances of students engaging in translation as a part of modeling and using language as a metaphor for modeling. Then, we considered the ways that modeling and translanguaging practices might help students learn science, specifically focusing on productive science discourse. In this context, we operationalized productive science discourse as interactions mediated by representations that helped students: (a) understand complex phenomena, (b) express ideas, and (c) legitimize diverse linguistic and representational practices.

RQ1 findings: Translating as a part of modeling

In this context, translating as a part of modeling showed promise for supporting productive science discourse, both when students translated between “named” languages, like English and Spanish, and when they translated between invented languages that they created. With the examples below, we show how translating as a part of modeling helped students understand phenomena, express ideas, and legitimize diverse linguistic resources.

To demonstrate how translating between “named” languages contributed to productive science discourse, we describe how Jennifer, a bilingual student classified as EL, translated during modeling. Jennifer leveraged her own and her peers' linguistic repertoires as well as a tool (Google Translate) to add Spanish terms to her diagrammatic biosphere and food web models. When creating their biosphere plan, Jennifer's group delegated a language to each student, and Jennifer was responsible for translating academic English to Spanish. This approach initially seemed to reify the idea of one-to-one correspondence between ideas and “correct” linguistic representations. However, “correctness” was problematized as Jennifer compared translations and built confidence in her linguistic resources. On Day 10, Jennifer used Google Translate to “check” her translations, erasing her own translations (for example, “piedras” for rocks) and replacing them with Google's (“rocas” for rocks). There was one exception: Google's translations for “male guppy” (*masculino*) and “female guppy” (*hembra*). Jennifer preferred her own translations, “pescado hembra” and “pescado hombre.” Jennifer's critical evaluation of Google's translations in this case and others may have contributed to confidence in her own resources. On Day 15, Jennifer used Google Translate for terms she did not know in Spanish, but she did not defer to Google's translations over her own. For example, her translation for “sun” (*sol*) remained on her poster even after Google Translate provided “dom,” an incorrectly inferred abbreviation for “domingo” (Sunday). Luis and Carlos also began to use Google to translate academic English terms, otherwise relying on their own resources. These examples suggest that selecting among translations can legitimize and add to students' expressive resources.

Our data also suggest that translating during modeling can help students develop nuanced understandings of phenomena. Translating offers students opportunities to attend to correspondence and salience, because their translations of the same term are context-dependent. For example, Jennifer selected different translations to label guppies. In the biosphere plan she used “pescado hombre” and “hembra,” but in the food web she used “guppy.” This is likely because the gender of the guppy was significant in the biosphere (a male and female guppy might reproduce), but not in the food web, which depicts one guppy. Moreover, in the food web, there were multiple types of fish – the more precise term “guppy” was necessary to distinguish the guppy from other fish. Jennifer's translations were context-dependent; the terms she chose were linked to the science content she was representing.

In addition, translation has the potential to enrich and add nuance to students' understanding of science

content by helping students see phenomena from new perspectives. In their interviews, Luis, Carlos, and Jennifer all said that using different languages changed how they thought about ideas. Jennifer explained how translating enriched her understanding of science content, even when she did not know the Spanish translation for an English term: “In English, it’s like ‘food chain’ and you know, like, it has to be connected to something because of the word ‘chain,’ and in Spanish you have to think of, like, multiple words to describe the food chain because, like, in Spanish there’s not really a word to describe food chain, so you have to, like – a sentence will describe a food chain, not just like saying two words.” Jennifer was not familiar with a Spanish term for “food chain” (e.g., “trófica” or “cadena alimentaria”), possibly because this term is more common in academic rather than everyday settings. Even so, considering how to translate the phrase created an opportunity for Jennifer to unpack and consider the meaning of “food chain.” She considered how “chain” connotes connection between organisms, facilitated by thinking of “multiple words to describe the food chain” in Spanish. Although we did not capitalize on this opportunity, it is possible that introducing Spanish terms like “trófica” could also help students learn cognate academic English terms (trophic), creating opportunities for bilingual language development as students connect non-English language resources to academic English terms and their roots.

In this classroom, students also created terms to describe phenomena that emerged as important. These practices created opportunities for students to understand phenomena, express ideas, and legitimize diverse linguistic resources. Students’ need for new terms was most evident during computational modeling activities, in which students observed common problems and patterns in their computational ecosystems. Ms. S created an opportunity for students to explicitly reflect on the creation and meaning of a class term on Day 17. Shared language had not yet emerged to describe a pattern in the computational model’s graph when the ecosystem was relatively stable, although this phenomenon is central to population dynamics. When asked to describe the pattern, students often mimicked the shape of the graph with a hand gesture. As this phenomenon became central to students’ discourse, Ms. S asked students to nominate English, Spanish, and invented terms to describe the pattern, legitimizing linguistic resources beyond academic English. Luis offered English, Spanish, and invented language: “We did fluctuate, *balanciado*, and we also made up a word. It’s from balanced and graph. It’s a *balagraph*.” These examples show the wealth of linguistic resources that students brought to interpreting the pattern. This activity enabled students to draw on their full linguistic repertoires to consider what was salient about the pattern, enriching their understanding of the phenomenon. Moreover, these terms stabilized a way of interpreting the graphs in the computational model, helping students make sense of these canonical representations.

In addition to whole group enactments of this practice, one small group created terms while modeling. On Day 10, Becca and Jesús created language that mimicked computer code for their biosphere plan. Including “code” in the model created an additional opportunity to engage in translation as a part of modeling. Broadly framing code as a language allowed Becca, a monolingual English speaker, to participate in a form of translanguaging. Whereas Becca’s participation in English-Spanish translation was limited, translating to code-language created an opportunity for Becca to unpack academic English terms and the ideas they represent, similar to how Jennifer unpacked terms like “food chain” as she translated between English and Spanish. In addition, translating to code-language offered Becca and Jesús a new way to express ideas, legitimizing linguistic resources beyond academic English and destabilizing English-only practices for monolingual and bilingual students. Classifying components of the biosphere created categories that would not have been evident with English or Spanish labels alone. Jennifer, who was not actively involved in creating code-language, noted this affordance both in her presentation of the biosphere plan in a gallery walk and in her interview almost two months later, describing the code-language as “specifying things more” than English and Spanish. Thus, creating code-language was an opportunity for students to express ideas and develop a precise articulation and understanding of the components of the biosphere and how they were related to each other while legitimizing new linguistic resources.

However, some classroom dialogue challenged language diversity and translating as a part of modeling. In Group 3, Sean seemed to feel excluded when Luis and Carlos used Spanish in their models. When working on the groups’ biosphere plan on Day 10, Luis initially used Spanish and pictures, limiting Sean’s perceived opportunities to contribute to the model. Sean said that he “can’t read Spanish” and implied this prevented him from understanding the model, challenging the use of Spanish in the biosphere plan several times. In our data, only two students (Sean and Jasper) challenged the use of Spanish as a part of modeling. Still, it is important to consider the ways that monolingual students might respond to multilingual practices, because monolingual students also shape the practices that are valued and accepted within the classroom community. Experiences like Sean’s reflect larger societal discourses, which prioritize English over other languages. Such experiences could contribute to monolingual students’ preferring English-only representations, defining what counts as “appropriate” participation in science in relation to dominant interests. It is important to note that students classified as ELs may frequently have similar experiences in majority monolingual English contexts like school,

where academic English is typically prioritized. Although challenging language diversity seems to reify the dominant script by supporting English-only norms, explicitly acknowledging and questioning linguistic diversity can be a first step to destabilizing English-only discourse (Gutiérrez, Rymes, & Larson, 1995). In future iterations of this design, we hope to reframe experiences like these as opportunities to help monolingual English-speakers empathize with students classified as ELs, and we hope to encourage dialogue that helps students consider the affordances of language diversity for themselves and others.

RQ2 findings: Language as a metaphor for modeling

In this section, we illustrate the promise of using language and conversation as metaphors for creating and interpreting multimodal models. We show how, in this context, metaphors of language and conversation helped students consider the affordances of modes and model types for understanding and expression (c.f., Sengupta, Dickes, & Farris, Forthcoming 2020). Putting models in conversation also helped students develop increasingly nuanced perspectives of ecological phenomena, because different models provided unique perspectives of phenomena. Our data suggest that these experiences helped legitimize diverse representations as valuable tools for understanding and expression in this classroom.

Identifying modes is a first step that can later support students in analyzing and selecting among modes and models in service of understanding and expression. To help students identify modes, we framed modes as languages, capitalizing on parallels between modes and languages: different modes (and languages) can be used to express the same idea, but different modes (and languages) may have unique affordances for sensemaking and expression. Throughout the unit, students were encouraged to identify and share the “languages” used within their models. For example, during the biosphere plan gallery walk, Luis said: “I used English, Spanish, and pictures for languages. Then I have a key over here that uses stickers, and that’s for the algae, because I just spread the algae all around...we just used different languages to describe what they use for energy, what they breathe.” In this description, Luis broadly conceptualized languages as including English, Spanish, visual modes (pictures), and symbolic modes (stickers).

Identifying modes can provide a foundation for more complex practices. We also encouraged students to put modes and models “in conversation,” capitalizing on the analogy of conversations to support students in comparing how ideas are represented across modes and models. Our data suggest that this lens can help students attend to ways that meaning shifts between representations. For example, in his interview Carlos explained how modes “talk to each other” within his computational model:

They talk to each other and combine to each other because if you look at this [the graph] it will show all the- the algae went down fast, so did the oxygen, oh but the algae went up again because the death of the guppies, and then it shows that the cichlids are almost dead, died out, and the clock speaks because if you could tell the model, if you set it up again, it starts at 1 and the population is 2 and those speak together because every time they move you could see, “oh, there’s six cichlids, oh there’s six guppies, oh it’s been barely 17 or 18, 19 seconds.”

Using a metaphor of conversation, Carlos coordinated data, attending to dynamic modes to understand complex ecological interactions. He coordinated between two dynamic lines on the graph (“the algae went up again because of the death of the guppies”), the simulation (“it shows that the cichlids are almost dead”), and information from the clock and data boxes, which “speak together” to report the time and the population of each species. In their interviews, all six of the focal students described how modes within models “talk to” or “learn from” each other.

Framing modes as making unique contributions to a conversation positions models as valuable for their unique context-dependent affordances, legitimizing diverse representational resources. Group 2 (Jasper, Driana, and Luna) and Group 5 (Sam, Alexis, Adam, and Darius) demonstrated this perspective when they compared their food webs. Canonically, arrows point from an energy source to the organism(s) acquiring energy. Group 2’s model used arrows in this conventional way. In Group 5’s model, arrows instead pointed from an organism to what that organism ate. In their presentation, rather than framing one model as “more correct” or “better” in an absolute sense, Sam described how each model showed a different way of understanding energy transfer: “On ours, it shows what each animal eats, and on theirs, it shows what energy it gives off to different animals.”

Considering the affordances of different modes can help students develop resources for expressing ideas to different audiences. During the biosphere plan gallery walk, Carlos described choices that his group made to increase the communicative power of their biosphere plan. He explained, “We used English and Spanish, color coded it, and numbered it, for then you can quickly see the colors and be like, oh, over here- that’s that.” In contrast to the quick visualization offered by color-coding, Carlos explained that the text in the model could “add more detail and specific thoughts.” He also explained why he chose to assign numbers to each sticker color: “Right

here as you can see there's little numbers... if you were colorblind, like Hunter, you could read the numbers."

Conversations between different model types also helped students consider the affordances of representations for understanding and expression. For example, on Day 17, Ms. S asked students to compare computational and physical models as they recorded data from their biospheres. When a student responded, "we don't have fish dying in our jars," Ms. S asked, "why can we see fish dying in the computational model, but not in the jar?" Students identified several differences between representations:

Luis: In the computational model we can speed up time.

Ms. S: What else?

Luis: You can set reproduction and energy rates.

Ms. S: Can you do that in your jar? Why would that be important to a scientist?

Jane: So you can see how much—what a real fish needs.

By putting models in conversation, Ms. S created an opportunity for students to reflect on the affordances of representations for understanding and expression (for example, computational models are good for making predictions because they can "speed up time" and their parameters can be adjusted to "see what a real fish needs").

Our data suggest that putting models in conversation also offered students new perspectives of phenomena, helping them understand ecological phenomena in increasingly nuanced ways. For example, students used the computational models to interpret phenomena in their biospheres, including the amount of dissolved oxygen in the water. Jasper shared his data:

Jasper: Our oxygen was 4.7 [mg/L] yesterday and it is 4.8 today.

Ms. S: Your number went up? And you have how many fish?

Jasper: Two fish, one plant.

Ms. S: Why do you think that's happening?

Jasper: I think that might be kind of normal because when we were looking at the [computational] model yesterday the carbon dioxide and oxygen were fluctuating.

Above, Jasper used the computational model to explain oxygen volatility in a different model – his biosphere.

In summary, in this classroom, using language and conversation as metaphors for modeling supported productive science discourse. These metaphors helped students express ideas by helping them engage in abstract modeling practices, including: identifying modes, comparing the content foregrounded by representations, and considering the affordances of representations. These metaphors also helped students take on new perspectives of the phenomena they were exploring, contributing to new understandings. Simultaneously, recognizing the unique affordances of modes and model types helped students value diversity in representations.

Conclusions and implications

In this study, we aimed to create a context that allowed and encouraged syncretic modeling and translanguaging practices – specifically, translating as a part of modeling and language as a metaphor for modeling. Translating as a part of modeling invites students to use their linguistic resources in new ways. In this classroom, translating as a part of modeling positioned Spanish as a resource for science learning. This practice put students' full linguistic repertoires in contact with the disciplinary ideas (e.g., food chains) represented in their models rather than positioning Spanish as a language to be used only in small-group or social conversations. Translating to appropriated and invented terms offered both monolingual and bilingual students an opportunity to critically examine terms (e.g., balagraph, balanciado) and structural features of language (e.g., code-language) as models of the phenomena they were representing. As it is enacted in K-12 settings, modeling alone does not always invite students to use diverse linguistic representations or carefully attend to the ways that language represents ideas. Our data suggest that linking translating and modeling can encourage students to leverage their full linguistic repertoires to build nuanced understandings and to create and interpret representations of phenomena. Furthermore, language offers students a metaphor for considering affordances of different modes and models, and conversation offers students a metaphor for coordinating and thinking across representations. Helping students compare and combine models is challenging, particularly when models represent different scales or aspects of a phenomenon (Blikstein et al., 2016; Schwarz et al., 2012; Sengupta et al., 2018). Our data suggest that the metaphors of language and conversation can help students use models together to develop understandings about a larger ecological system by drawing on their prior social experiences of conversations.

Our findings illustrate the promise of syncretic modeling and translanguaging practices for supporting productive scientific discourse. We argue that these practices are syncretic not only in their design, but also in their enactment; each contributes to overlapping and interwoven mediating processes, which have the potential to shape to students' understandings, practices, and values. Furthermore, each outcome has the potential to amplify the others. Legitimizing languages and modes beyond academic English invites students to leverage linguistic and representational resources they might not otherwise use in a classroom context. Understanding and expressing ideas using these resources can further legitimize these modes as resources in science.

In addition to identifying and refining these productive pathways, we have also identified challenges that suggest revisions to our design. For example, in Group 3 (Luis, Carlos, and Sean), Sean argued against Spanish because he “can’t read” it. In this study, we missed the opportunity to leverage Sean’s feelings of exclusion as a resource to reframe translanguaging. We might have drawn on these feelings to help Sean and other monolingual students consider the experiences of peers classified as ELs in school, where English is prioritized. Helping monolingual students empathize with peers and recognize that representations inaccessible to them may have value for others could contribute to a community that is more inclusive of language diversity. Furthermore, language diversity could be framed as an opportunity for linguistic development for monolingual students. Connecting colloquial Spanish with academic English could help students see languages other than English as valuable for learning academic vocabulary. For example, “respirar” is a cognate more similar to the academic English “respiration” than its colloquial English translation (breathe). It is also possible that allowing monolingual students to add new languages to their models using resources like Google Translate could help them feel included in translanguaging activities. This type of engagement in modeling would not offer the same learning opportunities as translating offers a bilingual student, because it would not create the same opportunities for mapping across languages with attention to correspondence and salience. Still, it could contribute to a more linguistically sensitive classroom, potentially challenging the English-only discourse often privileged in school. Further research is needed to explore these and other design features that could support productive engagement in syncretic modeling and translanguaging practices.

There is still much to learn about designing to support inclusive science practices, particularly in linguistically diverse classrooms. Exploring connections between modeling and translanguaging is one way to more deeply understand students’ resources for science learning. To realize the science-as-practice perspective at the heart of reform, we need to further explore syncretic approaches to cultivate students’ everyday practices as a part of equitable and inclusive classroom science practices.

Endnotes

- (1) From the perspective of translanguaging, “bilingual” and “monolingual” are socially constructed; there is no threshold of linguistic knowledge that distinguishes between monolingual and bilingual students. Still, these categories are important in discussions of social identity and sociolinguistic behavior (Otheguy, García, & Reid, 2015). We use “bilingual” to describe students who identified as bilingual and used more than one language (in or out of school). We use bilingual rather than multilingual for consistency with literature (e.g. García, 2009; Otheguy et al., 2015) and because we did not observe students drawing upon more than two languages in our data. We use “monolingual” for students who did not identify as bilingual and used English almost exclusively for speaking and writing. We recognize that “monolingual” students can leverage other resources, like gesture and drawing, and sometimes use resources from multiple languages.

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