Chapter 4
Science Teachers' Views on the Integration of Science and Language for Emergent Bilinguals in Grade Sixth Classrooms

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4.1 Introduction

Emergent Bilinguals (EBs), students who are learning a language other than their home language, face double challenges in learning content while developing English language skills in science classrooms. Adolescent emergent bilinguals are often placed in simplified science courses and have less access to advanced science courses (Thompson, 2015). To increase these students' access to challenging science, researchers have proposed that integration of science teaching with English language acquisition to help EBs simultaneously learn content and language in the classroom (Lee et al., 2019; Stoddart et al., 2002). In this scenario, the teachers' role is essential for the design and implementation of language-rich and inquiry-based science instruction that provides authentic and meaningful opportunities for students to read, write, talk, and engage in evidence-based argumentation to justify claims (Osborne, 2010). The issue is that these opportunities will not be incorporated in science classrooms unless the teachers view these activities as effective, meaningful, and practical (Hutner & Markman, 2016; Richardson, 1996).

This study stems from a larger project named Dialogic Inquiry for Socioscientific and Conceptual Understanding in School Science (DISCUSS). The purpose of DISCUSS was the development of a curriculum that integrated meaningful opportunities for English language acquisition while learning concepts regarding space science. Our research team comprising of two faculty, a postdoctoral researcher, and

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doctoral students in the areas of science education, bilingual education, and social studies, partnered with three sixth-grade science teachers and a science specialist in a local urban school district with an average of 40% EBs. The research team developed a four-week unit on a Socioscientific Issue (SSI) – Space Exploration during the summer term. After meeting with the school team for feedback, the topic of space exploration was chosen because it is geographically relevant to students in Houston and aligns with the district's sixth-grade science curriculum pacing guide which provides timelines for covering the content standards during the academic year. The unit addressed a central contestable question: Should the U.S. government increase funding for space exploration?

This qualitative study had two purposes. First, we explored middle school science teachers' views about science and language integration and emergent bilinguals to understand how views impacted teacher choices and practices. Although the DISCUSS project did not intend to examine teacher views as an intervention outcome, we fully recognize that views play a critical role in teacher decision-making and are of great interest to this research work. Views are defined as, "ontological, epistemological, and ethical commitments" (Mathews, 2009, p. 642). Examining teachers' views are important because they consist of sets of beliefs regarding a topic, such as phenomena, interests, or field of study (Dagher & BouJaoude, 1997). For example, scientific views consist of various sets of beliefs about science, such as the origins of science, scientific phenomena, scientific activities, and processes, as well as the limits of science and scientific knowledge. Since beliefs about teaching and learning can influence the choices teachers make in the classroom (Bryan, 2012; Hunter & Markman, 2016), understanding teachers' views provides an avenue to explore teacher choices. In addition, how a teacher views students influences what they think students are capable of and impacts their expectations of students (Cummins, 2000).

The second purpose of this study was to document and reflect on successes and challenges resulting from the development and implementation of a literacy-infused SSI-based curriculum in sixth-grade classrooms with predominantly emergent bilinguals. Drawing on previous literature on teacher resistance to pedagogical and ideological changes (Rodriguez & Kitchen, 2005), we unpacked institutional, ideological, and epistemological barriers for teachers to fully implement the integrated DISCUSS curriculum.

In this chapter, we first reviewed the literature on socioscientific issues and science education, teachers' views about science and literacy integration, and emergent bilinguals. We then describe the methodology used in this study and identified themes that emerged from the data about teacher views, followed by discussions about the implications for teacher preparation and teacher professional development for working with emergent bilinguals. Finally, we reflected on the challenges in developing and implementing language-inclusive science curriculum and pursuing external funding to continue this work.

4.2 Theoretical Framework

In this chapter, we view our work through the Culturally Relevant Pedagogy (CRP) framework. Ladson-Billings identified the need for a culturally relevant theoretical perspective that addressed the growing disparity between the racial, ethnic, and cultural characteristics of teachers and students (1995a). To address this, she coined culturally relevant pedagogy (Ladson-Billings, 1995b) to describe "a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural references to impart knowledge, skills, and attitudes" (Ladson-Billings, 1994, p. 18). Gay (2010) described culturally relevant teaching (CRT) as "using the cultural knowledge, prior experiences, frames of references, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them" (p. 31). Gay's CRT adapted Ladson-Billings' CRP further extended its definition by explaining that CRT is a combination of multiple pedagogies using students' cultures in the learning process. Although Ladson-Billings focused on describing the knowledge and practices of effective teachers of African American students, Gay (2013) emphasized modifying curriculum by including students' background to maximize learning by linguistically, racially, and ethnically diverse students that were not being served well through traditional schooling. Over time, Gay's CRP evolved to focusing on teaching with curriculum only as a component instead of the main component. CRP is especially important in science teaching because students in non-dominant groups often find school science curricula, instructional practices, and school science culture to be rigid, predetermined, and exclusionary of their values and experiences (Barton & Yang, 2000; Shanahan & Nieswandt, 2011). To promote science interest and engagement, science teachers should draw on culturally relevant science teaching to make the science they are teaching accessible and relevant. In our study, we used a curriculum for professional development that not only used a relevant issue as context for scientific inquiry, but also included lessons that made this relevant issue more accessible to EBs by using language and literacy strategies in inquiry-based science lessons.

4.3 Socioscientific Issues (SSI) in Science Education

Teachers must situate science learning within real-world problems because it helps to represent the field of science in authentic ways and promote scientific literacy to participate in critical social discourse (Sadler, 2004). One way to provide real-world scenarios for science teaching is to embed Socioscientific Issues (SSI) in the science curriculum. SSIs are contentious social issues with procedural and conceptual links to science (Sadler, 2004). Research has shown the promise of SSI-based lessons to enhance students' scientific reasoning, argumentation, decision making, and science content learning (Sadler et al., 2017; See review in Sadler, 2011). It is also well documented that collaborative argumentative discourse benefits science learning and students' understanding of concepts is enhanced when they are taught to reason, argue, and think critically (Osborne, 2010). However, most previous work on inquiry-based SSI instruction focuses on monolingual students for older adolescents, and rarely addresses the linguistic and cultural needs and resources of multilingual learners to successfully engage in SSI lessons (Osborne, 2010).

Despite the potential of SSI instruction to expand emergent bilingual students' linguistic and science practices, to our knowledge so far, there are no published studies on how literacy integrated SSI-based instruction may affect early adolescent EBs' science learning and English language development. There are no studies that address teachers' views of the value and challenges of literacy and SSI integration for EBs. Previous research suggests that teachers generally perceive the values of SSI in enhancing motivation and meaningful science learning (Sadler & Dawson, 2012), but there are several challenges to designing and implementing inquiry-based SSI lessons. Firstly, materials for SSI-based instruction are scarce (Sadler & Dawson, 2012). Secondly, implementing an SSI-based curriculum requires a flexible interdisciplinary approach, yet cross-curricular cooperation is lacking in many schools (Sadler & Dawson, 2012). Thirdly, teachers feel pressure to address state mandated science content standards and may feel they have limited time for teaching about social and ethical issues (Sadler, 2011). Lastly, and perhaps most importantly, teachers find it difficult to move out of the role of conveying accepted scientific knowledge to the role of the moderator of student dialogue (Osborne et al., 2002).

To address these challenges and create teacher buy-in, the research team in this project met with school leaders and science teachers to discuss SSI that best aligned with sixth grade Texas Essential Knowledge and Skills (TEKS), which are Texas's state content standards. Socioscientific issues were chosen based on four criteria: (a) relevance and interest to students; (b) science content behind the issue; (c) accessible ethical tensions; and (d) alignment with Texas state science curriculum standards. The research team met with the science teachers to co-develop the curriculum over the summer and conducted a full-day Professional Development (PD) workshop before the start of the intervention. During the PD, teachers were provided with a series of language and literacy instructional strategies to support EB students' participation in classroom discourse and science sense-making. The language and literacy instructional strategies included effective vocabulary instruction, reading comprehension strategies using thinking aloud and graphic organizers, small group collaborative discussions, and quick write of Claim, Evidence and Reasoning (CER) strategies. The authors sought to understand teachers' views about SSI lessons, and how language and literacy can be supported through SSI lessons for emergent bilinguals. Examining teachers' views about science and literacy integration can help inform educators about areas of need for curriculum development and teacher professional development to enhance science and English language learning for emergent bilinguals.

4.4 Teachers' Views About Literacy Integration in Science

For decades now, researchers have explored teachers' views of science and literacy integration (Lee & Buxton, 2013; Stoddart et al., 2002) and their impact on emergent bilingual student learning through teacher PD or interventions (Bravo & Cervetti, 2014; Maerten-Rivera et al., 2016; Waldrip, 2011). Stoddart et al. (2002) developed a science–language integration rubric based on study findings from interviews of elementary science teachers who participated in a science–language integration project. The complexity in science–language integration was represented on a "continuum of understanding that moves from a restricted view in which boundaries between domains are viewed as impermeable to an elaborated, differentiated perspective that acknowledges a reciprocal and synergistic relationship between domains" (Stoddart et al., 2002, p. 674). In other words, science-language integration ranged from science and language as distinct and separate concepts to science and language being intertwined and collaborative. Waldrip (2011) reported that elementary teachers who focused on science without strong integration with literacy tended to produce teaching that lacked contextual relevance, while teachers with more inclusive integration helped their students achieve deeper levels of understanding. The issue is that, in the United States, science and English language arts (ELA) are typically taught separately, and as independent content areas, specially at the start of middle school. Because of these disciplinary settings, science teachers often focus primarily on the development and understanding of scientific concepts with English literacy development as a secondary focus (Stoddart et al., 2002). Science teachers also find challenges when they move from viewing science and language as distinct areas for instruction to views of an integrated approach to science and language instruction (Stoddart et al., 2002). Teachers' views about the importance of language and literacy instruction in science classrooms influence their perceptions, judgment, and pedagogical choices, which impact student engagement, interest, behavior, and achievement (Mantero & McVicker, 2006; Pettit, 2011; Richardson, 1996; Rueda & Garcia, 1996). Therefore, it is important to understand teachers' views to learn how their views may influence everyday classroom choices particularly in multilingual settings.

The DISCUSS project is built on the premise that integrating Socioscientific Issues (SSI) with inquiry-based science instruction and language literacy strategies promote science and language learning for emergent bilinguals because relevant and authentic SSI provide a contextualized setting for extended dialogue, language-rich scientific inquiry, deeper understanding of science concepts, and academic language use to address complex and socially relevant science problems (Dolan et al., 2009). The ultimate goal of this instructional approach is to prepare scientifically literate citizens who both participate in ethical and well-informed decisions about critical societal issues.

The authors of this study aimed to understand the factors that impacted how and why teachers used or did not use the integrated DISCUSS curriculum. Throughout the project, we realized that the curriculum was not being fully implemented as designed by the research team. We noticed that one major issue was our initial lack of understanding regarding the impact of the participating teachers' views about science and literacy integration. Teacher views influence how they prioritize and situate learning, as well as the curricular choices they make when teaching. Therefore, for this study, we examined two middle school teachers' views about language-science integration for emergent bilinguals from the lens of Stoddart et al.'s (2002) continuum.

4.5 Teachers' Views About Emergent Bilingual Students

Just as teachers' views about the integration of science and English language development, as well as SSIs, influence choices in the classroom, teacher views about EBs hold important implications for instruction and expectations in the classroom. Teachers' views about emergent bilinguals may be exacerbated by teachers' prevailing monoglossic language ideologies—emphasis on clarity, appropriateness, and formality of language—an approach valuing the standardization of the English language (Lemmi et al., 2019). To better serve EB students, educators need to adopt culturally relevant pedagogy that resists and changes cultural and linguistic bias against EB students (Rodriguez & Kitchen, 2005). For example, instead of focusing on pronunciation and spelling of vocabulary terms, teachers could integrate culturally relevant examples of weathering and erosion by having students explore examples in their neighborhoods, or the impact of weather and erosion on important culturally relevant landmarks.

However, teachers generally report a lack of self-efficacy in teaching EBs. In fact, only 15% of teachers feel adequately prepared to work with EBs (Banilower et al., 2013; NASEM, 2018). Research work has shown that teachers with limited knowledge of multiculturalism and multilingualism, and instructional strategies appropriate for EBs have contributed to the achievement gap between EBs and monolingual learners (Lucas & Villegas, 2011; Murphy & Torff, 2019). Teachers with limited understanding of EBs' linguistic backgrounds, culture, and ethnicity tend to hold deficit views of students as a homogeneous group with language deficiency and assume EBs are unable or unwilling to communicate with their teachers or monolingual peers (Stephens, 2019). This, in turn, can influence teachers' instructional practices that may result in EBs' academic failure (Gilakjani & Sabouri, 2017; Lucas et al., 2015).

4.6 Methods

This study is part of DISCUSS, a larger project designed to integrate inquiry-based science and SSI-based curriculum for sixth-grade middle school science classrooms with predominantly EBs in Texas. The larger project involved three teachers that implemented the DISCUSS curriculum, as well as two control classroom teachers that taught the science content according to the school's curriculum pacing guide. Lessons were videotaped and multiple student and teacher outcomes were measured before and after the intervention, which are reported in separate research publications. This study employed a qualitative comparative case study approach (Creswell, 2014) to examine two teacher's views about science and literacy integration and teaching EBs after participating in the DISCUSS PD and intervention. This pilot study was funded by a university-awarded grant to the second author for a total of $20,000.

4.7 Settings and Participants

The study took place in an intermediate school in urban areas in southeastern Texas. About 80% of the students in the school were economically disadvantaged or eligible for free or reduced-price lunch (Texas Education Agency 2017–2018). For the current study, 53% of the student participants were non-native English speakers. Of these, Spanish was the primary language. Ethnicity included 48% Hispanics, 30% African Americans, 10% Asians, 2% European Americans, and 10% others or multi-ethnicity. Among non-native English speakers, most (68%) were born in the U.S. and foreign-born students made up 32%. Although Texas state curriculum standards maintain that use of students' primary languages is allowed during content-area instruction (TEA, 2020), inexplicit micro/school culture typically prevents teachers from using students' home languages in science classrooms (Langman, 2014).

For this study, we explored the views of the two middle grades teachers who implemented the DISCUSS curriculum. The participating teachers, Ms. Humphrey and Ms. Ortega (pseudonyms), were recommended for the project by the science lead person in the school. The research team met with Ms. Humphrey and Ms. Ortega and discussed the overall objectives of the DISCUSS curriculum. The teachers were also informed they would receive small financial incentives for input on curriculum development and implementation, as well as all curriculum materials including a set of stomp rocket kits for the rocketry lessons.

Ms. Humphrey is an African American teacher with 8 years of experience, who taught the general education science class that included a mix of ethnicities and language groups. She has taught speech and debate, financial education, social studies, and science in the United States. She has been teaching sixth-grade science to Gifted and Talented students for the past 2 years. Her original degree was in counseling. Early in her counseling career, she was asked by a school administrator to become certified in social studies and was eventually moved to a teaching position in social studies, and then certified and instructed sixth-grade science.

Ms. Ortega had 34 years of teaching experience working with special education and EBs. She is from Puerto Rico and identifies as Hispanic. Ms. Ortega speaks fluently in both languages, Spanish and English. She taught the bilingual science class at the school where the study took place, and all her students were Spanish speakers. She began her career as a bilingual teacher and has taught upper elementary science, social studies, and mathematics in Puerto Rico and the United States. She holds a bachelor's degree with a major in Special Education and a minor in Socially Disadvantaged and Autistic Children, and a Master's in Counseling.

After agreeing to participate, the research team regularly reached out to both Ms. Humphrey and Ms. Ortega for feedback on the development of the DISCUSS curriculum. We intended to co-develop the curriculum with the teachers, but given the busy summer schedule, we were only able to schedule two meetings during the summer to go over the drafts and seek feedback. The teachers were given small stipends to attend the meetings, and both attended the two sessions. Before the start of the year, the teachers received a 5-hour training on the DISCUSS curriculum and embedded science and literacy strategies, as well as developing students' English literacy skills, before its implementation. The professional development (PD) lasted for one day because it was before the start of the school year, and the teachers had limited time to meet with the research team.

Of note, the study was scheduled to occur after the first week of school's start. Unfortunately, Houston and surrounding areas experienced a major natural disaster during late August. Hurricane Harvey displaced many families from their homes; thus, the start of the school year was delayed by 3 weeks, and the intervention study was postponed to early October instead of being implemented in early September.

4.8 Researcher Perspectives

Although the research team created the curriculum, the researchers were considered participants for this study. The research team for this project comprises faculty, postdoc, and graduate students in science education, bilingual education, and social studies education. The first author of this book chapter is a Chinese, female faculty member in science education, and became fluent in the English language as an emergent bilingual when she entered kindergarten after immigrating to the United States as a child. The second author is a Chinese, female faculty member in bilingual education. She is a native Mandarin speaker and learned English as a second language. The third co-author is a doctoral student in science education and an elementary classroom science teacher. She is bilingual in both Spanish and English. The last author was a doctoral student in social education and is now a faculty member in the Philippines. She was instrumental in the DISCUSS curriculum design and implementation and is bilingual in both Filipino and English.

Our team takes an asset-based perspective of EBs' multicompetences (National Academies of Sciences, Engineering, and Medicine [NASEM], 2018). That is, EBs' linguistic and cultural resources are important to incorporate in science instruction as they provide rich and meaningful opportunities for diverse ideas and multiple perspectives in thinking about science (Lee & Fradd, 1998; NASEM, 2018). This point of view provides ways to enrich instruction, elevate proficiencies in science learning, and offers alternative modes of exploration that deviate from more traditional approaches. EBs are competent learners who contribute, collaborate, and thrive in settings that foster simultaneously development of proficiencies in science knowledge and multiple languages. The research team has been actively working with pre-service and in-service science teachers to integrate linguistically, socially, and culturally responsive strategies in science instruction through revising pre-service teacher coursework, teacher professional development, and field research with local school districts. The team values and supports bilingualism and English language development in authentic science classroom contexts.

4.9 DISCUSS Curriculum

The DISCUSS curriculum featured a 7E (Elicit, Engage, Establish, Explore, Explain, Elaborate and Evaluate) instructional model (August et al., 2014), and targeted the development of EBs' background knowledge (Elicit) and vocabulary of the lesson (Establish). We did this to design lesson following the CRP framework that addresses the growing language disparities between EBs and their non-EB peers. The initial lessons included a newsletter that introduced real-world issues related to Space Exploration, elicited students' prior knowledge, and prompted for initial thoughts on the central question. During the four-week curriculum implementation, students engaged in inquiry-based activities and read argumentative texts that were designed for EBs. The texts and all student materials were carefully crafted to provide learning support for EBs. For example, clear headings were used to highlight each side of the argument; key science content-specific vocabulary (e.g., *emissions, degradation*) and general academic vocabulary (e.g., *insulate, resilience*) were defined for teachers to access; in addition, relevant background information and visual representations (e.g., graphs and pictures) were provided to facilitate text comprehension. Furthermore, all students participated in small-group discussions throughout the 4 weeks, including topics regarding the impact of space exploration on technological innovation, earth and space environment, economy, and public policy.

Throughout the curriculum, there were prompts for the formation of student groups and for these groups to discuss their ideas, write claims, and evidence and reasoning (CER) statements while engaging in inquiry-based and hands-on activities designed to promote scientific discourse. Throughout the unit, students collected evidence as they engaged in the inquiry activities and reading, and considered both sides of the curriculum central question, which is whether the government should increase and why it should decrease funding for space exploration. The researchers attempted to prepare the participating teachers to use a series of scaffolding moves to facilitate small group Collaborative Reasoning discussions (Clark et al., 2003). The scaffolding moves include prompting for position and reasons, modeling and thinking out loud, asking for clarification, challenging, reminding, encouraging, fostering independence, summing up and re-focusing, and debriefing.

During the latter part of the intervention, students engaged in additional discussions about the central question and wrote individual decision responses stating their opinions on whether to increase or decrease funding for space exploration. The students' writing was supported through the collaborative work on argument diagrams outlining claims, evidence, and reasoning (CER) elements, weekly quick write, and peer feedback. A more detailed description of the DISCUSS curriculum is provided in Zhang et al., 2018.

4.10 Data Collection and Analyses

The primary data sources for this study were two interviews (Stake, 1995): A post-intervention interview, or Interview 1, conducted by the researchers to investigate the teachers' educational background, views of language, science, and integration of both. The teachers were also asked about the use of SSI, and the DISCUSS curriculum. Another post-intervention interview, or Interview 2, was conducted by the researchers one year after the intervention to gain understanding regarding the teachers' views on integrating science and literacy, teaching EBs, and the impact of participating in the study. Each interview lasted about 30–45 minutes in person. The interviews were transcribed verbatim for analysis. Additional data sources included classroom observations (at least twice a week in each classroom), field notes, informal conversations, and videotaped lessons.

We used a qualitative approach to identify and examine codes within the interview data. Thematic analysis (Braun & Clarke, 2006) was used to identify the themes from the four interview transcripts. The identified themes were triangulated from other data sources such as field notes, classroom observations, and informal conversations (Creswell, 2014). In the next section, we present themes that emerged from the data.

4.11 Findings

We share the identified themes from the multiple data sources described above concerning the teachers' views on the integration of science and literacy and EB students. Our analyses revealed four themes: teachers' conflicting views about science and language integration reflect two institutional barriers: constraints due to time and district pacing guide, and English-only school language policy; teachers hold varied views on their preparedness for working with EBs; teachers view their role and responsibility to integrate language and science differently; teachers' views about the EB students.

4.11.1 Theme 1: Institutional Barriers Prevented the Integration of Language and Literacy Within Science Instruction

An emergent theme from collected data revealed that two institutional barriers prevented teachers from effectively integrating science instruction and targeted English language acquisition strategies. These barriers included the district's time-restrictive curriculum pacing guide for science instruction, and the district's language policy. Both teachers agreed on the importance of inquiry-based hands-on instruction in science, but they shared that student-centered practices, such as inquiry-based hands-on learning, were constrained by the time-restrictive district's curriculum pacing guide. While Ms. Humphrey held student-centered views regarding science learning by emphasizing student exploration of concepts, further in the interview she revealed that exploratory activities do not occur often because of the time limitations inherent in the district's curriculum pacing guide. When asked about the parts of the DISCUSS curriculum she liked, Ms. Humphrey shared that "The essence of [hands-on activities are] great. I just think that the time [to conduct them] wasn't there" (Interview 1).

Like Ms. Humphrey, Ms. Ortega's viewed hands-on science activities with opportunities for reading as important components for student learning. However, she prioritized keeping up with the curriculum pacing guide over providing opportunities for students to engage in time demanding inquiry-based activities. When asked if she implements any activities or strategies from the DISCUSS curriculum, Ms. Ortega stated that:

> We are in a situation where they [administration] want science to be very hands-on, but the time given, which is 45 minutes at the maximum, does not permit [to do both] hands-on learning and reading instruction at the same time. So, reading activities cannot be as extensive or detailed as much as I would want it to be. (Interview 2)

Both teachers expressed concerns about the language-rich science activities described by the DISCUSS curriculum. They were concerned that the pacing of DISCUSS curriculum literacy activities were not well aligned with the district's curriculum pacing guide. For example, the DISCUSS curriculum unit on space science was expected to be taught in 4 weeks, however the district's pacing guide only allotted 3 days for space science instruction. Even though the teachers understood that the district supported the project, they viewed the pacing guide as more important due to the pressure to teach a pre-determined amount of science content in preparation for benchmarks and state assessments. The teachers stated that the DISCUSS lessons contained too many concepts and reading texts, and required dedicated time for discussions, reading and writing opportunities. As such, and the teachers felt pressured to teach the curriculum quickly.

Based on our observations, the teachers did not often follow the lessons as planned or skipped major parts of the lessons that focused on language integration. The teachers' behaviors supported Osborne et al.'s (2002) finding that teachers feel pressure to teach content and often exclude social and ethical issues, such as SSIs. Osborne et al. (2002) also argued that teachers often view their role as conveyors of knowledge and not as moderators of dialogue. This, coupled with time constraints, may have resulted in Ms. Humphrey and Ms. Ortega's explanations for wanting to implement inquiry-based science investigations activities, but rarely did so because of time constraints. In the end, both Ms. Humphrey and Ms. Ortega prioritized their views on following the district timeline over the extended time permitted by the district for this study and what research supports as effective practices to support EBs' learning of content and language.

The second barrier is the teacher's interpretation of school language policy. Ms. Ortega viewed the student's home language, Spanish, as an important tool to build science understanding for her Spanish-speaking students. When asked if she felt her ability to speak Spanish is beneficial in her teaching, Ms. Ortega shared that:

> I think it's important for a child that is new [to the U.S.] to hear a language that is their mother language, you know, that they don't have to struggle with everything. At least I can provide a secure environment for them to learn, and I let them learn. Like sometimes the new ones [students], they have so much to say, but they cannot express it. And then there are some [instances] where I just say I want you to express yourself in Spanish first, ok? (Interview 2)

Ms. Ortega viewed the use of Spanish was an important tool for science learning but was concerned about not following the school's language policy. She viewed it as her responsibility to comply with the district's monolingual policy, so her views on Spanish use and the language policy were in direct conflict with one another. When asked in what ways does she view using Spanish in the classroom as affecting students' understanding and learning about science, she shared that:

> So, all I could do is tell them that I'm not allowed to read this in Spanish, but if you want, I can give you a dictionary [to learn new words in English], and I will read it for you. And that is what I offer to the lower beginner students. So, depending on what level they are as bilinguals, I can maybe do some accommodations. (Interview 2)

Ms. Ortega seemed unresolved as to how and when to use Spanish and tried to use Spanish to mediate meaningful opportunities and occurrences to teach science and language. After an incident that involved a meeting with an administrator and that included criticism of using too much Spanish in her teaching, Ms. Ortega prioritized her views on the monolingual policy and minimized and discouraged the use of Spanish in science learning. In continuing to share her views on using Spanish in the classroom, and how it affects students' understanding and learning about science, she stated:

> They'll tell me, I think I can do it in Spanish. I'll tell them, let's do it in Spanish. Now, can you translate that? I don't have a problem with children translating words. But yes, there is a moment where too much Spanish in the classroom, it is too much. And I'll tell them, nobody is allowed to translate right now, you need to get the information directly from the teacher or directly from the reading, no translations. Let's see what you can pick up. And you'll see them flustered — did you get it? And then I asked them to just tell me what they picked up from listening or reading and what they did not, and we'll go from there. But yes, there are moments, as the year goes on, I'll say, I don't want to hear anybody translate. No

peer group now. Nothing, you need to focus on, understanding what I said in English, nothing else. (Interview 2)

Ms. Ortega's views that following the district's monolingual policy superseded her beliefs that Spanish could be an important tool to help her EBs negotiate science and language learning in her classroom. As the only teacher in this study that taught in a bilingual science classroom, Ms. Ortega viewed that teaching only in English may not have been effective for her EBs because of the students' various levels of English proficiency. Her views regarding the importance of using Spanish to help students access the content conflicted with the school's emphasis of English instruction and accountability mandates. To mediate this dissonance, Ms. Ortega utilized Spanish to facilitate learning vocabulary or simple concepts and found it necessary to scaffold the removal of Spanish supports over time.

It should be noted that the DISCUSS project did not stipulate on Spanish use and encourage teachers to follow the district's recommended practices. The project provided an opportunity for us to study teachers' language ideology and observe teachers' spontaneous use of Spanish in a bilingual science classroom. In another paper (Enriquez-Andrade et al., 2019), we have systematically transcribed and analyzed Ms. Ortega's Spanish talk during the four-week DISCUSS intervention period and the findings showed inconsistencies between the teacher practices and beliefs regarding Spanish use and literacy integration. Although recognizing the importance of Spanish use for science understanding for EBs, she used Spanish talk mainly to draw connections between Spanish and English vocabulary (e.g., el telegrama vs. the telegram) or for nonacademic purposes like redirecting behavior and reiterating instructions previously given in English. These findings are consistent with the literature that although teachers believe that the use of home language benefits student learning, they are constrained to enact such views because of English-only instructional policies in schools (Razfar, 2012). At the same time, the prevailing science standards that require educators to expect and use standard academic English as the 'proper' form of written and spoken communication within the science classrooms disregards the diversity of students' culture and linguistic backgrounds (Gutiérrez & Rogoff, 2003; National Research Council, 2012; Razfar, 2012).

4.11.2 Theme 2: Teachers Were Not Prepared to Teach EBs and Need Support to Develop Asset-Based Views

Another theme that emerged from the data was the difference in teacher's views regarding their level of preparedness to work with EBs in science, and suggested need of teacher support to combat deficit thinking. Ms. Ortega stated that she did not feel adequately prepared to draw on students' linguistic assets, even though she is a native Spanish speaker. When asked if she felt prepared to teach English language learners when she first started teaching in the United States, she shared that:

> When I came to Unites States, I was not, I felt that I wasn't as prepared. I guess just because of the pacing guide, what was asked, it was a new group, I mean, I handled third, fourth and fifth before, you know. I had been a special ed. teacher. So yeah, there were a lot of things going on. (Interview 2)

It was surprising to find that Ms. Ortega viewed herself as unprepared to teach EBs. This is especially interesting because Ms. Ortega is bilingual herself, and studies have shown teachers who know a second language tend to understand the challenges of learning content and language simultaneously (Pettit, 2011). This is also surprising because Ms. Ortega has spent a part of her career as a bilingual teacher. This may be because of the unique bilingual science class setting where all the Spanish speakers in her classroom were beginners and newcomers. During the interviews, she repetitively expressed the challenges in working with newcomers in her science classroom.

On the other hand, Ms. Humphrey viewed herself as being well-prepared to work with EBs. She stated she was prepared and knew to use the same strategies in her classes for EBs and non-EBs, because language and literacy strategies benefited all students. Although Ms. Humphrey felt that she was prepared, her views that EBs do not require differentiated instruction indicated a limited understanding of how to work with EBs. When asked if she felt prepared to teach EBs when she first started teaching, she shared that:

> I found it very easy [to teach English to EBs]. In a lot of cases, students [native English speakers] are behind in grade level so I'm really teaching everybody English. When you are talking about fluency, a lot of our kids are not fluent…I find it easier to train all of that at once. (Interview 2)

Ms. Humphrey's views that all students, include EBs, do not need differentiated instruction was emphasized again. When asked if there is any kind of professional development that she wished she had on working with EBs, she stated that:

> I know that most of my kids benefit from English language learning strategies. I think the mistake that many people make is thinking that English language learning is just strictly for English language learners. But really, most of the kids these days are underdeveloped in their academic discourse skills and their literacy fluency. So, unless they are in private school, a lot of kids need it [English language skills]. I find it very easy, and like after nine years, like I said, I know that this is the case with a lot of our students. They need the extra support for building up their vocabulary and their literacy skills. (Interview 2)

Additionally, Ms. Humphrey viewed herself as prepared for working with EBs because of her own experience living abroad in a non-English speaking country. She believed that her experience of being immersed in a non-English speaking country elevated her level of preparedness and knowledge on how language should be integrated into the classroom (See Suriel & Atwater, 2012). When asked who she thought is primarily responsible for teaching English to EBs, Ms. Humphrey shared:

> I am also a culturally immersed person. I went to another country for a whole month and that's just kind of works. I mean, if you're immersed into a new culture and its language, you're going to pick it up a lot faster, so I think that it's important. I mean those two things aren't exclusive — like part of being immersed into the culture when you go into the educational arena you would get that as well. (Interview 2)

Even though both teachers held differing views of preparedness to teach EBs, and their roles in integrating language in science, both seemingly held basic views about how to integrate science and language. Both teachers emphasized teaching vocabulary as the means to include language instruction in science teaching, which represents a simplified and basic understanding of integration (Stoddart et al., 2002) and did not include or discuss additional pedagogies or strategies to integrate English language learning with science. The two teachers did not fully recognize the importance of various language-rich discussion strategies from the DISCUSS curriculum. When asked how she integrates language into science teaching, Ms. Ortega stated, "I integrate science and literacy by teaching vocabulary, vocabulary is the key" (Interview 1).

Ms. Humphrey, who shared that she viewed herself as prepared and knowledgeable about integrating science and language, also emphasized the importance of focusing on vocabulary instruction as her main way of integrating language learning in science instruction. When asked how she integrates language learning in science teaching, she shared:

> Vocabulary foldables are important. [One can use] a vocabulary word, its definition and a picture and with the help of a peer, one can figure out which pictures best supports the definition. Vocabulary foldables, peer talk, annotations, things like that writing, speaking, presentations, things like that [are helpful to learning language]. (Interview 2)

Ms. Humphrey seemed to hold high self-efficacy working with EBs and felt that she did not need additional training to work with EBs but could benefit from targeted opportunities to develop an understanding of effective instructional strategies for EBs. This prompted our research team to wonder whether her high self-efficacy beliefs may hinder her professional growth with integrating English language learning and result in perpetuating learning gaps between EBs and non-EBs (i.e., Lucas & Villegas, 2011; Murphy & Torff, 2019). In addition, our project indicates that teachers did not leverage their students' linguistic assets for science teaching and learning, as we sought to promote, and instead held on to their low expectations. As mentioned earlier, deficit-based teaching views focus on what students need or lack. In contrast, asset-based views of EBs involves the appreciation of their linguistic and cultural diversity, as well as using these attributes to inform lesson planning, instruction, and assessment. Unfortunately, our study was too short, and it did not have enough funding to provide on-going professional development. This speaks to the need to support responsive and sustained professional development especially targeted for helping teachers identify, reflect upon, and change deficit views of multiculturalism and multilingualism.

4.11.3 Theme 3: Teachers Vary in Their View of Responsibility for Integrating Language in Science Classrooms

Each participating teacher in this study held differing views regarding whose role it was to integrate English language instruction in science instruction, but agree they have a role in integrating lessons with both sets of knowledge. Ms. Humphrey shared the view that she has a role in integrating language in the science classroom, while Ms. Ortega viewed that the responsibility of integrating language in science resided with the district specialists since they design the district's curriculum pacing guide. Ms. Humphrey viewed language integration as her responsibility. Although Ms. Humphrey based her understanding of integration on personal experiences (Caswell et al., 2016), she viewed herself responsible for integrating English language learning with her science teaching. When asked who is primarily responsible for teaching English to EBs, she stated:

> I do think that the teacher should integrate English language learning within the course they are teaching, however, it's a village activity. English is learned from day to day experiences. You don't just learn it in the classroom, but it's an important factor. When you're immersed into any culture, you're going to learn its language [and modes of expression] from different things, you know. But it should also be a priority to all teachers [to integrate English language learning]. (Interview 2)

On the other hand, Ms. Ortega stated it was not her role to integrate science and language, and the integration of English language learning within content areas should be prioritized by the school personnel that designs the district's curriculum pacing guide. When asked about who is primarily responsible for teaching English to EBs, she shared that "It is not the teacher that you have to talk to, it is actually the district specialist who make the pacing guide and they will have to incorporate something like that" (Interview 2).

Ms. Ortega also believed that integrating English language learning in science was not solely her responsibility but required collaboration with a bilingual teacher. When asked again during Interview 2 about her views on integrating language and science, she stated:

> When it comes to science, it is most important to develop the concept. I think that any language should be enough to develop the concept. Later if they [students] understand the concept, then the teacher can translate into the English. This is one theory for integrating English language learning and science content. (Interview 2)

Ms. Ortega's views support findings that middle school science teachers do not view it as their responsibility to teach language and science (Stoddart et al., 2002). This is of concern given the literature that views that silo language learning from content instruction impacts teacher judgment and instruction, which in turn, impacts student behavior, interest, engagement, and achievement (Mantero & McVicker, 2006; Pettit, 2011; Rueda & Garcia, 1996). It must have also been frustrating for Ms. Ortega to have been hired as a bilingual teacher, yet not have the preparation nor support from the district to teach EBs.

4.11.4 Theme 4: Low Expectations Prevented Asset-Based Instruction with Emergent Bilinguals

The last theme from this study regarded the teachers' low expectations about their EBs as *students* in their science classrooms. Views about students are critical as they frame thinking about their capacity to learn and expectations of learning. Teachers that hold more asset-based views embrace higher expectations from their students. During the interview, Ms. Humphrey stated that her students are divergent thinkers with great minds, and her goal was to foster this creative and divergent thinking. These statements seemed promising and showed that she held asset-based views of her EBs. However, one concern is that the class we observed also contained gifted and talented students. It was possible that her statements referred to this particular student population as divergent thinkers, however, the researchers did not prompt further. In the end, she seemed to veer towards low expectations when she stated that EBs were hesitant to participate in class, are often "far behind", and needed more time to learn. When asked whether she felt she was prepared to teach EBs when she first started teaching, she stated:

> I find it easier to, umm, to train all of them at once. Which is a little bit helpful. I mean it's unfortunate you know that they're so far behind academically as far as having academic discourse, but I find that all of them can use help with English language learning strategies – these strategies help a lot of my students, so I don't find it difficult. (Interview 2)

Ms. Ortega saw her EBs and newcomers from other countries as "clueless" and that they "bring very little to the table." Although Ms. Ortega recognized that EBs require additional time to process information in two languages, she viewed EBs as having limited prior knowledge in science and English and viewed her EBs students as unable to engage in appropriate and content-based discussions. When asked what she thought about the integration of socioscientific issues in the DISCUSS curriculum, she shared:

> I would have loved to sit down in a regular classroom to see if the children had more background knowledge on issues like that. Because what I noticed in this classroom [of mostly EBs] is that the students bring very little to the table you know. For example, when I try to flip the classroom, which means that I try to give them something to take home so that they can analyze it and bring it back for discussion, that part is not there yet. We are not there yet. With other groups, I can do that. (Interview 1)

Ms. Ortega may not have realized that there could have been other reasons that students were not ready for discussions. For example, students' limited English abilities likely prevented them from understanding assignments well, or there is no one at home fluent in English to help them with assignments. Again, these findings point to the need to fund more responsive and sustained professional development on culturally responsive teaching and multilingualism. Teachers' strongly held views, like those of Ms. Ortega, cannot change overnight, and sustained professional development could assist teachers better understand their own biases, as well as potential systemic inequalities that hinder EBs' learning.

Ms. Ortega also viewed EBs as students that lack prior knowledge. This is revealed when she was asked about the impact of the district's monolingual policy, she stated:

> We do have to understand that some of our bilingual children are coming in without any science [knowledge], so they are not bringing in any conceptual understanding. So, I have different levels of [understanding among the] children. I may have a child that has no or minimum exposure to science concepts, and that child may also not know any English. (Interview 2)

In addition, her lack of knowledge of, and support in, teaching EBs was disappointing because, based on our classroom observations, she spent most of the instructional time teaching vocabulary. She often switched to Spanish for non-science aspects of instruction, such as classroom management, but rarely used Spanish for teaching content. This instructional decision may be due to her views of English vocabulary as a prerequisite of science learning, a commonly held view by science teachers (Lee et al., 2019; Meier et al., 2020). Her views and practices presented as challenges to teaching diverse students, but this was compounded by the school's existing monolingual policy. The combination of her views, practices, and the existing monolingual policy hindered her ability to teach in her students' home language which she stated was an important avenue for reaching her EB students. Having Ms. Ortega facing teaching in the context of these challenges is especially troubling since she was the only bilingual teacher included in our study and had the highest percentages of EBs in her classroom.

Ms. Ortega's ability to teach EBs was also impacted by her low expectations of them because it prevented her from using her knowledge and skills as a bilingual teacher to help her EBs. For example, she could have used code switching and cognates to negotiate the learning of English and content over time if the monolingual policy did not prevent this. This supports the need for bilingual CRP educators to understand the challenges posed by institutional policies such as the one on use of the English language only. These views serve as ideological barriers to her teaching for diversity (varied English proficiency) and understanding (science inquiry, student-centered learning) in a bilingual science classroom (Rodriguez & Kitchen, 2005). The findings of this theme support Stephens's (2019) finding that teacher with limited understanding of EBs' linguistic backgrounds, culture, and ethnicity tend to hold deficit views of students as a homogeneous group with language deficiency and assume EBs are unable or unwilling to communicate with their teachers or monolingual peers.

We acknowledge that there are distinctions in the real inequalities and realities of teaching EBs, and teachers' actual deficit views. Although these are different ideas, these ideas may be reciprocal as the real inequalities, and the resulting decreased engagement in science and lower academic achievements, reinforce the low expectations teachers' held. Our project was not designed to address views, but we realize views played a large role in how the curriculum was interpreted and implemented. It is necessary, when implementing work that addresses teacher knowledge and practice, to include views as a target construct.

4.12 Discussion

This study contributes to the literature by examining the integration of science and literacy through the implementation of an SSI-based science curriculum that includes English language and literacy learning strategies in sixth-grade classrooms with predominantly emergent bilinguals. There is a need to address the growing disparities between EBs and their native English speaking peers by providing relevant, meaningful, and sustained professional development and teacher supports that address systemic inequalities and teachers' low expectations. Four themes are identified from the interview data. Firstly, evidence from two emergent themes indicated several institutional barriers for the teachers to fully implement the DISCUSS curriculum (e.g., limited time, district pacing guides, English-only policy). Secondly, the data revealed that one teacher felt unprepared to teach EBs, and the other teacher felt prepared, but this may not be so. Thirdly, the teachers varied in their views about whose responsibility it is to integrate English language learning and science instruction but focused on teaching vocabulary as a means to integrating language in science. Lastly, teachers' strongly held views of their EBs were impacted by their low expectations and the school's monolingual policy. This in turn influenced the teachers' pedagogical choices (Walker et al., 2004). Furthermore, teachers with compartmentalized views of academic disciplines and language or literacy, combined with low expectations for EBs hinder their ability to construct academic environments that are conducive for science-language integration (Stoddart et al., 2002).

4.13 Limitations of the Study

This study has several limitations. First, both teachers were provided the curriculum in advance to review before each meeting, but it seemed that neither prepared for each of the two meetings because the teachers exhibited limited understandings about the curriculum and provided minimal feedback. Over 3 months, the limited feedback provided by the teachers did not result in constructive revisions, so although we wanted to co-design the curriculum, the curriculum was designed by the research team without significant teacher feedback.

Another limitation of the study was that the intervention originally scheduled to take place in early fall was postponed to late fall due to Hurricane Harvey, a natural disaster that flooded many areas in the Houston metropolitan area. The disaster resulted in school districts delaying the start of school by approximately 3 weeks. The second author of the chapter was a victim of Hurricane Harvey. We were grateful that the pilot study was carried out later than planned, but the timing was not ideal and all stakeholders including teachers, students, and researchers were heavily impacted by this unprecedented natural disaster.

4.14 Implications and Future Directions

Despite the mentioned limitations, the current study has important implications for language-inclusive and equity-focused STEM research, policies, and practices to address disparities in opportunities to learn. First, the findings call for teachers' preparation programs and professional development to provide more direct and purposeful opportunities for teachers to elicit, examine, and reflect upon their ideological and pedagogical orientations about the linguistic and cultural diversity of emergent bilinguals and science-language integration. Teaching for diversity should be made a priority in teacher preparation and professional development to fully implement the integration of science and language for EBs (i.e., Buxton et al., 2015; Caswell et al., 2016; Shaw et al., 2014); change teachers' views about diversity and equity; and address the pervasive resistance to pedagogical change and resistance to ideological change in science (Rodriguez, 2015). In addition, PD should include educating teachers about students from different countries, particularly from low SES, that might not have had consistent schooling and science instruction previously. Targeted PD on CRP and multilingualism may have helped teachers, like Ms. Ortega, to gain a better understanding of these students and effective practices to use in her classroom.

To promote teaching for diversity and understanding, deliberate opportunities to elicit, discuss, and reflect upon views through authentic dialogical conversations can result in a positive change in teacher views and beliefs (Rodriguez & Kitchen, 2005; Walker et al., 2004). From the bilingual education perspective, it is critical to shift teachers' language ideology from treating language as a problem to language as a resource to right (Ruiz, 2010), and from exclusive language ideology (valuing standardization of English) to inclusive language ideology (valuing multiple forms of language or multiple language uses) (Lemmi et al., 2019). For teachers, school leaders, district administrators, and other educational stakeholders to support and advocate for socially, culturally, and linguistically responsive science learning opportunities for EBs, it is critical that all stakeholders engage in these conversations for systemic change to occur.

Second, creative, and transformational fieldwork in STEM education requires a long-term, mutualistic, and trusting research-practice partnership (RPP) (Penuel & Gallagher, 2017) with teachers, school principals, and district science leaders. Educators and school partners should respectfully negotiate and mutually agree upon common problems of practice and policy parameters that may serve as institutional barriers to fully implement innovations. To facilitate teacher learning, allow teacher ownership of curriculum, and increase flexibility to adapt lessons, a research team may consider developing educative curriculum materials (Davis & Krajcik, 2005), instead of providing prescribed lesson plans and supporting materials.

Third, much funding support is needed to engage all stakeholders in this important yet challenging work. With more appropriate funding, teachers can be provided a better incentive to participate in curriculum co-design; more systematic and coherent teacher support can be developed including intensive teacher PD, ongoing coaching, and feedback necessary to integrate language strategies in science. Teachers can also be provided with release time to observe other teachers, which can help the teachers shift to more assets-based views. Moving forward, research work will need to focus on more time and ongoing support to help teachers, school leaders, and educators appreciate and embrace a more asset-based and inclusive view and belief system.

4.15 Challenges and Perseverance in Seeking Funding

The research team has been pursuing federal and foundation grants to continue this work. The top challenge we have encountered so far is that we are constantly asked by the reviewers to address the alignment of our theoretical framework and project design with NGSS. We are working in a non-NGSS state, and it is difficult to balance the content-focused State Standards in Texas and NGSS while developing curriculum and building research-practice partnerships. Secondly, funding agencies seem to be more interested in supporting quantitative research on teacher- and/or student-related outcomes, but we argue that qualitative methods, such as case studies and critical ethnographies, are needed to unpack the complex dynamic nature of the interactions between teacher language ideology, science and language practices, and school language policies before scaling up the innovations in STEM education.

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