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Transforming Practice: Supporting Secondary Science Teachers of English Learners

Author
VALADEZ, MARCELA

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Transforming Practice: Supporting Secondary Science Teachers of English Learners

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by

Marcela Denise Valadez

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ABSTRACT OF THE DISSERTATION

Transforming Practice: Supporting Secondary Science Teachers of English Learners

by

Marcela Denise Valadez

Doctor of Education

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Professor William A. Sandoval, Chair

This study investigated whether collaboration between science teachers and ELD teachers would result in changes to teachers' perceptions about their role and responsibility to support English Learners in their science classes and whether professional learning opportunities provided would result in planned implementation of strategies and practices to support those students. Science teachers of English Learners benefitted from professional learning opportunities that engage science teachers and English Language Development teachers in the process of working together to help revise lesson plans to better support English Learners. This Professional Learning intervention engaged science and ELD teachers in 10 sessions conducted over the course of 5 weeks. Using a qualitative research design, data from pre and post interviews, observations from professional learning sessions, reflections from learning sessions and teacher created activities and lesson plans revealed that science teachers benefit from learning about California's

expectations for teaching English Learners, the typologies, proficiency levels and capabilities of students at different proficiency levels and opportunities to practice implementing strategies and practices that support English Learners in their Science classes with coaching from ELD teachers.

The dissertation of Marcela Denise Valadez is approved.

Alison Bailey

Anne J. Gilliland-Swetland

Kristen Lee Rohanna

William A. Sandoval, Committee Chair

University of California, Los Angeles

2022

DEDICATION PAGE

To my past, present and future. There is no me without you.

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ACKNOWLEDGEMENTS

I ran in circles for a while before getting to the finish line. This accomplishment would not have been possible without the support of the following people:

My family: *mi mami chita y papi pepe*, my parents, *suegros*, my departed *tio*, siblings, *cuñados*, *sobrinas y sobrinito* and cousin. May all generations of our family learn from this journey. *Que todas las generaciones de nuestra familia aprendan de este proceso.*

My line: You motivate me to be the best version of myself.

My students: you are the inspiration for this work.

My committee: I appreciate your guidance and support - especially toward the end. You pushed me to think about my work in ways I hadn't thought to, and it has greatly improved.

My chair: Dr. Sandoval thanks for not letting me disappear. I appreciate your patience and guidance more than you could ever know. When I was stuck in the quicksand you lent me a hand. When I felt like I was drowning, you tossed me a life preserver. You helped me see the forest from within the trees.

To the team: I knew you had it in you! I appreciate your willingness to fully participate, share your confusion and discomfort and commit to growth.

"[T]here can be, and usually is, some degree of pain involved in giving up old ways of thinking and knowing and learning new approaches. I respect that pain. And I include recognition of it… and talk about the discomfort it can cause." - bell hooks, *Teaching to Transgress*

VITA

2000-2004	University of California, Santa Barbara Bachelor of Arts in English and Chicana and Chicano Studies
2004-2006	University of California, Los Angeles Masters in Education California Single Subject Teaching Credential English
2005-2007	Santee Education Complex, LAUSD School of Fashion, Design and Visual Arts 10th & 11th Grade English, ELD
2007-2018	Bell Gardens High School Culinary Hospitality Occupations Pathway AP Language, American Literature, Journalism and ELD teacher
2018	Rosewood Park School Teacher on Special Assignment Multi-Tiered Systems of Intervention and Support Compensatory Education and English Learner Programs
2019	Montebello Gardens Elementary Multi-Tiered Systems of Intervention and Support Teacher on Special Assignment Compensatory Education and English Learner Programs
2021	California Teachers Association Institute for Teaching Impact Grant Recipient for “Full STEAM Ahead with the Tinker Collaboratory”
2022	Rosewood Park STEAM Academy Teacher on Special Assignment Multi-Tiered Systems of Intervention and Support Compensatory Education and English Learner Programs

CHAPTER 1: INTRODUCTION

Of the 6,002,523 total students enrolled in K-12 schools in the California, approximately 1,062,290 students, or 17.7% of students are currently classified as English Learners and another 1,053,625 or 17.6% of students have been reclassified as fluent in English. Currently, EL Students lag behind their English-speaking counterparts in two major areas, their proficiency on the National Assessment of Educational Progress (NAEP) and on-time graduation rates (U.S. Department of Education, 2018). Under the new demands of the Next Generation Science Standards (NGSS), the problem will likely become magnified due to increased language expectations. If English Learners were not currently meeting graduation requirements in the previous standards era, the high school completion rate will likely decrease under the higher expectations of the CCSS and NGSS. The Common Core literacy standards present an additional layer of challenges due to emphasis on literacy in science, social science and technical subjects. Moreover, since the Next Generation Science Standards (NGSS) also emphasize literacy-based scientific practices that native English speakers struggle with (such as scientific argumentation), science teachers will need to respond to support English learners in inquiry-based learning and scientific argumentation (Miller, Lauffer & Messina, 2014; Lee & Buxton, 2013; Lee & Buxton, 2013b; Zwiep & Straits, 2013) Above all, school systems are not currently prepared to foster the academic success of English Learners in the sciences. The *Promising Futures* report (NASEM, 2017) emphasizes that as a result of the diversity of ELs in terms of their cultures, languages, and experiences, many schools are not prepared to provide adequate instruction to ELs in acquiring English proficiency while ensuring academic success.

The introduction of the Next Generation Science Standards shifts science teaching and learning in a number of ways, namely that science learning becomes language intensive and performance based. Previously, science standards in California were primarily based on scientific concepts, whereas now, students must learn the language of science and while also learning key ideas and crosscutting concepts (Miller, Januszyk & Lee, 2015). As a result, few science teachers, most of whom have little knowledge of teaching literacy or written argumentation, have had professional development related to addressing the language needs of English Learners that arise from the CCSS and NGSS. English learners have trouble comprehending and following spoken English, they require opportunities to demonstrate their understanding visually or using a hands-on approach that then can inform their ability to explain their learning in written or spoken form, with literacy supports like outlines and sentence frames. Science teachers of ELs need the space to explore these language development strategies and others such as a classroom environment that provides consistent routines, outlines and connections to prior knowledge in addition to those previously noted. In order to provide English Learners with equal access to the CCSS and NGSS, raise graduation rates and bridge the language and achievement gaps, science teachers must be effectively prepared to confidently address the literacy needs of English learners (Darling-Hammond 2006).

Furthermore, California implemented the California English Learner Roadmap in 2017, which outlines four principles that develop a comprehensive approach to EL education with the goal of supporting district leaders, school leaders and teachers to work together to meet the needs of English Learners by affirming EL students' multilingual abilities and recommending research-based strategies and practices to support their unique and varied needs. However, some districts have not yet implemented the EL Roadmap because the California Dashboard accountability

measures are not set to include EL achievement as part of a school or district's overall rating until the 2022-2023 school year. Moreover, Every Student Succeeds Act of 2015 (ESSA) moved to ensure that language proficiency development and academic progress for English Learners are now both accountability measures under Title I, whereas under NCLB the connection between language and academic progress were ignored because the academic progress and language proficiency accountability measures were separately measured under Title I and Title III, respectively. Title 1 requirements under ESSA now require states to not only adopt rigorous content standards in Language Arts, Mathematics and science, they also require that English Language Development standards reflect the skills and practices that English Learners need to engage in content areas like science. As such, California's English Language Development Standards are meant to be taught in tandem with content standards as a bridge to content understanding and can be linked to CCSS standards directly and NGSS by tracking NGSS links to CCSS that then connect to ELD standards (Lee, Quinn & Valdes, 2013).

Despite these policy developments in support of equity for English Learners, if these policies and best practices are not communicated to teachers, and teachers are not provided with professional learning opportunities to develop skills and confidence to meet the needs of English Learners, then policies are essentially useless and the top down approach fails students and teachers.

Purpose of this Study

The purpose of this study is to provide science teachers at a large suburban high school with the opportunity to participate in professional learning to support language learners and work

collaboratively with English Language Development teachers to develop a project that meets EL students' needs in science. A survey conducted by the National Science Teacher Association indicates that only about half of teachers have had training to teach the NGSS. Of those surveyed, 35% indicated that they need more access to materials, while 30% indicate a need for more training. In either case, the majority of teachers are not prepared to teach the NGSS. Practitioners and researchers have found that the NGSS presents a unique opportunity because it provides opportunities for the development of both scientific concepts and phenomena coupled with language, because the two are inherently linked (Bodzin et al 2013; August et al., 2014; Harmon and Pegg 2013; Lee, Quinn & Valdes, 2013). However, at the school site, science teachers are not provided with professional development specifically related to the language needs of EL students. Their opportunities for team curriculum planning time to improve their confidence and effectiveness with regard to teaching English Learners is also limited. Many science teachers at the site have expressed frustration over the expectation that their lessons now embed literacy standards and ELD strategies because the support and guidance to do so have not been provided. Teachers were provided one hour of introduction to the revised ELD standards and two hours of planning to develop an entire unit that addresses ELD students' needs, however, their ability to understand the ELD standards was not the problem. The application of strategies tailored to differentiate instruction for their learning was at the root of their complaints. This study will expose teachers to language development strategies that create opportunities for students to think, reason and make meaning (Adams & Pegg 2012; Harmon & Pegg 2012).

Lack of preparation and support have already been established as needs for the mainstream CCSS and NGSS shift, and now teachers at the site are verbally indicating that they require more support to specifically address the needs of ELs. Instructional confusion then

results because teachers at the site are not trained sufficiently or uniformly, and many are not trained at all. This study aims to provide a space for science teachers to learn about, select and test strategies to meet the needs of their students using professional learning study.

The study is designed to answer the following research questions:

1. Does science teachers' thinking about their ability to provide language support to their EL students change through their participation in this project?

2. Does participation in this project increase science teachers' intentions to implement language supports as evidenced in lesson plans?

Research Site

Champion Unified School District (CUSD, a pseudonym) is situated in the southeastern quadrant of Los Angeles County. Approximately 33% of the student population of the district is classified as English Learners (California Department of Education, 2017), of which 25% are categorized as long-term English Learners. Approximately another 8% of the student population are Redesignated Fluent English Proficient (RFEP) students who still benefit from language support because the primary language is spoken at home.

Omega High School (OHS, a pseudonym) is a comprehensive high school located in the southeast region of Los Angeles County and serves 3,043 students in grades nine through twelve. Of those students, 8% receive special education services, 22% receive English Learner support, and 95% qualify for free or reduced-price lunch. The student population's racial and ethnic makeup consists of 98.90% Latino or Hispanic, .60% Caucasian, .20% Asian, .10% Pacific

Islander, .10% African American, .10% American Indian or Alaska Native and .10% multiracial (CDE 2019).

At OHS English Learners are graduating at rates 10% to 20% lower than their peers. None of the students in the 2016-2017 graduating class demonstrated English proficiency on standardized tests, yet 56% had been Redesigned as Fluent English Proficient (RFEP) using other means. On the spring 2016 administration of the California Assessment of Student Performance and Progress (CAASPP) 3% of English Learners (those in the United States for more than 12 months) in the class of 2017 demonstrated proficiency in English Language and Literacy, compared approximately 60% proficiency demonstrated by English only (EO) speakers, Initial Fluent English Proficient (IFEP) students and Redesigned Fluent English Proficient (RFEP) students. The spring 2017 administration of the CAASPP on the class of 2018 identified a 2.2% decline in English Learner Progress. Regarding evidence-based arguments and inquiry, 35% of English speakers (EO, IFEP and RFEP) performed above the standard, 54% were close to meeting the standard and 11% were below standard. By contrast, the EL population had 3% above standard, 53% percent near the standard and 44% of students performed below standard.

Given that the site's English learner outcomes closely mirror that of the United States, the site would provide a relevant cross-section examination that could prove generalizable.

Research Design and Methods Overview

This study was a professional learning case study. The goal of the project was to enable the practitioners to bring about change in their own practices. Teachers did this by focusing on

their own practice and revising lessons to better support the EL students in their science classes.

The professional development study introduced science teachers to policy, strategies, instructional practices, typologies and proficiency levels of English Learners to determine whether providing access to the information required to address EL student needs would have an impact on their thinking and attempt to implement said strategies.

CHAPTER 2: LITERATURE REVIEW

Science teachers struggle to adequately educate English Learners (ELs). This is in part because the Next Generation Science Standards (NGSS) integrate literacy as a means to express content understanding, leaving teachers at a loss as to how to address the needs of English Learners. It is the belief among scholars that there is a serious lack of educators with formal training in the teaching of ELs and leaves science teachers at a loss (Darling-Hammond & Berry, 2006; Santos, Darling-Hammond and Cheuk, 2012; Gandara, Maxwell-Jolly & Driscoll, 2005). In addition, teachers do not always have the opportunity to begin work to address the issue. According to the results of the 2018 National Survey of Science and Mathematics Education, approximately 76% of schools surveyed indicate that science-related professional development opportunities at their schools are inadequate and approximately 67% of schools indicate that they have inadequate materials for differentiating instruction (Banilower et al. 2018). In addition, ELs struggle to grasp science content due to a lack of literacy support, which contributes directly to English Learners' struggle to grasp content and in turn limits their opportunities for rich science instruction because there is a misconception that a certain degree of English proficiency must be achieved before ELs can access science content (Callahan, 2005).

I begin my literature review by explaining the causes of the achievement gap for English learners in science followed by an overview of research-based strategies to address the needs, including an exploration of productive teacher collaboration as a means of addressing needs. I will end by highlighting implications for professional development providers as related to structures and characteristics of successful professional development for teachers.

Background

The EL Achievement Gap in science

Support for English Learners is particularly important because the percentage of children in the U.S whose home language is not English is expected to grow to 40% of the K-12 population by 2030 (Crawford, 2000) and in some states, such as California, an estimated 30% of students enrolled in secondary schools are classified as English Learners (California Department of Education, 2019). Bailey, Maher and Wilkinson (2018) report that with reference to the NAEP Science Assessment, the achievement gap in science among ELs has grown. In 2015, 4th graders classified as English learners scored 37 points lower than English speakers and among 8th through 12th graders the gap had increased to 47 points. Moreover, in states like California, where the numbers of ELs are highest in the nation, 24% of those ELs dropout of high school (California Department of Education, 2012) and among 18-24 year old ELs not enrolled in high school, only 69% possess a high school diploma or GED, compared to 90% of those who were never classified as English Learners (Callahan, 2013).

Clearly English Learners are struggling to meet graduation requirements and the relatively recent implementation of CCSS and NGSS have raised the bar. Unfortunately, when school districts and teachers are unprepared to teach ELs the gap continues to grow, resulting in an increased number of Long-Term English Learners and high dropout rates among the English Learner population. There are several factors that contribute to why students are not developing their understanding of science. They include a lack of resources for teachers, low expectations and underprepared teachers (Darling-Hammond & Berry, 2006; Santos, Darling-Hammond & Cheuk, 2012; Gandara, Maxwell-Jolly & Driscoll, 2005).

A major contributing factor to the achievement gap for English Learners occurs as a result of the previous standards (Bunch et al., 2013). Prior to the adoption of the NGSS, literacy was taught to ELs in English Language Development (ELD) classes, and science teachers did not typically receive professional development to meet the specific needs of English learners. Now that the NGSS integrate literacy, the CCSS include standards for Literacy in History/Social Science, Science and Technical subjects, and the ELD standards link to CCSS, which can be linked to NGSS, teachers are expected to foster literacy development in the context of learning science because content understanding is inherently linked to the process of learning language (Bunch et al., 2013, Santos et al., 2013).

The modern science classroom requires "practices [which] are generally less familiar to many scientists and require a shift" because engagement in the NGSS is also language intensive (Lee, Quinn & Valdes, 2013 p.225). The National Research Council's (NRC) Board on Science Education (BOSE) issued "A Framework for K-12 Science Education" in 2011 (NRC, 2012), which is the basis for the Next Generation Science Standards (NGSS Lead States, 2013). The focus in the new standards is for students to engage in practices of science in order to learn desired concepts, and these science practices are fundamentally dialogic (Kelly, 2014). Specifically, students obtain, evaluate and communicate information, they engage in argument from evidence, they construct explanations and design solutions, and develop and use models (NGSS Lead States, 2013). In these new standards, literacy is the means by which content knowledge is demonstrated.

This connection between science and literacy is meant to further students' understanding of how language is used to create meaning within academic subjects (Lee, Quinn & Valdes, 2013). However, a shift in standards is useless if teachers are not prepared to shift their practices.

Language is at the center of the CCSS and NGSS and it "[calls] for levels of engagement in, and production of, language and literacy that go well beyond the focus of "basic skills and scripted curriculum" of previous standards (Bunch 2013, p. 299). At the same time, although the new standards may have been created with an eye toward equity, educators must not embrace the more rigorous standards and yet fail to support students. For this reason, it is necessary to create classroom environments to support ELs in their development of literacy skills in tandem with science to foster academic language and literacy while building content knowledge (August et al, 2014; Bunch, 2013) and educators must recognize that the content taught in science subjects is not separable from the language used to present content, just as it isn't separate from the expression of learning (Schleppegrell, 2007; Lee, 2018).

Understanding the needs of ELs in science

Scholars including Vygotsky (1987), Cazden (2001), and Halliday & Moses (2013) have argued that language is the core of teaching and learning, while Piaget emphasized the importance of acknowledging environment and building on prior knowledge (Piaget 1972) and Dewey theorized that learning most effectively occurs through the process of doing (1938).

Vygotsky's work is an investigation of human development as a system within dynamic, physical, social, cultural, natural, and historical systems at the center of which are the processes and interactions through which language is acquired and a system of meaning is created (Vygotsky, 1987b). "Vygotsky saw a dialectical relationship between language and thinking processes, with each process shaping and being shaped by the other in an internal mental system that resulted from their unification" (Mahn, 2013). Most simply, teachers cannot teach children to make meaning of content without understanding that there are cognitive processes involved

that allow students to construct meaning and find the words to communicate that learning. (Bunch et al., 2013).

Vygotsky also believed in student-centered approaches to learning but specified that interaction precedes development and that the social aspect is key to the learning process. His theory of learning through social interaction in which students are challenged within their zone of proximal development (Minick, 1987; Vygotsky, 1978) lends to a classroom structure that emphasizes collaboration. To connect Vygotsky's theories, Schleppegrell (2004) explains language functions to produce meaning in order to fulfill a goal that stems from social interactions. He explains that the goals vary depending on the context and with whom the interaction occurs. It can be said that theories on learning as a product of social interaction were building upon Jean Piaget's idea of learning as an individual construction, which is to say that individuals construct knowledge by interacting with their environment, and that their newly constructed knowledge varies based on how their interactions and experiences build on their current knowledge (Perkins, 1991; Piaget, 1972; Vygotsky, 1978). Thus, an individual's prior knowledge and cultural experience should be the base for the construction of new knowledge. For example, classroom experiences should encourage ELs to draw on their primary language or familiar cultural elements from their homes and communities so they can connect them to new concepts. Aside from schools being enriched by the diverse experiences and perspectives of students and families from different cultural backgrounds, these experiences born from family, community and culture can act as a springboard for EL students to learn science (Gutierrez & Rogoff, 2003; Moll et al., 1991, Ishimaru, Barajas-Lopez, & Bang, 2015; Nasir et al., 2014) For EL students to successfully learn science they need opportunities to engage in classroom and real-world experiences that foster use of multiple resources to make meaning (Moll et al., 1991).

Their various interactions then allow them to draw from multiple resources to make meaning and engage in science content and practices while simultaneously building language. Halliday (1978; 2014) and Halliday and Martin (1993) best describe the process through their theory of systemic functional linguistics which understands language choices to be based upon modalities that students can draw meaning from, the relationships enacted in the process and the actual content they're engaging in. Students shift registers depending on all of these things. If the content shifts, they're working with a whole new set of vocabulary and have access to different modalities and with that shift comes a new community of practice. The three are not simply related. They are inextricably connected as are parts of an equilateral triangle.

Project-based learning in science offers students a unique opportunity to merge the three in a relevant way. As an extension from Vygotsky's theory on learning through social interaction, John Dewey emphasized that students can best learn by constructing or doing. He posited that when students learn-by-doing in a collaborative, inquiry-based and flexible way, they grasp concepts better in the long run (Dewey 1938). Dewey's theory on learning also influenced William Heard Kilpatrick's development of The Project Method, whose principal strategy is to engage students in projects that both pique their interests and implement some kind of action in the world around them (Kilpatrick, 1918). The inclusion of projects mirrors the student-centered approach that Dewey and the progressive educators of the 1920s advocated while offering a context for Halliday's theory. Figure 1, below, is inspired by Aristotle's rhetorical triangle. Aristotle argues that in rhetoric, a speaker's ability to persuade an audience hinge on the three rhetorical appeals or strategies to persuade the audience. Similarly, effectively engaging EL students in science hinges on who is involved, how meaning is communicated and the topics, processes and activities of the content. Effective experiences for ELs in science offer

a context for all of these things to coexist. Halliday explains that meaning is expressed, and, in this case, science learning is expressed through the interplay of modalities (how meaning is presented for understanding), content (choices shaped by the topic, processes and activities within the content, disciplinary literacy), and community (level of formality, grouping, role, status). For instance, if the content area changes, the types of modalities available to communicate meaning change and so will the community of practice. If the community of practice changes, the way the content learning is communicated and the types of appropriate modalities for communicating the learning will change. All three are connected and rely on one another within the context of effective science learning for ELs. Engagement in real-world science practices provide the inquiry and the relevancy students benefit from and if the teacher is effectively positioning students to succeed, they are implementing multiple modalities both linguistic and non-linguistic, they are leveraging the power of students' culture and community and recognizing that who is involved matters. The teacher should also understand that based on all factors students should have a choice about how they express the learning because it is shaped by the process.

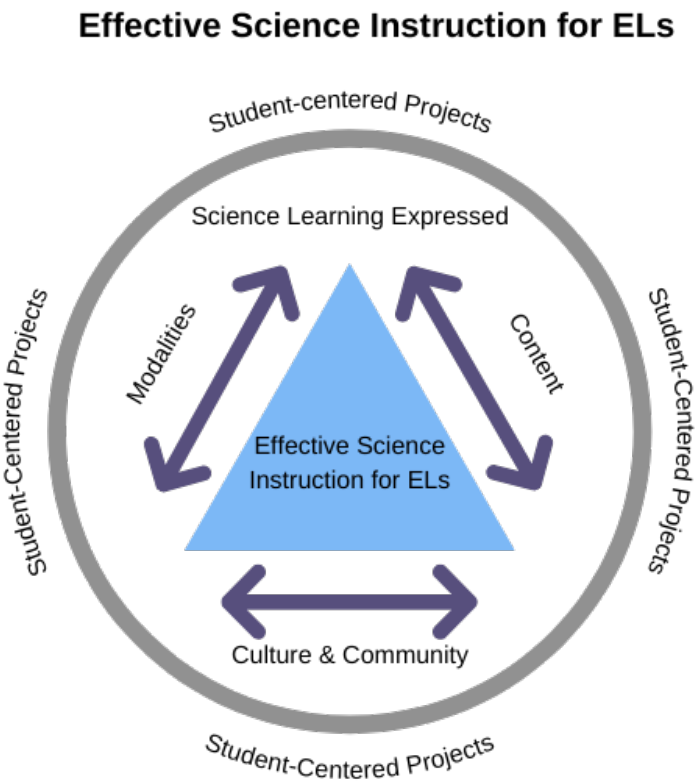

Figure 1
Effective Science Instruction for ELs

Practices and Strategies to meet the Language needs of ELs in science

Second-language acquisition theories have informed programs and instructional strategies designed to meet EL students' linguistic needs. Researchers and practitioners have worked to reimagine approaches to meet the needs of ELs in science classes as well as identify practices and strategies that further students' understanding of science and language. Some practices that must be reimagined, include frontloading vocabulary because pre-teaching vocabulary will make sure the students know the word, but they cannot understand its true meaning unless it is taught

in context, making it a product of science learning, rather than a prerequisite (Gibbons, 2006). Along that frame of thought, it is also important to stop creating learning goals that separate language from science objectives and instead, advocate for a functional use of language that allows students to engage in scientific practices -- in other words -- do the things scientists do. Moreover, many teachers often think they must simplify content for ELs, but the truth is, their difficulty is not with cognition, it is with language. As a result, teachers should amplify opportunities for language learning within the context of science instruction, without simplifying the content, but instead implementing language support scaffolds.

According to a report that encompasses research about ELs and STEM, a number of scholars studying how English Learners best develop language and scientific understanding have learned that aside from using culturally sustaining pedagogies, the best approaches to teaching science to English Learners involve the following best practices: engaging students in disciplinary practices, engaging students in productive discourse and interactions with others, utilizing and encouraging students to shift registers and use multiple modalities (NASEM, 2019). Implementing these strategies, while also taking the time to focus on how language functions in the discipline and leverage students' ability to use strategies to draw meaning are critical steps to teaching English Learners science. The strategies selected often function in conjunction with one another or overlap in their implementation based on students' language needs and the content learning goal.

Engaging Students in Science Practices

The process of engaging students in science practices provides opportunities for rich language development. The practices that researchers have identified as productive, when

implemented together, present an ideal opportunity for ELs to develop the language necessary to express their conceptual understanding (National Academies of Science, Engineering and Medicine, 2018). When selecting phenomena or problems for students to investigate, it is critical to consider students' culture, everyday language and primary language because students are more likely to invest in the learning (National Academies of Science, Engineering and Medicine, 2017). Students' interests, narratives, personal and cultural worlds contribute to how they are positioned and how they come to see themselves as science learners (Brown, 2006; Varelas et al., 2008; Varelas, Kane, and Wylie, 2012). ELs comprise a wide variety of home cultures and languages, and teachers need to take that into consideration when constructing opportunities for science learning. (Bang, 2015; Bang et al., 2013; Hudicourt-Barnes, 2003; Warren et al., 2001). Doing so will make modeling, arguing, explaining and reasoning more engaging to students, which develops language through the process of engaging in science (Moll, et al, 1992; Lee, 2018; Lee et al, 2019). As children learn new concepts, they also learn new discourse patterns, new ways of using language to interact with all the ways they can make meaning. Then they can share their perspectives as they engage with the concepts. Thus, language development and concept development occur simultaneously; in humans, language development and concept development are inextricable (National Research Council, 2000). As students develop their understanding of science disciplines, their language evolution expresses conceptual understanding, making them connected. For instance, when ELs engage in highly demanding science practices, they process and question the ideas, concepts, and procedures to transform what they learn into a project or present their learning to a public audience. They have rich conversations about what they are learning, make connections between spoken and written practices, evaluate evidence, and begin to critically question (Zwiep & Straits, 2013).

Productive Discourse and Interactions with Others

For students to engage in productive discourse, ELs should engage in meaningful interaction with others. For interactions to be considered meaningful, scaffolds that support students to participate must be implemented for students to begin developing and testing evidence-based conjectures about the world. With those supports in place, they will engage in science as scientists do as they try to make sense of phenomena. Layering collaboration with science practices makes content more accessible for English Learners. However, as with any challenging task, ELs will require varied opportunities to engage and interact for learning to occur.

Depending on students' needs, teachers can determine the most appropriate scaffold, as scaffolds can occur as a structure and as a process (Walqui, 2006; Walqui and van Lier, 2010). They can also be utilized in multiple levels (van Lier, 2004). For instance, macro-level scaffolding involves the design of long-term sequence of lessons or projects, with recurring tasks that vary slightly over an extended period. Meso-level scaffolding involves the design of individual tasks as a series of steps or activities that occur in a sequence or in collaboration with others. Micro-level scaffolding involves unpredictable interactional processes of appropriation, stimulation, give-and-take in conversation, collaborative dialogue (Swain, 2000). Selecting the appropriate scaffolds, organizational sequence of learning and activities for learning are necessary aspects of providing English Learners access to disciplinary practices in a productive and culturally relevant way.

Structured Disciplinary Talk and Modeling

Part of being a scientist is the ability to talk like a scientist, so teachers need to create classrooms that allow for disciplinary talk (Michaels and O'Connor, 2012), which develops students' oral language and their ability to speak as a scientist would, which are areas where EL students typically struggle. Science talk formats are one important way to structure ELs engagement with science. Coaching students in disciplinary talk helps them to make better sense of the material and engage with it. When they have the opportunity to engage in different types of talk (whole class think alouds, small group structured or unstructured discussion, paired tasks) and individual thinking time to prepare for these talks, they are able to better make sense of and access the curriculum because each type of talk supports the different ways in which scientists communicate and reason (Michaels & O'Connor, 2015).

Another way to teach academic talk would be to model the academic language of the discipline in context, define disciplinary terms when using them and plan ahead to ask students unanticipated questions at strategic places throughout the lesson. Over time, students learn to speak in ways scientists do: asking their own questions, which is reminiscent of the inquiry in which scientists engage (Cervetti, DiPardo & Staley, 2014). Teachers can then rephrase students' language when they contribute answers, which allows them to hear their ideas in a more academic register (O'Connor & Michaels, 1993), and model language that can be used in a formal discussion. When teachers set-up their classrooms to support opportunities for students to talk about science, they also learn other valuable ways that scientists engage. They begin to share ideas, clarify their own thinking, listen to and comprehend another's ideas, expand on another's ideas, support their own reasoning using evidence, ask questions and make comments that allow

them to grasp and build upon another's process or thinking. Explicitly teaching these processes helps EL students to productively and equitably participate in school (Michaels and O'Connor, 2015).

Utilizing Multiple Modalities

Multiple modalities are valuable in both science and for EL learners. Within the science disciplines, multi-modal forms of communication, such as graphs, symbols, and equations are a necessary part of understanding the content because they are integral to communicate information and participate in disciplinary practices. (Lemke, 1998). In a classroom, students use a range of both linguistic and non-linguistic modalities to communicate thinking and ideas.

In the field of English Language development, multiple modalities are typically seen as scaffolds to support language learning. As a result, the importance of multi-modal learning in science fields lends naturally to supporting emerging language learners to engage in science practices such as understanding sequencing, explaining the function of mechanisms or when arguing from evidence (Lee, Quinn & Valdez, 2013). Some researchers would go as far as to argue that multiple modalities are essential for ELs to engage successfully in science practices (Grapin, 2018). Teachers who successfully utilize multiple modalities in the science classroom as a support system for ELs have the potential to shift the narrative about language learners in the sciences from a deficit model, to one that recognizes the potential ELs have to utilize their ability to harness multiple meaning-making resources to contribute and thrive in a science classroom. Therefore even multiple linguistic modalities such as register shifts are also important. Not only are they a way for students to build a bridge from informal, everyday language, to more formal

academic register, they constitute a linguistic modality that functions as a scaffold and a resource for meaning-making.

Although academic language is the expectation for formal assignments and presentations in science, it is only one means students use to express their understanding of science concepts and reasoning. As a result, teachers should not discount informal language, because it is possible for students to use informal registers to communicate precise claims (Lee, Quinn & Valdes, 2013). Informal language is also important because it allows students the space to make sense of phenomena or concepts during the learning process. It is the steppingstone to understanding during the initial exploratory phase (Barnes, 2008) or during small group. For instance, Grapin (2018) explains that students often use every day register in conjunction with nonverbal means of communication such as gestures or using objects to develop a precise understanding. However, one important thing to note is that teachers should not discount informal language, because it is possible for students to use informal registers to communicate precise claims (Lee, Quinn & Valdes, 2013).

Moschovich (2012) in her investigation of language support in the Math classroom, recognizes that students can develop that precise understanding using informal means and then an additional layer of academic language support can be provided for formal assignments. Similarly, in science, Lee, Quinn & Valdés (2013) found that perfect English is not required for ELs to demonstrate precise understanding. That is because the concept of precision is not a matter of selecting the right individual words. It is an issue of writing explanations in sentences that allow for claims to be more or less specific (or precise), even if they don't use the best academic vocabulary. Students can argue a position in support of a claim, express specific understanding and explain the rationale for their selection of evidence to support that claim in

imperfect English. (Quinn, Lee & Valdés, 2012). Then, over time, the academic language is layered in as teachers demonstrate the value of shifting registers and provide scaffolds such as science talk frames along with multiple opportunities to communicate scientific content in ways actual scientists do. Michaels and O'Connor (2015) in their investigations of academically productive discussions, have identified "teacher moves" that coach students in their development of academic communication, such as rephrasing, asking for clarification, building on what students say and revoicing to rephrase students' spoken informal language in a more formal register.

Strategies in Action

Science teachers of ELs are essential to ensuring that ELs learn disciplinary concepts and practices. Moreover, as the newer content standards call for both sophistication in science learning as well as in English, the teacher needs to attend to both the content as well as the language (Bunch, 2013). Collaboration with English Language Development teachers may play an important role in facilitating ELs progress as they engage in science.

Given that language and content are inextricable, the instructional strategies proposed to foster ELs' learning of science disciplinary practices acknowledge this relationship. It is important to focus on engaging ELs in productive discourse as they are also engaging in disciplinary practices. Teachers can focus on the language that is used in the disciplines to develop ELs' ability to utilize multiple registers and modalities in the communication of their ideas. At the same time, this calls for leveraging the experiences that ELs bring to the classroom.

In Swanson, Bianchini, and Lee (2014), a high school teacher had her students engaged in the process of generating and evaluating arguments from evidence, sharing ideas and understandings with others in public forums, and using precise language while doing so. Her approach provided her EL students with multiple, scaffolded opportunities to articulate their ideas about natural phenomena; engage in the process of developing arguments from evidence; and read, interpret, and evaluate scientific information. Her view of science as more than simply consumption of content information allows students to be scientists and do what scientists do, which is the very process Piaget, Dewey and Vygotsky espouse as the foundations of learning. The teacher's implementation of strategies to meet the needs of ELs allows her EL students to effectively participate and learn science and language in context.

A quasi-experimental study which took place from 1996-2004 involving 55 secondary teachers and 2000 middle and high school students found that EL students whose teachers utilized cognitive strategies instruction scored 32% better on writing assessments for 7 consecutive years compared to students whose teachers did not implement cognitive strategies (Olson & Land, 2007). The organization of learning in a classroom helps students to create meaning that they can then communicate in writing. The use of cognitive strategies guides students in their understanding of complex concepts and scientific phenomena and brings that complexity within their zone of proximal development (Vygotsky, 1987). When teachers in a mainstream setting explicitly teach EL students to use cognitive strategies in reading and writing, they learn how to think about and grasp rigorous content. The cognitive strategies trigger processes that Vygotsky explains act as scaffolds that help students create meaning (and then to develop the language to express that learning) that English Learners require additional support to express that learning through language.

The researchers found that modeling the use of cognitive strategies coupled with guided practice and scaffolds to help EL students read and write about complex texts results in higher achievement. Essentially the cognitive strategies bridge the gap for learners so that they can begin to construct the language necessary to demonstrate their thoughts. They also found that when teachers apply these strategies consistently over the course of the school year, students internalize them and begin to use them independently (Olson & Land, 2007). Then, once content and language merged, teachers were able to demonstrate the use of some of the cognitive strategies such as mind maps and fact and inference charts to help with writing. Teachers also had students examine sample student anchor papers using three colors. Throughout the process, students frequently interacted with teachers and classmates, which is beneficial to student success (Michaels and O'Connor, 2015). Teachers guided and modeled these strategies for their EL students over eight years (Olson & Land, 2008), which surpasses the amount of time that it takes students to become proficient in academic English (Cummins, 1979). The additional layer of language supports like sentence starters and color coding to analyze ideas present in writing helped students to engage in the process of guided and peer revision, which also relates to Vygotsky's theory that learning is also a product of social interaction (Vygotsky, 1987).

There is also a body of evidence that supports Dewey, Vygotsky and Piaget's theories that the process of problem solving and doing something to demonstrate learning develop a more concrete understanding of a content and its language. Investigation and experimentation, reading and discussing and sharing ideas are all strategies that EL students benefit from (Olson & Land, 2007, 2008,). Project-based learning requires students to present their products to a public audience of peers, experts and outside community members who use a rubric to assess and facilitate reflection, but it is also partly influenced by Dewey, Vygotsky and Piaget's theories

which relate to student choice, peer-to-peer collaboration, exploration, inquiry, problem solving, individualized activities, and reflection—activities that are essential to project-based learning. Their theories develop a conceptual framework for understanding project-based learning, and they are the roadmap to teaching and learning activities in project-based learning.

In more recent years, two major fields have further shaped project-based learning as we know it. Research in neuroscience and psychology have supported that the combination of doing, along with problem solving and reflecting, within specific contexts for learning, deepens individuals' learning experiences (Gardner,1987; Piaget, 1972; Vygotsky, 1978). Scholars understand that learning is enhanced through meaningful social interaction, and that culture, community, and past experiences all influence learning (Bandura, 1977). Furthermore, just as the industrial age shaped schooling in the nineteenth and twentieth centuries, today's digital and information age requires schools to adapt to the twenty-first century (Partnership for the 21st Century, 2008). The workplace today requires graduates with soft skills. It is necessary for graduates to be able to plan, problem solve, collaborate, and communicate in a globally interdependent world. This cultural and societal shift only adds to the appeal of project-based learning.

The unique attributes of project-based learning, which are rooted in constructivist pedagogy and social learning theory, demonstrate its potential to increase student learning, particularly among English Learners. Teachers of mainstreamed EL students in California's project-based learning secondary schools seek strategies to meet the demands of the new standards. Instructional and linguistic support facilitates English Learners' work with academic content (Collier, 1987; Cummins, 1981b, 1992, 1999; Walqui, 2000a). Teachers who utilize project-based learning approaches provide some linguistic support to these students by

embedding cognitive strategies, but also through collaborative work groups in which students work with peers to develop and manage their projects.

In a study of collaborative learning for ELs, collaboration and cooperative learning were found to increase learning (Kagan & McGroarty, 1993; Lee, C.D & Smagorinsky, 2000). Discussion among peers produces less anxiety than speaking before the entire class. Cooperative learning groups lower the EL student's affective filter and promote the development of content literacy, which promote both language skills and content knowledge (Minicucci & et al., 1995). Furthermore, group discussion and processing develop critical thinking and increases comprehension (Meltzer & Hamann, 2004). Cooperative learning and collaboration are research-based best practices for English learners that just so happen to be unique attributes of project-based learning (Markham, Larmer & Ravitz, 2003). Investigation and experimentation, reading and discussing with others, and sharing ideas through the writing process are all fundamental parts of project-based learning that support recommended EL interventions for secondary students (Olson & Land, 2007, 2008).

Project-based learning provides students with the opportunity to establish a common ground between traditional school material and real-world skills valued in the workplace. While participating in Inquiry-based projects, students make connections between how the English language functions in an academic setting by producing an academic work-product, based on an investigation related to a real-world problem. In doing so, students understand the nuances between how language functions at school in an academic setting, compared to a real-world experience all while working on the same project (Echeverria et al, 2013). Throughout the process, students, even novice English learners, communicate in collaborative groups, conduct interviews or take field observations, all of which require different modes of language. They

develop skills that allow them to plan, organize, negotiate roles and duties, develop and support claims, and establish a consensus about issues such as how information will be researched and presented (Blumenfield et al., 1991). English learners benefit from project-based learning through the strengths of their team members and learn to communicate orally among each other (Echeverria et al, 2013).

Projects that follow a project-based learning approach are student-driven with the teacher playing the role of a facilitator of learning instead of that of a sage on the stage (Chard, 2001; Markham, 2003; J. W. Thomas, 2000). The project-based learning approach allows the teacher to create opportunities for students to ask and investigate questions of interest within the subject matter to establish a practice of voice and choice. Since the teacher functions as a facilitator within the project-based learning model, she is not the sole source of the knowledge, and thus both other students and the teacher can support EL students' needs. Projects provide students more time to grow in their ability to identify and find information for their projects and evaluate and organize the information—skills that are germane to project-based learning (Breivik & Senn, 1994).

The common thread woven through studies on literacy support in the sciences goes beyond basic reading and writing of print texts. The literature presents methods that encourage students to broaden the definition of a text from a book to anything that can be examined and used as evidence to argue a position on a topic or issue, solve problems or make scientifically and logically sound decisions. Project-based approaches to developing students' argumentation and inquiry skills provide English Learners with social, student-centered, hands-on approaches that will provide both sociocultural knowledge and linguistic knowledge. Students will get cognitive supports that will both build their understanding of scientific phenomena and concepts,

as well as their language base and create the sociocultural experiences that they need to interact in a 21st Century academic setting (Krashen, 1981; Swain, 1985; Eyring, 1989).

In one particular study, researchers (Bodzin et al., 2013) utilized Geospacial technology (GT) as an extension of the textbook. Students interacted with Global Positioning Systems (GPS) and Virtual Globes (Google Earth) and the concepts in their textbooks came to life. When the language of a textbook is too far above an English Learner's Lexile level, or a teacher lectures about concepts to an English Learner, the student cannot process the information they are expected to learn because the language is too complex. Project-based learning provides students with comprehensible input, which Krashen defines as a message slightly above a student's language level. This allows for meaningful interaction which contributes to language development. At the same time, in the example above, students participate in an experience that allows them to understand the content by experimenting with it. Students understand the technology and socialize through the experimentation aspect of the project thus, enabling students to comprehend the ideas, which results then in the functions of output, as students are able to explain the process of their learning. As such, the GT fostered energy literacy by engaging students in problem solving using energy learning activities.

In another case, students engaged in project-based learning that challenged them to make an informed decision about whether to erect a new electrical power plant. To do this, students had to examine and analyze geo-spatial relationships like precipitation, wind speed, tidal ranges and annual sunshine among others, synthesize their understanding of the various variables and develop an argument to support their decision about where to place a new power plant. Using these tools, students gained knowledge that allowed them to demonstrate a sound conceptual understanding of energy resources specifically related to the acquisition of renewable and non-

renewable sources of energy. The tools helped students develop a deep understanding of scientific concepts associated with making energy decisions. When compared to students expected to understand the same concepts from a print textbook using a business as usual (BAU) approach, the students who utilized a Geospatial approach to energy literacy demonstrated 10 percent higher score on the post test as compared to the BAU group, when initially their pretest results were only half a percent different. The data also indicate that students who participated in the GT approach to energy literacy also came from lower socio-economic and more linguistically diverse backgrounds. Thus, the researchers concluded that a hands-on approach to content creates more opportunities for content literacy and language development.

Similar findings resulted from a Texas study involving middle school science students. The study was implemented at ten middle schools in a high-poverty district of the Rio Grande Valley with a high percentage of Latino EL students. 1,309 sixth grade students participated in the study. Of them, 27% of them were classified as English learners. Fifteen teachers who were qualified to teach science participated with each of their two classes randomly assigned to be control classrooms and two of their classes randomly assigned to be treatment classrooms.

In treatment classes, researchers had teachers implement inquiry-based science lessons that incorporated demonstrations and modeling of science content, student academic discussions centered on the science content, and scaffolding techniques such as deliberate partnering, graphic organizers and close, guided readings of the textbook. In these classrooms, EL students were partnered with English proficient students. Control classrooms used the Prentice Hall textbook and workbook along with district-developed labs that were aligned with textbook content (August et al., 2014).

Comparisons between the control group and the treatment group proved the intervention to be statistically significant. However, when the data were disaggregated, the EL population demonstrated statistically significant growth in academic language only. Further examination of the research indicated that implementation of the interventions in treatment group classes was only at about 66% fidelity, which likely skewed the results. Researchers estimated that with the implementation at 100% fidelity the effect size for the EL population in the treatment group classes would have also been statistically significant in increasing science content knowledge. Another important aspect to note about the findings is that students in the treatment classes were at various levels of language learning, with some newcomers requiring additional scaffolding to improve understanding of science concepts or post-test items. Although researchers included all levels of EL in the treatment groups because many schools group students that way, it is important to realize that some ELs require more support.

The research also demonstrates that providing opportunities for students to engage with different types of texts can promote higher order thinking skills that develop science-based literacy. Research from a college-level Biology course builds upon this idea of a living text via laboratory experiments. However, the approach also brings lecture concepts to life via literacy strategies. These ideas are also represented in August and colleagues' (2014) study with inquiry-based labs and embedded literacy strategies. In this study, researchers used a combination of tools and strategies to create a bridge to traditional lecture and print text. Although not specifically related to English Learners, the scaffolds embedded would also benefit English Learners in their development of both literacy and content understanding because they blend sociocultural and linguistic approaches to language development.

For this study, there were three types of Biology lab sections. The primary author (Harmon) led three sections of the lab. Two of the sections used both a lab experiment as a hands-on extension of the text and embedded literacy strategies linked to lecture concepts. These were called "treatment groups." Harmon also led a third lab section only using the lab as a hands-on extension of the textbook. This was called the "comparison group." The other six sections were led by graduate students who used labs as a hands-on extension of the textbook. These were referred to as "Other" sections.

The treatment groups benefited from embedded literacy strategies in addition to a lab connected to concepts from the text and lecture. The strategies included concept mapping, comparison charts, such as Venn diagrams, drawing out scientific processes and academic vocabulary. These strategies emphasize that students make connections or see relationships between concepts. Overall, the two treatment lab groups which combined strategies with the labs demonstrated the most growth from pre-test to post-test, which averaged to 8.8 points. The comparison group only averaged a 5.6 point growth, while the other sections experienced a 5 point growth by the end of the term as compared to their pretest. In this case the growth students in the treatment group was even greater than the 10% overall growth of students in the energy literacy unit which introduce Geospatial technology as a text (Bodzin et al 2013).

Although these two studies were not related to specific instruction of ELs, there is a connection between the strategies Harmon and Pegg (2013) and Bodzin et al. (2013) utilized and those that Lee, Quinn and Valdes (2013) outline in their discussion of how to support ELs through the shifts required by the CCSS and NGSS. In this case, Harmon and Pegg's results (2013) most accurately support Lee, Quinn and Valdes in that Harmon made a point to both redefine texts, and embed literacy supports to further students' knowledge of scientific concepts.

Lee et al (2013) highlight that "when students, especially ELs are adequately supported to do specific things with language, both science learning and language learning occur" (p. 224). When students in the Treatment group participated in mapping concepts, comparing reactions in charts, drawing out scientific concepts, engaging in content specific vocabulary instruction and asking focused questions, they performed much better than students in the other groups. This leads to an important connection between empirical data and theory that although embedded literacy strategies may be commonly used to support ELs, all students benefit. Moreover, literacy supports are a powerful tool to build content area knowledge (Lee et al 2013).

According to studies in understanding interactive visualizations in Geospatial energy literacy and laboratory activities in Biology (Bodzin et al. 2013; Harmon & Pegg 2012), literacy supports are a proven vehicle to content level understanding. At the same time, the investigative nature of learning in Bozdin's and Harmon and Peg's studies also contributed to students' development of scientific language. Thus, a combination of investigation with literacy supports intended for English Learners can develop both language and content understanding. When the tenets of Inquiry-based projects: Investigation and experimentation, reading and discussing with others, and sharing ideas through the writing process are combined with clear language objectives and the natural fit of inquiry-based science, it can be expected that students' mastery of both language and scientific understanding will be furthered.

Implications of Professional Learning for Science Teachers of ELs

If science teachers lack the knowledge of how to help English Learners successfully access and master the NGSS and CCSS, and English Language Development teachers are

expertly trained to further students' ability to grasp rigorous content and complex text, it makes sense for the two groups of teachers to collaborate to learn from one another (Truijen et al., 2013). Research on the outcomes of teacher collaboration also supports that collaboration yields positive results for both teachers and students (Vangrieken et al. 2015). Darling Hammond (2006) posits that quality teachers and teaching, access to challenging curriculum and well-organized classes will ameliorate the achievement gap for ELs. The new standards give students access to rigorous curriculum but making a shift that supports English learners to meet the expectations of the new standards requires more specific professional development. Teachers need to be prepared to integrate disciplinary language instruction along with their content instruction, but scholars do not all agree on a framework for that process (Bunch, 2013; Lucas and Villegas, 2013; Turkan et al., 2014).

George Bunch, of the University of California, Santa Cruz believes there should be a purposeful integration of language and literacy instruction within science content instruction, which requires teachers and students to change the learning process in the ways both science and language are learned because they are linked. This shift in focus that Bunch recommends would require science teachers to develop what Galguera (2011) and Bunch refer to as pedagogical language knowledge. Bunch draws a distinction between pedagogical content knowledge about language, which is the content that language development teachers possess and pedagogical language knowledge, which is an additional layer of knowledge that content teachers require to integrate disciplinary language support in the content classroom. In other words, pedagogical language knowledge requires content area teachers to know how to support language development in their content area by integrating supports to facilitate both content understanding and language development. Bunch believes that all content area teachers require this degree of

understanding of language in order to effectively support second language learners to meet the demands of recent standards shifts.

Lucas and Villegas (2013) do not necessarily agree with Bunch's demands of content area teachers, and instead believe that content area teachers simply need to be linguistically responsive, which is that they care enough to try to support language learners but are not experts in language development because language is not their content. Their content is the discipline they teach, which is science, social studies, literature or any other content. As such, Lucas and Villegas believe that there are three characteristics and four types of pedagogical knowledge and skills that teachers need to be aware of in order to be considered linguistically responsive. The three characteristics that Lucas and Villegas must be present in a linguistically responsive teacher include their awareness of the effects of society on language, an appreciation of linguistic diversity and a desire to advocate on behalf of English Learners. Aside from those characteristics of mind, Lucas and Villegas believe that content area teachers require certain pedagogies to be successful content teachers to English Learners. They include a wide range of knowledge and strategies to learn about the linguistic backgrounds of their students, the ability to apply important tenets of second language acquisition, the ability to understand the language demands of the tasks they assign to students to complete and the ability to scaffold strategies to help students access the learning material and goals.

Turkan and her colleagues propose that teachers need to possess what she calls disciplinary linguistic knowledge, which is a base that will facilitate teachers' ability to develop ELs' understanding of the discourse within their content area. Specifically, it requires that content area teachers of English Learners be able to identify the linguistic features of the types of communication associated with their content area and the ability to model for ELs how to

communicate disciplinary meaning through engaging students in using the oral and written language of the content. Without the ability to identify the linguistic features of the content, it would be difficult to make content accessible to students. Therefore, it would also be difficult to teach students how to engage as an expert in the content would. As a result, students would struggle to express their learning, if they learned at all. Emphasizing the importance of linguistic features and their connection to students' ability to both understand and engage in content discourse would shed light on any gaps in a teacher's knowledge of content discourse and their ability to effectively challenge their ELs to claim disciplinary discourse by engaging in it. In making this connection, Turkan and her colleagues identify the specific role that content teachers play in their development of EL students' language.

All in all, scholars agree that when it comes to teaching English Learners, the knowledge that content area teachers must possess goes beyond good teaching and the best practices for one content area may not be valid in another content simply because context plays a role (Ramirez & Celedon-Pattichis, 2012). Content area teachers of English Learners require a combination of strong content area teaching and the ability to integrate disciplinary language to support and challenge English Learners. Although Bunch, Lucas and Villegas, and Turkan and colleagues were not specifically discussing teaching science to ELs, they provide a lens from which to view quality instruction for ELs. In terms of science content instruction, the strategies deemed effective for teaching science to ELs all fit within the frameworks designed by the aforementioned scholars. Science professional development providers need to ensure that they provide support students to acquire discipline-specific academic language, explain and support the development of the kinds of linguistic demands of content-specific texts and tasks, implement instructional strategies to help students access concepts and language and organize

their classrooms to support students to build a deep understanding of language and content. Effectively supporting science teachers to successfully challenge their ELs is a complex issue that must address differences across grade-level bands, science subjects, teacher experience, and the many facets within EL student populations. The variety requires a move beyond generalized frameworks and best practices for teacher learning toward specifically designed settings that focus on the unique assets and needs of ELs when learning.

Conclusion

If educators are going to commit to working together to support English Learners' access to science, then content literacy and English language development deserve a place in every classroom across science disciplines, ability levels and grade levels. There have been and will continue to be skeptics. However, all the research has proven the opposite. What has been most enlightening about this investigation is that college professors even recognize the validity of this work and hope high school teachers would embed more literacy supports as a means of better preparing students for the specific content understanding of the majors they will ultimately choose to study in college. English Learners face enough barriers and the achievement gap is real. We cannot possibly expect students to be prepared for college and career if we ignore students' need for content literacy support as a bridge to content mastery. Moreover, the English Language is important, but sometimes in our effort to help students learn content in English, we fail to see the resources they bring into the classroom and leverage them in support of their learning.

CHAPTER 3: METHODS

Effectively supporting science teachers to successfully challenge their ELs is a complex issue that must address differences across grade-level bands, science subjects, teacher experience, and the many facets within EL student populations. The variety requires a move beyond generalized frameworks and best practices for teacher learning toward specifically designed settings that focus on the unique assets and needs of ELs when learning. I will conduct a professional development program with a team of science teachers at one high school as a means of understanding how such professional learning settings can be designed and what teachers learn in them.

I ask the following questions:

Research questions

1. Does science teachers' thinking about their ability to provide language support to their EL students change through their participation in this project?

2. Does participation in this project increase science teachers' intentions to implement language supports as evidenced in lesson plans?

Research Design and Rationale

This is a descriptive, qualitative case study. I collected data on participants' thinking through a range of data sources, including video transcripts of learning sessions, written responses to journal prompts for reflection and pre and post interviews. I also compared pre and

post intervention project plans. During the pre-project phase, I conducted a 30-45 minute baseline interview. During Phase one of the intervention, I collected data from screencasts of learning team meetings and participant journal reflections. During Phase two of the intervention I collected data from screencasts of learning team meetings and participant journal reflections. During Phase three of the intervention, I continued with collecting data from screencasts of learning team meetings and participant journal entries, but also had data from participant activities. These data collection methods allowed me to track the progress of teachers' understanding of strategies and trace changes in their thinking. During Phase 3 teachers also analyzed a preexisting lesson plan, which revealed their emerging understanding of strategies. They then worked together to revise the plan, which yielded data about their intentions to implement the language supports they learned and practiced in previous sessions.

A professional development case study is most appropriate because most science teachers have little experience tailoring instruction to help their English Learners flourish, and do not see themselves responsible for more than the science content or tasks (Tan, 2011) and typically, Science educators see themselves as the experts when it comes to teaching their content (Arkoudis, 2000 & 2003). Together, they can work to overcome the institutional hierarchy that privileges content teachers over language development teachers (Arkoudis 2006) and utilize established relationships and a collaborative team environment to promote work with ELs in Science classrooms that focus on science objectives that lead to participation in disciplinary practices (McDonald et al, 2017). Science would still be the focus of the learning, but there would also be embedded functional language supports that allow EL students to fully engage in the science practices because their language needs are supported and they can interact in meaningful ways by drawing on their language and meaning-making resources to make sense of

scientific phenomena and develop a more sophisticated understanding of science (Francis & Stephens, 2018). The collaborative learning team sessions will engage science and English Language Development teachers to investigate the ways in which they can work together to understand how to better support English Learners in science classes. The structure of learning sessions combined with activities and collaboration is the best approach to allow teachers the space to develop and take ownership of their process, which research indicates will yield more meaningful results (Main 2008; Felner et al., 2007; Eisenman et al 2003; Levine 2010).

A qualitative approach is the most appropriate form of data collection for this project because a deep understanding of teachers' perceptions and planning processes is necessary for professional development providers to understand their teacher colleagues better. Without the ability to ask probing questions in interviews after reading teachers' journals and reflections, it would be a challenge to determine how perceptions affect the process or how outcomes occur. A quantitative survey instrument could easily measure teachers' perceptions of learning, but it would not explain in detail why or how teachers came to a deeper understanding of approaches to teaching science to English Learners or why specific curricular decisions were made or why certain strategies or practices were selected to address specific language demands or student needs (Denzin & Lincoln, 1994; Yin, 1994; Marshall and Rossman, 1999; Maxwell, 2004). Qualitative observations will allow me to describe more objective details about the attitudes of participants toward the learning that would lead to a deeper understanding of teachers' perceptions of community and the learning process (Creswell, 1994).

Site Selection

The Champion Unified School District (CUSD) district serves students from several southeast Los Angeles County cities. A high percentage of students in the district are Redesignated Fluent English Proficient (RFEP), English Learners (ELs) or Long Term ELs (LTELs) who have been struggling to learn and maintain a strong foundation of English as their second language. Although some may argue that once a student is redesignated, he is no longer considered an English Learner, oftentimes a student's home is not rich enough in academically spoken English to maintain fluency. Considering these populations comprise a large portion of the district, I selected Omega High School (OHS) because it has a good portion of students who fit this description. Moreover, my experience in this district has allowed me to form relationships with teachers and gather participants without risk of coercion.

At this comprehensive high school, English Learners encompass 26% of the student body, which is comparable to the state (California) average, making Champion Unified School District and Omega High School appropriate for a study on English Language Learner development making the study outcomes applicable to many schools with similar populations. As a result, similar schools across the state could benefit from the outcome of this study. The selection of this site will also be relevant to future audiences as the population of English Learners in the United States grows and as teachers and schools across the country work to support their increasing populations of English learners in science courses. Considering that Omega High School is establishing a science academy focused on related career fields and several EL students have enrolled in those pathways, the site would be excellent.

Finally, the English Learner Facilitator and the science Department Chair at Omega High School began discussing opportunities for teachers to develop curriculum that addresses the NGSS standards and the CCSS standards for Literacy for science, Social science and Technical Subjects in tandem with the California English Language Development Standards. The outcomes of the study would then inform science instruction for ELs district-wide.

Participants

The case study tracked the changes in a group of Environmental science teachers' thinking and their intent to implement strategies to support EL students after a professional learning intervention. Teachers in the Environmental science pathway team were my target for recruitment to participate because we had a prior working relationship, and they were interested in participating in the project in hopes of learning more. In addition, the Environmental science pathway is 30% English Learners and the teachers were interested in participating in this project to support, retain and attract more students to the program.

Bob (a pseudonym) identified as Chinese-American. During the study he had been teaching science for 20 years, and the last 15 were taught at Omega High School. At the time of the study, he was teaching the Inter-coordinated Science 1-2 course for 9th grade, the Inter-coordinated Science 3-4 course for 10th grade and the Environmental Technology course for 12th graders. Prior to becoming a science teacher, he was a chiropractor for 10 years. English was not his first language. He learned English through school immersion.

Gloria (a pseudonym) identified as Mexican-American. At the time of the study she had been teaching science for 25 years and has spent her entire career at Omega High School. At the

time of the study, she taught Environmental Science and AP Environmental Science courses for students in eleventh grade. English was not her first language. She learned English in school.

Leslie (a pseudonym) identified as a monolingual American of English and Irish ancestry. Teaching was her second career. Prior to teaching, she served 8 years in the United States Navy and after her service she was a structural engineer for a short time before becoming a drafting teacher. She taught drafting at Omega High School for 10 years before her class was cancelled and she became a science teacher. She has taught science at Omega High School for the last 15 years.

All three teachers are members of an existing Environmental Science linked-learning pathway team that uses Project-Based Learning (PBL) to engage students in real-world projects. I was once a member of their pathway team, but since I became an out of classroom intervention teacher at other schools, I had not worked with them since 2015. They have been working as a team since 2009-2010 when their pathway was established. Before the intervention, they regularly met bi-weekly to plan projects and examine student work in an existing community of practice. I was once part of that process as the English teacher and ELD teacher who taught courses for students in the Environmental science and culinary pathways.

Their participation in this case study provided several opportunities to potentially implement strategies to support English Learners in science. As a result of their participation, science teachers recognized that students need specific instruction that places emphasis on the language demands and functions of science discourse. They learned that they should utilize EL students' resources for meaning-making and provide productive interactions as they engage in inquiry-based science practices (Zwiep & Straits, 2013; NASEM, 2018, Carrejo and Reinhartz, 2013).

The Project

The project is designed to gather data on science teachers' learning and perceptions of their ability and intent to support English Learners. Due to the COVID-19 pandemic, which has resulted in a "Safer at Home" order throughout Los Angeles County and California, the project was conducted virtually over the course of 4-5 weeks, using Google for Education applications.

Prior to the start of the project, I sent an email to targeted recruits for my study. Once the participants expressed interest, I had each participant create an email account using a self selected pseudonym. Each participant sent me an email with "Research Participant" in the subject line. Once all five participants emailed, I sent each participant an invitation to an individual virtual meeting. During that meeting I explained the expectations and commitment requirements of the study, completed the informed consent process and shared a code to a virtual password protected classroom. Then I sent each participant a link for their individual interview. Interviews took approximately 30 minutes to one hour to complete. Once interviews were complete, they were transcribed and stored in a private password protected virtual folder on my personal computer that is protected by antivirus software and a firewall. Twenty-four hours in advance of each meeting, I placed research team meeting agendas, presentation materials and handouts or activity links in the virtual classroom. I also assigned the journal reflection prompts after meetings 1, 2, 4, 5, 6 and 8 and programmed them to close to responses by 8:30 pm to ensure reflections were completed in a timely manner. All science teachers completed all reflections.

Below (Table 1) is an overview of the Session Topics. Phase 1 consisted of the first two sessions on the EL Roadmap. Phase 2 consisted of two sessions on the Overlap between the EL

Roadmap and research-based strategies for teaching science to ELs and practice to understand ELPAC Scores, student proficiency in the different domains tested and Phase 3 consisted of practice to implement strategies and a revision of a selected project unit.

Table 1
Phases and Sessions of the Professional Learning Intervention

Phase	Session	Topic
1	1	EL Roadmap Principle 1 - Culturally 7 Linguistically Responsive Strategies, Typologies of EL Students
	2	EL Roadmap Principle 2 - Instructional Strategies to support EL Students, Review Typologies
2	3	Teaching Science to ELs - Reviewing Research-based strategies for teaching Science to ELs, Finding Overlap in the EL Roadmap, Clarifying strategies
	4	Examination of EL Student Rosters, Discussion of Students, Understand ELPAC Scores, Reviewing Language demands by domain and Introduce Activities to be reviewed xt week
3	5	Review activities - Hypothetical examples of how to support ELs to complete projects and tasks
	6	Analyze a pre-existing ICS 1-2 project: How can we encourage friends and family to reduce their e-waste?
	7-10	Revising a Pre-existing ICS 1-2 Project: E-waste - How can we encourage friends and family to reduce their e-waste?

During week one, the team met twice to receive professional development on Cultural and Linguistically Responsive Strategies and Learning strategies that support English Learners. During week two, the team met to understand the research identifying which strategies best support English Learners in science. Teachers then completed activities that allowed them to try to apply their learning and receive coaching and opportunities to practice effective implementation. During week 3, the team decided to examine and revise an Inter-Coordinated science (ICS) unit because they noticed that the entry level science class has the widest range of English Learners and the highest percentage of English Learners among all the classes in the pathway. During weeks 4 and 5, the team worked to revise the ICS unit. Throughout the analysis and revision of the project, the teachers reviewed, unpacked, analyzed, reflected upon and shared ideas with one another.

This case study relied upon data from observations during virtual team meetings, transcripts of those meetings, individual journal reflections, individual virtual interview responses, and a comparison between a unit plan taught in the previous academic year and a revision of that plan.

Data Collection Methods

Virtual Learning Team Meeting Observations

The team met virtually twice weekly for 5 weeks. The observational focus was on determining the degree to which participants understood strategies and practices and to determine the participants' perceptions about supporting EL students in science as well as potential changes in their sense of responsibility to implement and support students and colleagues. I observed to establish teachers' understanding of the NGSS, ELD standards and how strategies can serve to support students in their development Weeks 4 - 5 will consist of the last 2-4 virtual meeting observations, which will be dedicated to finalize their new unit or project, (as needed).The meetings were recorded to help with the accuracy of observation notes and for transcription purposes. Each meeting was guided by a few guiding questions (Appendix A). I took freehand notes during activities and discussion using a basic observation template that identifies 3 foci for each meeting session (Appendix B). Initially I planned to take observation notes throughout each session, but it proved difficult to deliver professional learning while also observing, so the observations for sessions 1-4 were completed using the recordings. I also paid specific attention to participants' comments during that time and used them as evidence about how teachers' thoughts and perceptions about their role in the education of English Learners in

their science classes had developed. When observing the meetings, I also paid attention to their understanding of the strategies and practices and tracked their degree of understanding on a scale of 1-3 with 1 being knowledge of the strategy's definition, 2 being their ability to explain the purpose of the strategy and 3 being their ability to demonstrate how it would be applied to support English Learners (Table 2).

Once the team was working together to analyze and revise lesson plans during sessions 5-10, I was able to observe remaining sessions as planned following the same process explained in the previous paragraph. The observations focused primarily on identifying instances of language during meetings that demonstrated changes in participants' perceptions, degree of understanding of strategies and their intent to learn and implement strategies, their understanding of students' language and content related learning needs and language that demonstrates critical thought about the planning and revision process and growth in practice as described in Table 2.

Virtual Learning Team Meeting Screencasts

The screencasts were used to support opportunities for observation, which would have otherwise not been possible during weeks 1 and 2. To record the learning team meetings, I used an application called Screencastify to create a video of the screen which was saved to my computer and stored on a secure server. The screen casts allowed me to view footage at reduced speed, to assist in reviewing observations as described in the previous section. The screencast allowed me to review the video to see if I may have missed something and provided me an opportunity to return to take notes a second time to code information to units of observation as they related to the meeting's guiding questions (Appendix A) and the research questions. One

benefit of a virtual setting is that it allowed me to enhance settings to include images of each participant on the bottom of the screen but zoom in on the image of the speaker.

Participant Reflection Journals

Journal prompts were designed for completion after most team meetings (Appendix C). Participants responded to journal prompts on an individual basis. Participants received a link to a Google Form toward the end of each meeting and they responded before 8:00 PM that same night. The form was locked for responses after the deadline. The deadline was set so journals function to capture the participant's perspectives on the day's work. Journals allowed me to gather specific information about participants' attitudes and perceptions about their role in instructing English learners, their understanding and confidence level about their ability to provide support to one another and students, and their intentions to implement language supports in their unit plan. The information gathered was used as evidence to determine ways the intervention is working for them as well as additional support they need as well as allow me to monitor their changing perceptions, attitudes and needs throughout the study. I then used the information gathered to cross reference what they write in their journals with their comments and spoken contributions during team meetings during a later process.

Interviews

Two thirty to forty-five minute participant interviews took place before the start of the study and at the conclusion of the study. All interviews were conducted via zoom. Appendix D consists of a set of questions that were used. The first virtual interview was designed to gather an understanding of teachers' baseline knowledge of their English Learners, their proficiency levels

and needs. Questions also asked about teachers' perceptions of their ability to meaningfully engage their English Learners in their science class, their opinions about their role in instructing English Learners and as well information about the professional learning opportunities they have had or participation in collaboration opportunities to help them support their English Learners.

The final interview helped me determine whether or not their participation in the study was fruitful. Questions at the end of the study asked teachers whether they believed the collaboration improved their confidence and ability to meaningfully engage the English Learners in their science classes. I also had them re-assess their knowledge of their English Learners, their proficiency levels and needs as well as their opinions about their role in instructing English Learners. I also asked them to compare professional learning opportunities and collaboration opportunities they have had to this study to determine whether it was more helpful and whether it was functional or could be further developed to inform my work going forward.

Lesson Plan Analysis Chart

In weeks 3-4, teachers did a critical analysis and unpacking of a unit project they had previously taught in the Inter-coordinated science 1-2 class, using the Instructional Plan Analysis Chart (Appendix E). Teachers agreed to focus on ICS 1-2 because based on their learning in sessions 3 and 4, they recognized that the ICS 1-2 class has the largest percentage of English Learners and the widest range of language proficiency levels among them. Teachers turned in a PDF of their Initial Instructional Plan Analysis chart. During the process of completing the chart, the science teachers shared a basic outline of the project with the English Language Development teachers and then proceeded to identify and unpack the NGSS standards. Then the science teachers on the team identified the scientific practices and other tasks students

completed, while receiving support from ELD teachers to identify the language intensive aspects of each task. During this time they also identified the strategies they used to support students (not necessarily just EL students). They also had a location for notes where they were encouraged to write notes about how the strategies worked in their first run of the lesson. Because this process occurred after their initial professional learning process, it also prompted them to recognize ways they could have organized the project, taught skills or supported their students differently. However, they were asked to note those ideas and save them until it was time to revise the project.

In weeks 4 and 5, teachers decided that they would like to revise the previously analyzed unit plan. During the unit project revision process, the Instructional Plan Analysis was the same template, only this time they had to specifically explain how the strategies they selected would be implemented and how the strategy would benefit their students. Overall, the Instructional Plan Analysis was designed to give teachers an opportunity to both document and critically think about whether their previously used lessons meet the language needs of their English Learners. During my comparison of these two pieces of data, I paid close attention to evidence that demonstrated their intention to support English Learners by implementing strategies. To determine this, I had to think about how the work products and language support strategies changed, whether additional language support strategies were layered in and whether the team's understanding of the strategies and students' needs have changed.

Data Analysis Methods

I began my analysis by reviewing all of the data and looking for trends. I had data from screencasts and observations, journal entries, interviews and lesson plans to analyze. My analysis

of the data began with an examination of each source, with a specific eye to how it answered my two research questions. I first began by highlighting any piece of information that helped me to answer my research questions. As I moved through all sources, I noticed trends, and codes emerged from the data. At that point I documented the types of changes in teachers' thinking about providing language support to their English Learners (Q1) by focusing on how science teachers' understanding of strategies and practices to support English Learners changed over time, whether their thoughts about their role to implement those strategies and practices changed, and whether their confidence to implement the strategies and practices changed throughout the learning team sessions. Then, I linked the changes I observed to specific quoted from the data.

To help me to interpret their degree of understanding of the strategies, I established three degrees of implementation (see table 2, below) and went back into the data and gathered evidence to track changes in their degrees of understanding of the strategies and again, link to quotes from learning team sessions. The degrees of implementation were as follows: 1, was a general understanding of the strategy by definition, a 2 was an understanding of the strategy plus an ability to explain its purpose, and a 3 was their ability to show how the strategy or practice could be applied to support English Learners. This chart became the basis for the analysis of science teachers' changing thoughts and perceptions. I used comments made during learning sessions to substantiate teachers' levels of understanding of the strategies and practices and measure the changes in their understanding to determine whether their understanding had any impact on their thinking about their role to support English Learners or their intention to implement the strategies and practices to support English Learners in their science classes. Table 2, the Strategies and degrees of Implementation chart (below), helped to mark changes in teachers' understanding of strategies.

Table 2

Strategies and degrees of implementation.

Strategy	1 = Can identify or define the strategy.	2 = Can explain the purpose of the strategy	3 = can show application of the strategy in practice.
Understand-ing of language proficiency levels	Teacher knows there are different language proficiencies and domains -- 4 language domains and the way a student performs in each domain (1, 2 or 3) makes up their language level as assessed on the English Language Proficiency Assessments for CA.	Teacher can explain the expectations for different fluency levels of student in any of the four language domains.	The teacher can select domain appropriate strategies based on students' fluency level.
Primary Language Support	The teacher knows that they can provide science materials in their students' primary language or allow for opportunities to speak in their primary language.	The teacher can explain that resources and opportunities for students to use their primary language help students express their science understanding in English.	The teacher can show specific primary language resources they have or intend to use.
Routine use of strategies	The teachers knows that implementing rituals and routines means they should implement strategies listed in this table every week as needed on an ongoing basis throughout the school year.	Teacher can explain that a routine use of strategies scheduled in advance every week helps EL students know what to expect so they feel less anxious about meeting learning expectations.	The teacher can demonstrate their understanding of how to apply routines to benefit English Learners by giving an example
Home-School Connection Activities	Teacher knows that home-school connection activities invite families to engage in the learning process.	Teacher can explain how home-school connection activities promote student engagement and interest for EL students.	The teacher can demonstrate that they can select or modify activities to provide more opportunities for home-school connections
Multi-modal non-linguistic supports	The teacher knows that visuals, graphs, maps, sensory experiences, audio, speech, movement, gestures, facial expression, color, and everyday materials communicate meaning in science.	The teacher can explain how multi-modal non-linguistic supports serve as scaffolds to aid ELs to make meaning and access science content and understands that the more support a student needs, the more resources or opportunities they need to make sense of science.	The teacher can demonstrate how their lesson plan will provide varied and multiple uses of multi-modal non-linguistic supports to support students of different language abilities and typologies to make meaning in science.
Interactive notebook	Teacher can describe the structure of the interactive notebook	Teacher can explain how other strategies in this table can be used in an interactive notebook as appropriate for English Learners.	The teacher can offer specific examples of embedded strategies in an interactive notebook used as part of their curriculum.

Table 2

Strategies and degrees of implementation, cont'd.

Strategy	1 = Can identify or define the strategy.	2 = Can explain the purpose of the strategy	3 = can show application of the strategy in practice.
Relevant Curriculum	Teacher knows that curriculum can be made relevant. relevant curriculum can make students more engaged.	Teacher can describe their students' interests, language, culture and experiences in relation to curriculum.	The teacher can select or design materials that involve students' interests, culture, language and experiences to implement as part of their curriculum.
Flexible Grouping	The teacher knows that flexible groups are opportunities for students to collaborate in either small or large, like ability groups or mixed ability groups based on students' needs relative to the task.	The teacher can explain how flexible groups provide collaborative opportunities for EL students to develop science understanding and support language development.	The teacher can demonstrate planned opportunities for students to engage in flexible groups and give a specific example of how they address EL students' needs.
Critical Questioning	The teacher knows that critical thinking questions are a combination of who, what, where, when, why and how questions.	The teacher can explain that English learners benefit from explicit instruction that relates questions to language functions. Critical questions help EL students engage in science by teaching them to ask for basic information, help form an opinion, draw conclusions and connect ideas.	The teacher can demonstrate a plan to apply critical questions to support English learners by leveling questions and activities to encourage deeper thinking.
Functional Language Frames	Teacher knows that sentence frames model the structure of grammatically correct sentences and questions in use to support language development.	Teacher can explain how sentence frames support students to better understand language functions and sentence structure in English	The teacher can demonstrate that they can plan the use of sentence and question frames to support students in delivering an oral presentation, writing a report or essay or engaging in a discussion.
Structured Academic Talk	Teacher knows that structured academic talk opportunities are organized into steps and guide students to practice language in academic context with support such as sentence frames.	The teacher can explain that opportunities for structured academic talk provide the skeleton for students to build their own ideas and increase the frequency with which English Learners have opportunities to practice application of different language functions in science.	The teacher can demonstrate how they will construct norms and clear protocols for students to engage in structured academic talk opportunities to practice language in the context of science.

I had a general understanding from my prior experience working with the team about their prior experience running the program was but I did not have any information about how their thoughts might change over time, so I chose to use the strategies as a way to track changes in their thinking via their understanding of the strategies. To do this, first I paid close attention to science teachers' interaction with the strategies and practices that support English Learners during each learning team session, in every journal entry and in their interviews. I tracked the frequency that each strategy or practice was mentioned, and each participant's degree of understanding in each data source. I learned that for the most part, each teacher progressed similarly, with some minor differences, but as I consolidated the data to track their collective development of understanding, I documented the growth based on when all three science teachers understood the strategy or practice at the same level and charted that to document how their understanding of the strategies changed over time. I read journal responses and examined learning team meeting transcripts and observation notes each weekend in order to determine how science teachers' thinking changed. Then I then cross referenced my interpretation of their understanding with their comments in journal entries, learning team sessions and interviews to determine whether my interpretation of their understanding was accurately rated and whether their understanding of the strategies and practices might be affecting the changes in their thoughts or their intentions to implement the strategies in their lesson plans.

I tracked science teachers' intentions to implement the strategies and practices by comparing the attitudes expressed in their interviews from baseline and final interviews, examining the activities from sessions 3 and 4 and comparing their lesson plan Analysis Charts and the final plan. All data were analyzed as they were collected by reviewing observation tools, screencasts, journal and interview responses, and lesson plans.

Science teachers' review and revision of their previously developed unit project provided important data that helped me to determine whether what science teachers said during learning team sessions, in journal entries and in interviews could be substantiated. I was then able to gauge whether teachers' intentions to implement language support increased, as well as how well they learned to use each strategy. A summary of my data analysis is outlined in the table below.

Table 3
Data Sources, Collection and Analysis Methods

Data	Collection Method	Analysis Method
Learning team meeting observations and transcripts	Observation protocol (Appendix D); Screencast	Observation notes documented responses to the meeting's focus questions. Responses were coded using the Strategies and Degrees of Implementation Table and focused on language that answered the research questions.
Journal Responses	Structured	Journal responses were analyzed based on the Strategies and Degrees of Implementation Table. They also allowed for emergent themes and documented changes in teachers' perceptions.
Interview Responses	Semi-structured	Documented teachers' ideas and any changes that occurred between the beginning and end of the intervention.
Lesson Plan Analysis	Lesson Plan Analysis Chart	Helped to establish whether teachers' use of instructional strategies changed by comparing the original lesson plan Analysis Chart to the Final Lesson Plan Analysis Chart.

Ethical Issues

When the team members agreed to participate in the research study, I informed them of my intentions as a researcher. As such, I informed them that as a researcher I would ensure my commitment to confidentiality during observations of team meetings, while reading their

reflective journals, during interviews, and throughout the process. I agreed not to attribute any comments directly to any participant by name, but simply in aggregate or by pseudonym.

I also disclosed that I would be collecting data from all of their meetings together. The teachers were provided with a Research Information Sheet and Informed Consent document that addressed confidentiality and time commitments. In that memorandum, I described the research, their commitments and the purpose for the intervention. I also explained that I am learning along with the group and am not acting as an evaluator, nor will I share identifying information with their evaluators.

Credibility and Trustworthiness

Some concerns that may arise as a result of this study are small group size, the credibility of curriculum, and bias, since I once worked closely with participants.

Given the scale of the project, it was necessary to include multiple sources of data and describe collection methods with as much specificity as possible. Observations, journals, and interviews effectively provided increased opportunity to understand attitudes that occur as a result of the intervention. Furthermore, the multiple data collection methods allowed for depth and triangulated pieces of evidence to support conclusions drawn. Triangulation will dispel doubts that may arise on account of the scope of the study and demonstrate that the data are sound and findings not imagined.

Because the team of science teachers have already made attempts to work with English Language Development teachers before the study began and the study is an attempt to understand how teachers work together to collaborate to better understand teachers' comfort with

NGSS for English Learners, there may be concerns about the generalizability of results cannot occur. While the teachers already knew each other and worked together, this study introduced new forms of collaboration around new topics. Their prior collaboration was informal, unstructured and did not have any professional learning components. As a result, the process can be replicated.

Bias may arise on account of my previous employment at the site as the English teacher who once worked closely with those on the team. However, to offset concerns about bias that may result, I l engaged in a process of data analysis that will quell possible concerns about accuracy of interpretation and utilize a combination of journals, meeting observations and unit plans as opportunities to further understand participants' process and also provided several direct quotes in the findings section to support results. To gather data I established protocols and then used them to determine themes and then triangulate the data to ensure accuracy. Doing this allowed for a multi-step process of data analysis that can be supported with multiple forms of data.

Summary

The purpose of this study was to learn about how prepared science teachers feel to teach English Learners and whether their thinking changes after an opportunity to learn about and apply research-based approaches to teaching science to English Learners. Through professional learning and collaboration, I learned that the intervention and collaboration to revised a project resulted in more confident science teachers who were willing to use what they learned to increase language support for the students in their science classes. I learned about the challenges

the team faced working in a high school with a large population of long term English Learners and how the process provides opportunities to learn about collaboration and the potential impacts for English Learners, once implemented. It is my goal to share the findings of this study with science teachers in the school district and hopefully District-wide, so that schools can work to empower their teachers to create a sustainable practice of investigation and learning that is tailored to the specific needs of their English Learner populations and informs professional development needs in their departments and districts.

CHAPTER 4: FINDINGS

My research questions sought to explore how science teachers' thinking about providing language support to their science students would change through their participation in a professional learning intervention and whether their participation would affect their intent to implement language supports in their lesson plans. I present the findings from my analyses in two parts. First, I use data from interviews, session transcripts, and teachers' responses to journal prompts to trace how the three science teachers, Bob, Gloria, and Leslie, changed their thinking about language supports through the course of the intervention. Following this, I present data from their lesson plans to draw inferences about their intent and approaches to implement language support strategies in their classrooms.

Tracing science Teachers' Thinking about language supports

Through the course of the intervention, Bob, Gloria, and Leslie changed their thinking about the provision of language supports in three ways. First, their ideas about their roles and responsibilities in providing language supports changed. Second, and not unrelated, their understanding of the English Learner students changed. Finally, they developed their understanding of specific language support strategies targeted through the intervention. The following sections trace each of these areas of change, in turn.

Role and Responsibility

At the start of the intervention, I was not sure what kind of changes to their thinking I would see. As the intervention progressed, I noticed that science teachers' thinking about

teaching EL students and their perceptions of their role, responsibilities and ability changed as they learned more about student needs and the strategies to support them. During their pre-intervention interviews all three teachers initially reported that it was not their responsibility to support their English Learners to develop science language or provide language support to them. For example, Leslie explained her lack of confidence in her ability to meaningfully engage her English Learners in science, "Well I teach science. I don't teach English, so if I don't feel confident that I can teach my English Learners how to engage in science that's because of their language issue and I don't teach language." Similarly, Bob said he "[cannot] fully support [EL students'] needs" and "[doesn't] think it's fair to ask science teachers to address language development [because] that isn't [their] area of expertise." Gloria also admittedly prioritized content: "my focus is on science and if they're new then I try to translate, but I need to focus on the standards." Besides showing that these teachers did not see language support as part of their role, these responses reveal a lack of awareness of their obligation to teach integrate ELD strategies and practices into their science instruction.

Teachers' pre intervention perceptions of their role also revealed their dependence on administration to provide information about their EL students' test scores and proficiency levels, as opposed to taking the initiative to access or seek out that information themselves or taking the time to collaborate with colleagues who teach ELD to gather information about their students or even take the time to assess and get to know their students to learn more about their needs. Gloria said "normally I would get a list [and it would say]: "these are your English Learners, these are their proficiency levels, this is their ELPAC score... We didn't get any of that this year." When I asked Bob, he said he had "no idea" about their ELPAC scores and Leslie said "I don't have a list. I never got the list." Their reliance on someone to provide a list of EL students

and their language proficiency information caused several issues to be discussed in further sections, one of which was their knowledge about their students and their needs.

Reflection journals collected during phase 1 demonstrated science teachers' confusion about their role to support language needs and the connection between language support and quality science instruction for English Learners. For example, Leslie wrote, "I don't think it's my role to develop language. It's my role to help them understand science. The writing I implement… isn't to develop their language or literacy. It is for them to show me what they know [about science]." Leslie and Bob seemed to be in similar stages of understanding, because neither could demonstrate an understanding of the role they play in supporting ELs in science and instead see language support as a tool for language development as opposed to science instruction. However, Gloria demonstrated a slight shift after just one session. Gloria said, "I need to take the time to know more about my students so that I can support them," but also stated that she "[doesn't] think [her] primary focus should be language. It should be science, but they can't succeed in understanding science content and practices if I'm not addressing language because it is definitely related." Gloria's reflection after session 1 definitely revealed some growth in her understanding of the needs of English Learners that her colleagues had not experienced because they still demonstrated a lack of clarity about the relationship between language support and content understanding after session 1.

By the end of phase 2, however, teachers' reflections indicated a shift in both their understanding of the importance of supporting English Learners and in their confidence. All three teachers found the information valuable and expressed appreciation for the information about how to interpret students' test scores to better support them. Bob said "No one has ever explained [test scores and score reports] to us. I didn't used to think that any of this was part of

what I needed to know." Leslie shared a similar response "we have never received this information and it would have been very very useful." Gloria was most impacted by her access to this information, she said: "if I had ever gotten this, I would feel less… I beat myself up a lot lately about not being able to support [EL students] or not feeling like I'm doing a good enough job with supporting them." their responses demonstrate a shift from their previous sentiments that they are only required to teach science to a developed understanding that supporting EL students is part of teaching science.

Leslie reported that the most valuable thing she learned was "about new state requirements and expectations for teaching English Learners." She also expressed that in the past students had pretended not to be able to speak to avoid having to participate, and in her journal she remarked, "Now I know more about what they can do at each level so they can't [pretend they are unable to understand or complete a task]." She also commented that the most useful strategies for her to use to help her students were flexible grouping, the interactive science notebook and visual supports because she felt her students "are less stressed because they are supported to do well by working collaboratively and having a notebook with activities that they can refer to later that will help them with what we're learning." Leslie's thinking has gone from unwillingness to accept her role as a science teacher who should support language development, to a teacher who feels more confident in her interactions with her students and her developing ability to select appropriate strategies to support them. Similarly, Bob also appreciated learning about the ELPAC and students' ability levels and their associated skills. He "could understand what students can typically do at each level and connect that to the strategies we can use to help them get the material…" Specifically, he referenced the interactive notebook "which can provide different modes for them to communicate their learning… I can have them use a mind map or

draw or just write to think before we discuss or do a paired partner response and then when I check notebooks it's a chance for us to kind of dialogue through their learning." Gloria expressed similar change, "Before we started I could not even identify my English Learners and now I have highlighted their names on my rosters and noted their scores." Some of the strategies and practices that Gloria used, according to her session reflection were the interactive notebook with visual and thinking supports, flexible grouping and primary language support. She explained that "visual and thinking supports in the interactive notebook ... help students to grasp material that they might have otherwise missed if the textbook is too advanced… [grouping] them so that they always have someone to ask questions to in a small group and they ... can send me private chat messages and I can pose questions privately to check for understanding or get them to extend their thoughts." Gloria learned more about her students and now that she did, she was more equipped with the knowledge to determine which strategies could be used to support her EL students and understood how the strategies could work together to support them further.

By Phase three, all three teachers' had gone from feeling little or no sense of responsibility or confidence to support the language needs of English Learners to feeling confident enough to take responsibility to address their students' language needs, whereas before there was no specific effort. Leslie said: "I know there are things I can do to help them even if I am still learning." Bob also acknowledged that he "can do a little better every day" and that he is "better equipped" than "when [they] started and will be even better as time goes by." Similarly, Gloria said "I can make changes to better support my students." All three went from not believing that supporting EL students was their responsibility, to acknowledging their growth and efforts to do so, which indicate a growing sense of responsibility by phase three.

Teachers' thinking about their role and responsibility for supporting the language needs of their students is also evidenced by their desire to know more about their EL students and their increased knowledge of the support strategies that serve them. More detailed information about science teachers' increased understanding of their EL students will be discussed in the next section, followed by a discussion of their knowledge and application of strategies.

Understanding of EL students

Teachers' knowledge about their EL students changed in three ways: their understanding of the California English Learner Roadmap Policy (CA State Board of Education, 2017) and their understanding of EL students' academic needs as related to typologies and proficiency levels. At the pre-intervention phase, science teachers could only minimally describe what they thought their students could do, and they could not give specific information about proficiency, test scores or numbers of students in their classes. However, by the post intervention phase, interviews and the final lesson plan analysis reveal that teachers can plan to address the needs of their English Learners based on their understanding of their students' typologies and proficiencies.

Their pre-intervention knowledge of their students was not specific to types, proficiency levels or percentages of ELs. For example, Leslie described her students as being "all over the place" and Gloria "just totally [threw] up a ballpark guess" and elaborated that she had "[students who] read and write well, but are super shy to speak," and also shared that she "can't even tell if [students are] English Learners when they speak, but when it comes time to write things down, they have difficulty." Bob described that "All [his students could] speak English, but have trouble writing and [understanding] what they read." He also guessed that he had "about

30-35% [EL students] at most, but "only 2 of [his] EL students are in ELD 5-6 and "the rest are not in an ELD class." Bob's comments reveal how little he knows about legal requirements for placement of EL students in ELD. If a student is an English Learner, they are required to have a designated ELD class programmed into their schedule. All three science teachers' responses indicate a lack of information about EL students enrolled in their classes. It is clear from their initial responses that they estimated their percentage of EL students because they had no data on their students, but their responses also shed light on confusion about the definition of an English Learner.

As Phase 1 of the Professional Learning commenced, science teachers learned about policies, typologies and proficiency levels and started to try to apply their learning about types of EL students. For instance, Gloria disagreed with Bob that one student was a well-educated newcomer. She thought he was a Long-Term English Learner "because his counselor placed him in intensive survival English, but he didn't need it." However, her point actually supported Bob's argument that he was a well-educated newcomer because Gloria said, "he was moved into mainstream classes and he did ok." The teachers' had learned enough about the characteristics of English Learners to begin to identify them which is necessary to support their needs. For example, Leslie was able to accurately identify a student's type and use his profile to justify that he has an interrupted formal education "because he only completed [elementary] and he came to the United States as a 17-year-old, so he has a huge gap." The professional learning session resulted in a greater sense of understanding of the qualities and needs of different types of English Learners, allowed teachers to demonstrate their understanding of typologies and move toward recognizing that not all English Learners are the same. The teachers' ability to discuss and justify their assessment of students' typologies places them at a proficiency level 1 on the

rubric because they can accurately identify students' typologies but have not moved toward explaining why understanding their typologies is necessary or how to apply strategies to serve specific types of English Learners.

During phase 2, teachers demonstrated more knowledge of their EL students' proficiency levels. All three science teachers were able to give detailed information about the number of EL students in their classes and their proficiency levels, but all three teachers still remained uncertain about their students' typologies, although they could define each typology.

Reflections after Phase 2 activities also supported my interpretation that teachers' knowledge about their students' proficiency levels and needs increased after every phase. They perceived themselves to know more and their confidence to meet their students' needs increased. Their responses also demonstrate that they have started to think about the EL students in their classes, determine their needs and try to implement strategies. They started to think about synthesizing their knowledge from phase 1 and phase 2. For example, Bob said: "It helped to be able to understand what the test score means and then as we learned more about the parts of the test we could understand what students can typically do at each level and connect that to the strategies we can use to help them get the material so that they learn the material and also get support to move up in whatever they need help with -- if its speaking or reading or writing or listening. " Leslie acknowledged that "Learning about [EL students'] ability … and now getting a chance to think about ways to adapt the projects we use and how to identify strategies that support lower level ELs was helpful because I have more of those students in my class and it helps to know there are things I can do to help." Gloria's journal response also demonstrated a similar sentiment: "I feel better prepared than before, but would not say I am an expert. I do know that I can make changes to better support my students, but I have more advanced students

and that seems more difficult to me because they need to step up their language to do more than communicate on a basic level and I am not at that level yet." In general they acknowledge that they know more, they have improved and they demonstrate a desire and belief in their capacity to learn more. Gloria also explained in one of her phase 2 reflections that she had begun to apply what she learned: "I have highlighted [EL students'] names on my rosters and noted their levels. I also have a little cheat sheet that I screen shot from the guide just in case I forget what students at each level can do, but I pretty much know that a student who is a 3 across has a functional use of language and is almost fluent, versus a student who is a 1 needs much language support to access content…I plan to make better notes on my roster so that I am always aware of their needs."

By the conclusion of phase three, teachers started to use their knowledge about EL students to apply the strategies they learned in phase one based on the knowledge about typologies and proficiency levels they learned in phase 3. Bob said, "it helped to be able to understand what the test score means and then as we learned more about the parts of the test we could understand what students can typically do at each level and connect that to the strategies we can use to help them get the material so that they learn the material and also get support to move up in whatever they need help with -- if its speaking or reading or writing or listening." Gloria acknowledged that "[she] pretty much [knows] that a student who is a (proficiency level) 3 across has functional use of language and is almost fluent, versus a student who is a (proficiency level) 1 still needs much language support to access content." Leslie expressed that she "is not fully equipped, but [has] improved [her] knowledge" and later in another reflection, added that "Learning about their ability last week and now getting a chance to think about ways to adapt the projects we use and specifically how to identify the strategies that support lower

level ELs was helpful because I know there are things I can do to help them." As teachers learned more about the needs of their students, their desire to implement additional strategies increased.

As teachers learned more about students' typologies, proficiency levels and needs, they learned to select support strategies which synthesize their knowledge about types and proficiencies of English Learners to practice meeting their needs.

Knowledge of Support Strategies

Teachers' knowledge of strategies to support EL students naturally increased because they were explicitly taught and practiced throughout Phase 3 of the professional learning sessions. Phases 1 and 2 allowed for teachers to learn about strategies, whereas Phase 3 engaged teachers in practical application. Table 4, below, shows how each of Bob's, Gloria's and Leslie's understanding of specific strategies targeted in the professional learning developed over the three phases of the intervention.

Table 4

Science teachers' understanding of strategies across Phases

Phase	Pre			Phase 1						Phase 2						Phase 3						Post		
Session	Pre			1			2			3			4			5-6			7-10			Post		
Teacher	B	G	L	B	G	L	B	G	L	B	G	L	B	G	L	B	G	L	B	G	L	B	G	L
Typologies				1	1	1	1	1	1	1	1	1	1	1	1	3	3	3		3		3	3	3
Proficiency Levels					1		1	1	1	1	1	1	1	1	1	1	3	2	2	3	3	3	3	3
Home-School Connection	1			1	1	1							1	1	1	2	2	2	3	3	2	3	3	3
Primary Language Support	1	1		1	1	1	1	1	1	2	2	2	2	2	2	3	3	2	3	3	3	3	3	3
Routines	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	2	2	3	3	3	3	3	3
Relevant Curriculum						1		1	1			1	1	1		2	2	2	3	3	3	3	3	3
Multi-Modal Non-linguistic Supports	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3	2	2	2	3	3	3	3	2
Interactive Notebook	1		1					2	1		2	2	2	2	2	3	3	3	3	3	3	3	3	3
Flexible Grouping	1	1	1	1	1	1	1	1	1			1	1	1		3	2	2	2	3	2	3	3	3
Critical Questioning	1		1			1	1	1	1			1	2	1		2	3	3	2	2	2	3	3	3
Functional Language								1				1	1	1		2	2	3	2	2	3	2	2	2
Academic Talk												1	1	1		2	2	2	2	2	2	2	2	2

During the pre-intervention phase, all teachers mentioned a superficial understanding of routines, multi-modal non-linguistic supports and flexible grouping in their interviews. At this time they simply identified the strategy and they did not demonstrate understanding of their purpose for implementing strategies or how they could be used to support EL students. They all indicated that they have an agenda everyday and standards posted, which is a standard expected routine at most schools. When asked which strategies they use to support their EL students, Gloria answered: "Google Translate, Breakout Rooms or small groups, journals, assignment templates, outlines with questions and projects." Leslie also listed "vocabulary, video clips,

charts and pair share." Similarly, Bob said "vocabulary, hands-on group activities, and questions." Listing a strategy indicates an awareness of it, but could not be considered an understanding of the purpose for implementation or its specific application in support of English Learners without further elaboration.

Teachers also indicated that they had not had any professional learning experiences recently, and that those that were offered were unproductive or lacked accountability and continued support. For example, Bob said: "Um, we've never had anything about English Learners and science. A few years ago [the EL Facilitator] did something for the whole school on how to support English learners in content classes... at one point, she asked us to bring a lesson plan, but we were in groups by our conference period and there was no other science teacher there when I was there. So there was no one that I could work with, but she wanted us to look at our lesson plans and then and then add in like an ELD component, but she didn't explain what she meant. It was an ELD goal, I think. Something for the ELs. But there were only five of us. Not a lot of people went, and I don't think they even took attendance." Leslie also commented that there had been no offerings of professional learning related to English Learners "in more than three years, maybe five years." Gloria commented that "we do data teams, and we have interventions, but no one has ever said these are interventions you use for your English learners." Their comments were indicative of the lack of attention paid to the needs of EL students, and further demonstrate that current achievement accountability measures for English Learners may not be in effect at their school.

After Phase 1, all teachers demonstrated a greater understanding of primary language support, routines, multi-modal non-linguistic supports, flexible grouping and critical questioning. Session two reviewed many instructional strategies that the teachers recognized, and in their

discussion during sessions, they demonstrated awareness of the strategy and they all indicated that they "try" to implement them. Although they had not been trained to use any strategies with a specific focus on supporting English Learners, they recognized through the professional learning that some of the things they do can be used specifically to support English Learners. For example, Gloria said, "In my class we do a lot of critical thinking and … inquiry-based learning. We always have a text and a text can be visual… it can be a chart; it can be a picture. I do try to scaffold [and] give my students access to the full curriculum even if it means translating for them and they always work in groups." Leslie agreed with Gloria, "We do the increased critical questioning and thinking, we have print rich, we have visuals, we scaffold, and we group them." Bob said, "on top of the things [Gloria] and [Leslie] shared, I do a lot of cooperative learning in steps starting with think pair share, then small group then whole class." At this point the teachers still demonstrated an entry-level understanding of the strategies because throughout the session the ELD teachers told them how their use of these strategies was supporting their EL students. One such example was Bruce's explanation of how Bob's example can be adjusted to specifically support EL students. He said, "that does help them, but it's important for us to provide explicit instruction every step of the way. If we have students model the think, pair share activity then afterward we want to tell the class what they did well. Did they use formal academic language, did they roll in vocabulary?" Although they are all able to identify and define the strategies they use they are still at proficiency level 1. The ELD teachers are providing tips to help them learn to adjust these strategies and understand how they can be used to support their EL students and eventually apply them.

By the conclusion of phase 2, teachers demonstrated a proficiency level 2 on routines, primary language support, multi-modal non-linguistic supports and the interactive notebook.

They all demonstrated proficiency level 1 in the home school connection. Most notably, Bob and Leslie went from believing that the home-school connection wasn't relevant to learning science, initially describing it as "inappropriate to science" and "touchy feel-y" to reconsidering after Cesar the ELD teacher provided an example of a well-known school event that establishes a home-school connection: "Ask a Scientist Night -- that's a home school connection. You're bringing your families in, and students are given the opportunity to engage with science and Engineering professionals and their families come and they also get to showcase their experiments. Families are a part of the learning and feel valued as partners in their children's learning" After this interjection, both Bob and Leslie shifted their perspective. Bob said, "I definitely didn't think of that as a home-school connection" and Leslie said, "I didn't think it was appropriate to bring families into the classroom, but it doesn't have to literally be bringing their parents into my class." The discussion shaped their understanding of the strategy, and they could then understand how the home school connection is relevant to science instruction. This awareness of the home-school connection indicates that they are at proficiency level 1 because they can define and understand the strategy, but because they required the ELD teachers to explain the purpose of the strategy and how it supports English Learners, they cannot yet be placed at a proficiency level 2.

During this phase they also demonstrated a greater understanding of primary language resources. Leslie said, "I want to work to include more resources in their language or allow them to find resources in their language to use when they research as a scaffold to understanding so that they can focus on understanding the content and then work to build language." At this phase she demonstrated a level 2 understanding of primary language support because she explained that the use of primary language support helps her students understand the science content better.

Similarly, Bob also said "I want to include more quality texts and language support scaffolds." He also expressed plans to go into his classroom over the summer and "add more resources for [English Learners] to the walls of my classroom." Gloria commented in her reflection at the end of session 4 that "[she] need[s] more language scaffolds and more primary language resources...I'm thinking more texts in their primary language." As I described in Methods, I coded such statements as level 1 because they could identify and define the strategy but did not elaborate specifically how the strategy of primary language resources would support students.

Throughout phase 3 teachers began to make connections to strategies they were already using that would support English Learners. Gloria mentioned that she "always [includes] open-ended critical thinking questions and [encourages] her students to question and investigate topics and go back to look things up and find the answers to the questions they have [during a project]" She connected the concept to Costa's (1981) levels of questioning typically used in AVID classes: "I have them always start with the level one question and then I ask them to take it up a notch and develop a level two question and then again, a level three question. So then they have different types of questions, open-ended questions, higher level questions, critical thinking questions, and then just your run of the mill information, but they understand the different types of questions. And how each of those questions is very important to understanding the big picture." EL students benefit from engaging in Costa's critical level 2 and 3 questions, but their engagement in critical questions requires question frames that are connected to functions of questions such as asking for information or clarifying information, which was not mentioned. Gloria did attempt to relate critical questions to the inquiry process present in Project-Based Learning, but again missed the mark in her explanation of how these strategies are specifically engaging EL students. For example, she explains that students "work collaboratively" in her

class to “share ideas and build off one another’s ideas and work … because even though it's, it's a problem that they're trying to solve using science, they're using every subject usually to try to solve the problem. So they're doing research, they might be understanding the history of the community and how it's changed in order to understand the problem and solve it.” Collaboration in PBL is useful, but can only be considered support for English Learners if the flexible grouping of students for collaboration is intentional. Leslie expressed important concerns that highlight a similar lack of specific support for English Learners. She explained, “We use inquiry centered and Project based approaches to foster critical thinking [in students] to solve problems and answer questions … but is concerned that “they're [supposed to be] supported to develop high levels of English language in and across the curriculum and have opportunities to develop proficiency” Her concern was valid considering the focus of this professional learning was to learn about how to better support English Learners. There is a natural connection between inquiry science and language development, but teachers require nuanced understanding to effectively engage ELs, which had not been demonstrated in their understanding at this point. However, the discussion did allow for the ELD teachers to enter the conversation and explain further.

Learning more about collaborative grouping and Structured Academic Talk opportunities allowed the ELD teachers to step in and provide additional support for how to tailor these strategies specifically to support English Learners. Bob agreed with his colleagues that “[they] do a lot of collaborative learning, we do think - pair - share, then we have a small group, then we have a whole group Socratic discussion. I get them to have the discussion with a partner and then in a small group and they do those things before we do the big whole group discussion.” Bob’s comments demonstrated his level 1 knowledge of the structure and ideal execution of the

strategies but without specific description of the support offered to EL students in this process from him or his colleagues. The ELD teachers entered the conversation to explain how his approach to discussion was a scaffold that supported students' oral language development. Bruce explained that "when you provide students the opportunity to go from a pair to a small group, to a whole class, they're building their confidence every time and they're getting practice in their oral language, but they need support to get there." The ELD teachers guided the science teachers to further develop their understanding of structured academic talk opportunities and flexible grouping, explaining that the strategies can be scaffolded but also need to be specifically structured to support them to participate. Leslie commented, "We provide as many scaffolds as we can, and we group them to, to help them get the support that they need. I don't think that I specifically focus on quality models, but I try to call on students who have strong oral language [skills] so that they can talk and I think that counts, and then we group them [based on who can help who]." Bob affirmed her process and Bruce helped them to understand how this practice can be adjusted to specifically support English Learners. Bob said, "If you pick someone who speaks well and is articulate, then they hear that. I would like to think that they would internalize it and try to practice speaking that way." Bruce explained, "that does help them. But it's important for us to provide explicit instruction in that. So, if we were to call on a student who's very articulate, and they speak when they're finished, we want to point out what they did. Specifically, what language do they use? Which words were elevated, and which words can we elevate to take the language from informal to academic? What kind of sentences did they use? So, we want to take the time to pause and really focus on the quality of language that the student used. So that that would be, I think, what this is asking for. As opposed to just calling on a kid who speaks well." Bruce's coaching provided an example for science teachers to start thinking about adjustments to

their teaching to better serve English Learners and hopefully take them from general knowledge and understanding of cooperative learning and structured academic talk opportunities to opportunities to talk like a scientist, just as they think like scientists.

Integrating Language support for science instruction

Teachers participated in two activities during phase 3 of the professional learning during which they demonstrated understanding of strategies suggested in the CA English Learner Roadmap and explained how they would help English Learners engage in science, thus elevating them from proficiency level 1, to proficiency level 2 in structured academic talk, functional language sentence frames, multi-modal non-linguistic supports, home school connection activities, relevant curriculum and group learning. Figure 2, below, is a screen capture of the Padlet activity.

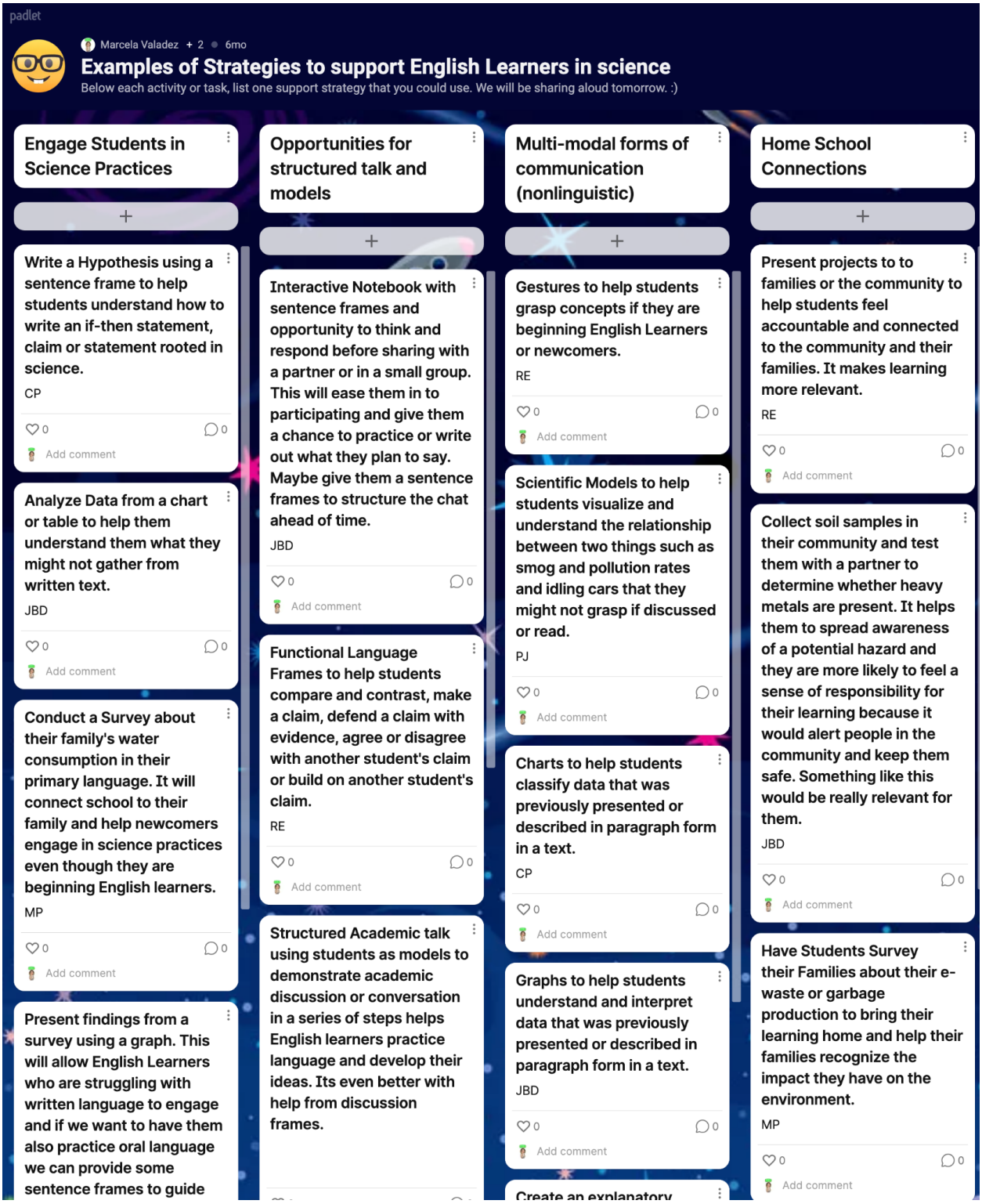

Figure 2
Examples of Strategies to support English Learners in science

For example, In the column labeled “Engage Students in science Practices,” Gloria initially wrote, “collecting samples,” but after a review of her students’ ELPAC scores and taking the opportunity to understand the needs of various students at different levels of language development, she elaborated “collecting soils samples and charting data with a partner allows them to collaborate and ensure they are correctly gathering samples without contaminating the specimen.” Similar growth happened for Bob and Leslie. For example, Bob’s response initially said “Conduct a survey” and after reviewing language proficiency levels, he elaborated and expanded, even explaining overlapping strategies and practices: “Conduct a survey about their family’s water use in their primary language. It will connect school to their family and help newcomers engage in science practices even though they are beginning English Learners.” Leslie’s initial focus also ignored the language support aspect. Her initial response said, “Analyze data,” but given the opportunity to elaborate further, she made the connection to multi-modal non-linguistic supports, specifically a chart or table and revised her answer to read “Analyze data from a chart or table to help them understand what they might not gather from written text.”

A similar process occurred with the “Opportunities for Structured talk and models” section of the activity. Before the revision opportunity, science teachers’ listed responses: “Have a language support wall,” “Think-Pair-Share” and “sentence frames.” Upon the opportunity to re-think, Gloria adjusted her response to read “Have a Language support Wall with examples of visuals, charts, models, vocabulary and sentence frames related to the current unit of study to give students content to refer to if they're struggling to understand.” Bob elaborated on his “Think-Pair-Share” to add “using sentence frames, talk models and opportunities to help English Learners develop science talk and practice oral language” and Leslie recognized that her use of

the interactive notebook could support opportunities for talk. She expanded her recommended use of sentence frames to include those frames within the science notebook she already uses. After revision, her response read, "Interactive Notebook with sentence frames and opportunity to think and respond before sharing with a partner or in a small group. This will ease them into participating and give them a chance to practice or write out what they plan to say. Maybe give them sentence frames to structure the chat ahead of time." Leslie realized that she can adjust a strategy she already uses to embed additional support for her English Learner students. In her reflection after session 4, she wrote "These strategies [position] students to do well… having a notebook full of tasks that use visuals and other strategies to refer to that help them access and engage in what we're learning." This activity helped teachers to think about ways the strategies can work in conjunction with one another and how they can modify what they're already doing to support English Learners, whereas before this activity, they focused on what they could not do and what they did not know.

Understanding of the Home-School connection and cultural relevance

Another area in which teachers demonstrated growth was in their understanding of the home-school connection and cultural relevance of learning. Whereas initially teachers did not believe home and school could connect or even that science could not reflect or connect to culture, this activity helped them to understand ways to bring science home and use it to validate students' culture and community. Specifically, Gloria's example highlighted a connection to a practice that teachers who do Project-Based Learning already use, but they had not previously considered it as a home-school connection. She wrote "Invite parents and community members to judge projects and give presentation feedback or learn from students about environmental

issues and impacts." Gloria explained that one aspect of Project-based learning, is to have a "public product" and "inviting parents to be the audience and experts from community environmental organizations like local environmental justice group East Yard to provide feedback and judge projects" makes the learning relevant because "it connects the learning to their homes and the real world." Leslie and Bob demonstrated similar outcomes. For instance, Leslie's example said "Collect soil samples in their community and test them with a partner to determine whether heavy metals are present. It helps them to spread awareness of a potential hazard and they are more likely to feel a sense of responsibility for their learning because it would alert people in the community and keep them safe. Something like this would be relevant for them." Her example made an environmental studies project relevant to the community, which also made the learning relevant and meaningful. Teachers learned to bridge home and community with science learned in school by making the learning relevant to their lived experiences. The same happens with Bob's example. His revision focused on bringing a previous project on e-waste or garbage into the home by "[having] Students Survey their Families about their e-waste or garbage production to bring their learning home and help their families recognize the impact they have on the environment." His example could demonstrate to students that they have a direct impact on the world, that their actions affect the environment, and they can have an influence on their families and community at large.

In addition to solidifying the home-school connection, the activity also emphasized teachers' understanding of how multi-modal non-linguistic supports help students. Science utilizes lots of multi-modal non-linguistic supports in graphs, tables, models, diagrams, but teachers were using them as part of their everyday business and not with an eye toward English Learners. Once they realized they were, as Bob put it "already kinda doing these things," and

they learned about the needs of different proficiency levels of students, being intentional became more natural. For instance, Gloria identified scientific models "to help students visualize and understand the relationship between two things such as smog and pollution rates and idling cars that they might not grasp if discussed or read." She explained in session that "sometimes [she notices] that even after completing an experiment or collecting samples and gathering data, the relationship doesn't click, and they need help connecting the dots. They see a visual and they'll understand and then work together to figure out if their data do the same thing." Bob and Leslie both shared similar examples, which involve offering a visual representation such as a model (Bob) or graph (Leslie) to "to help students understand [a] process that they might not have understood from a reading" or "to help students understand and interpret data that was previously presented or described in paragraph form in a text." Bob elaborated that students benefit from both "seeing" and "experiencing" it. Overall, the activity helped teachers better understand the effects that their instructional choices must support students.

During the second activity in Phase 3, Teachers also demonstrated an understanding of how multiple strategies could be combined to provide layers of support to Newcomer English Learners to complete activities such as an infographic, a social media campaign or a public service announcement. Figure 3, below, is a screen capture of the activity teachers engaged in to practice how they would support a Newcomer student to complete some of the project tasks they have previously assigned in their classes.

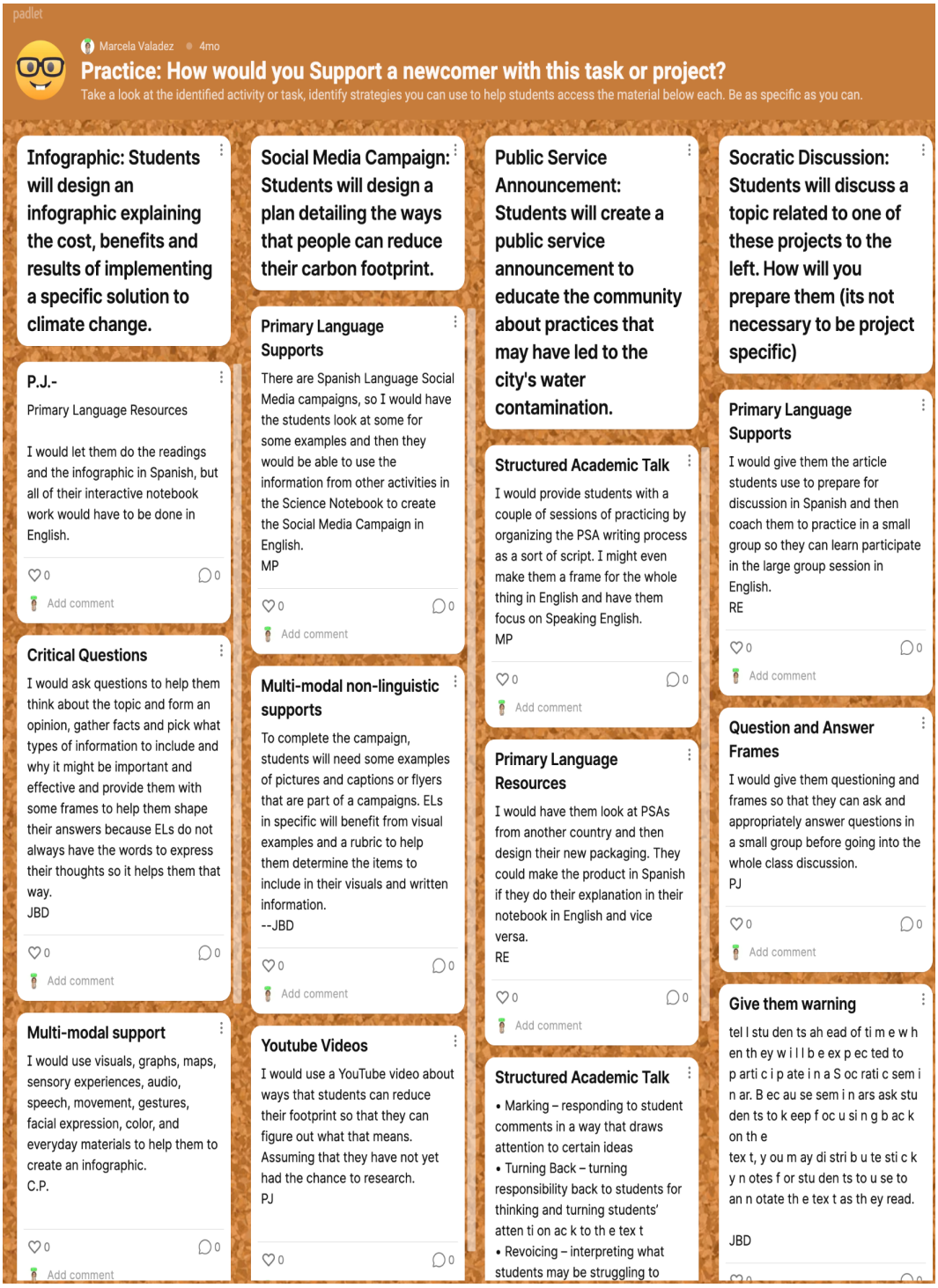

Figure 3
Teachers' application of strategies to support newcomers with tasks and projects

In response to the climate change Infographic, Gloria wrote, "I would let them do the readings and the infographic in Spanish, but all of their interactive notebook work would have to be done in English." She explained that she "would select readings in Spanish to help them understand the topic and then they could do the assignment in Spanish because they might still feel nervous about completing a culminating task in English as a newcomer, but they would need to practice English with me through the notebook." Her implementation represented a level 3 understanding of the use of primary language resources, but also of understanding of language ability level and typology because she demonstrated knowledge of the students' academic and social emotional needs. Bob also demonstrated an ability to combine strategies in his use of selected multimodal non-linguistic supports as part of the interactive science notebook to support newcomers with the infographic. For instance, Bob wrote, "I would use the interactive notebook to guide them through readings, videos, and interviews to help them learn about different solutions to climate change, and have them reflect, draw conclusions and pose questions and offer support by giving feedback and offering language supports when I see they need them." Bob's explanation of how he would use the digital interactive science notebook demonstrated that he has thought about how to implement multi-modal non-linguistic supports for his English Learners and could explain how they would support students to complete the infographic using the strategy. Similarly, Leslie blended critical questions and sentence frames to support newcomers with the infographic. She demonstrated a connection between the questions and the different functions of language such as how to ask for information, build on ideas and information, draw conclusions and form opinions. Leslie explained: "I would ask questions to help them think about the topic and form an opinion, gather facts and pick what types of information to include and why it might be important. I would provide them with some frames to

help them because ELs do not always have the words to express their thoughts so it helps them that way." In this example, Leslie was able to blend critical questions with answer frames to help students respond to questions that help them gather necessary information to include in the infographic. She touches on a few different language functions such as forming an opinion and gathering information, which would place her at a proficiency level 3. She understood specifically how the critical questions work with frames to support ELs and could explain how she would use them in a lesson to support newcomers to complete the infographic.

Phase three also marked when teachers became more comfortable defending their instructional choices. For example, the social media campaign detailing the ways people can reduce their carbon footprint. Bob decided that he would first expose students to a Spanish language social media campaign "but then they would be able to use the information from other activities in the science notebook to create the social media campaign in English." When ELD teachers asked why he chose to have newcomers complete the task in English, he responded "it isn't a solo project, so I would be sure to group them with students of varying English abilities for support and also give them access to resources like sentence frames. Plus a lot of a social media campaign is visual." His response indicated that he could justify and use multiple strategies to support students, which places him at a proficiency level 3 in flexible grouping, sentence frames, primary language support and visual supports. Plus, a social media campaign is relevant to high school students, especially if they can get the ASB director to allow them to do a social media takeover of the school's account to spread awareness using their campaigns. Leslie also demonstrated an understanding of an interplay of strategies when implementing the interactive notebook to help students complete the social media campaign. She explained how she might use this strategy to support newcomers to complete the social media campaign. She

wrote, "To complete the campaign, students will need some examples of pictures and captions or flyers that are part of a campaign. ELs in specific will benefit from visual examples and a rubric to help them determine the items to include in their visuals and written campaign information." Their understanding of the benefits of multi-modal non-linguistic supports for newcomers demonstrated that they could use them as scaffolds to help students access the task and can provide multiple opportunities to students as needed to be successful. This placed teachers at a level 3 in their proficiency for this strategy because they understood how these strategies could help EL students to participate in coursework, but also because they could explain specifically how they would apply them in their classes to help newcomers.

The next activity that the teachers discussed was how they could support newcomers was the Socratic Discussion. Gloria's response demonstrated an understanding of how different strategies and practices could be used in concert to support newcomers to engage in a Socratic discussion. She wrote, " I would give them questioning frames so that they can ask and appropriately answer questions in a small group before going into the whole class discussion." She blended small group practice opportunities with critical questions and answer frames to support students to participate in a discussion where they would be expected to pose their own questions and respond to classmates' questions about a topic. If a teacher struggles to support EL students, then they in turn will struggle to participate unless they are provided with opportunities to learn about what is expected and given a chance to practice those skills. In response to Gloria's example, Cesar coached teachers to support students further "An additional layer could be a small group model of the academic talk before the small group discussion happens. It would help the students see the skills in practice and then experience them in the small group and then take them up a notch for the whole class discussion." Cesar's coaching helped the teachers to

understand how explicit instruction in talk processes is the ideal application for support with Socratic Discussion. It also validated Bob's thinking about using structured academic talk as a practice technique for the PSA assignment.

Intentions to Implement Language Supports

Learning about strategies and practices that support EL students in science helped participants identify what was missing from one of their own plans and where there were missed opportunities for Language Support. Professional learning sessions 7-10 allowed science teachers the opportunity to work with ELD teachers to revise their Project and develop some resources to support their EL students. ELD teachers engaged science teachers in the process of finding standards that would help teachers support students with the language tasks required to demonstrate knowledge of science core ideas and complete the learning task or work products. Teachers worked collaboratively to complete a more well-rounded project that builds in specific strategies and practices, activities and learning products with an eye toward supporting English Learners. The ELD teachers also demonstrated to the teachers how the ELD standards could be layered in to support NGSS standards based on the language domain that students would be performing in. The final product demonstrates that science teachers intend to implement the following strategies and practices to support EL students: Home School Connection, Culturally Relevant Curriculum, layered standards, multi-modal non-linguistic supports, primary language resources, structured academic talk, critical questions, and primary language support,

The first notable change in the Post Project Analysis Chart is in the standards section. Whereas the pre analysis chart included only NGSS standards, the Post Instructional Plan

Analysis Chart included NGSS Disciplinary Core Ideas, science and Engineering Practices and the related CCSS standards in Reading in science and Technical Subjects as well as ELD standards. This happened because Gloria explained to the ELD teachers that NGSS standards had footnotes that aligned to CCSS and from there they were able to help the science teachers connect to ELD standards because the CCSS standards in Literacy connect to the ELD standards in the same way that the NGSS connect to CCSS. Gloria's knowledge saved the team lots of time because the ELD teachers are not experts in NGSS, and they had explained to science teachers that "the best way to use the ELD standards to support your standards is to look at the language tasks and then go into CCSS and pick the standards that apply and those standards will link to the ELD standards." When Cesar explained this, Gloria recognized the similar relationship between NGSS and CCSS and teachers were able to work backwards from NGSS to CCSS to ELD standards. As a result, the revised Post Instructional Plan Analysis includes all three types of standards. This took teachers two entire sessions to map out, but they were able to work backwards from NGSS to CCSS and then from CCSS literacy to the ELD standards with support from the ELD teachers.

The next notable change in the Post Instructional Plan Analysis Chart was the specificity of the strategies used within the work product detail. Each work product now specified tasks and embedded strategies. Whereas in the Pre-Instruction Plan Analysis Chart there were no specific activities and details. For example, the Entry event is described as an Image Journal, followed by a video presented for viewing with subtitles and then linked to a Think-Pair-Share structured discussion protocol and finally a whole class discussion. Teachers also took the time to write out critical questions in the work products section for the entry event and preliminary introduction to the project topic. Although the degree of specificity in the Learning Task or Work Product

section of the plan did not occur throughout the Post Instructional Plan Analysis Chart because the research tasks are still lacking some specificity about how students will be supported to read and comprehend the articles, the science teachers identified support strategies specific to the research task and provided a general explanation of how they would use them.

Teachers also implemented the Critical Questioning strategy for use with student research. The team wrote "Every article or source that students will gather information from will result in them working in a collaborative group to discuss critical questions listed on the lesson plan, but our major overarching question is: why should our community care about e-waste in the same way that scientists and economists do? These types of questions would prompt students to think critically about new materials, and we would provide the question-and-answer frames to help students work together in groups to answer the questions." This was similar to what they did for the Pre-Instructional Plan Analysis Chart, however their explanations were more specific to how their practice would adjust to support students to complete the task.

A similar pattern occurred with the "Structured Academic Talk" strategy explanation. It initially read "The teacher gives students clear step-by-step instructions and a protocol to help them practice learning to speak academically," which lacked specificity. Whereas in the Post chart, teachers were more specific about how they would use the strategy to support their students: "We plan to use this to provide students with planned chances to practice language so they can build their own ideas and get models and feedback in a safe, supportive, and caring environment, which helps them to grow speaking confidence." The same shift occurred for all other strategies and practices identified in the Post Instructional Plan Analysis Chart, which can be seen with subsequent activities. What is most important to note is that the focus was on why

and how they're using the strategy as opposed to what the strategy entails, which places them at proficiency level 3.

The next notable difference occurred with the student support for creating and Distributing a Data Collection Survey work product. Although in the Pre-Instructional Plan Analysis there was no description of how science teachers would support English Learners to complete the task, the teachers indicated that they would support students with primary language resources, establish a better home school connection, pose critical questions, allow opportunities for structured academic talk through discussion, allow students to work collaboratively and provide sentence frames as academic talk models. The Post Instructional Plan Analysis Chart explained how each strategy would be used, and the project plan write up provided more specific detail. For instance, science teachers planned to allow beginning English Learner students to write and conduct the survey in their primary language. They also planned to provide the opportunity for students to survey their families to strengthen the Home-School connection. They also noted Critical Questioning, Structured Academic Talk, Collaborative Grouping and Sentence Frames to support students' creation and administration of the survey. However, their description of the critical questioning strategy did not apply to the creation of the survey and there was no specific detail in the Project Plan write up that provided additional specificity. Teachers also planned to have students practice delivering the survey to one another once it was completed, which would provide the academic talk support. Furthermore, the description of the Sentence and Question Frames strategy also indicated that EL students would receive sentence and question frames as models for the types of questions they could pose in their surveys. The description of the Collaborative Grouping strategy also indicates that students would be grouped either homogeneously or heterogeneously based on their needs. For instance, it can be

determined that since teachers intend for beginning EL students to be able to write and conduct the survey in their primary language, that they will be grouped homogeneously by their language proficiency level, whereas other students would be grouped heterogeneously to support scientific academic language development in English.

Another major difference between the initial project plan and the revised project plan was the step-by-step guidance for students to write their survey and analyze the data. In the initial project plan, students were simply provided with information about what a survey was and asked to analyze the data, but in the revised project plan write up, there were critical questions that proposed to guide students to think about what types of questions to ask their respondents and there is a sample of a chart that students can ask their respondents to complete to help them gather the data needed to complete the project. There was also a link to a resource guide for students who might need additional guidance about how to design a survey and once students gather the data, the teachers planned to provide steps to help them analyze the data and provided support steps to help students do the math necessary to calculate percentages of the types of devices disposed and the methods of disposal and create a chart to detail their findings.

Most interesting was a new section added to the revised project called "Other Questions to think about" which would provide students opportunities to differentiate and tailor the project to their interests and/or challenge themselves more by exploring correlations between attitudes about topics like recycling and their e-waste choices. Doing this demonstrated that teachers were trying to make the project more relevant and interesting to students and meet the needs of various populations of students in addition to English Learners. The Post Lesson Plan analysis Chart and the Post Project Plan both indicated that teachers' thinking about providing language supports for their students have changed and that their participation in this project has affected their intentions

to implement language supports based on a comparison of a project plan conducted before the professional learning sessions, their conversations as they analyzed their plan to complete the Pre Instructional Plan Analysis Chart after the learning sessions and their Post Project Plan and Post Instructional Plan Analysis.

CHAPTER 5: DISCUSSION

This study conducted a professional development program with a team of science teachers at one high school as a means of understanding how such professional learning opportunities can be implemented to support science Teachers to plan ways to meaningfully engage English Learners in science. I sought to learn more about whether teaching science teachers about the needs of English learners would cause them to change their thinking about their role and responsibility for addressing their students' needs and work to meaningfully engage them as evidenced by their intent to implement language supports in their revised lesson plans. Overall, the science teachers' thinking did change, and they did make the effort to implement language supports specifically to better engage their English Learners in science.

Significance of Findings

The motivation behind this study resulted from my own experience as an English Language Development teacher. I continually watched my students fail their science courses when I knew they were capable of learning and passing. To support them, I developed lessons that worked to weave together ELD strategies and science practices and noticed that there were many strategies and practices typically used in science that naturally supported Language Development. Yet, although they performed well on science related projects in my class, they struggled in their science classes, and I needed to understand why. Thus, this project was born.

As the study began, it became clearer why students like mine struggled in their science classes. The three science teachers who participated in this professional learning intervention did not initially see themselves as responsible for supporting the language needs of their students.

They also were not equipped to provide such support, leaving them unable to see their potential as effective teachers of science to English learners. Their early expressions of their role and responsibility suggested unwillingness but their perceptions shifted as they began to learn more about students and their needs through their examination of student language typologies, profiles and assessment results that demonstrated students' needs. I also piqued their strong sense of professionalism by informing them of the expectations the state of California has for science and other content teachers to provide integrated ELD support.

Science teachers felt responsible for meaningfully engaging their EL students

These three science teachers took on the responsibility for language development after they had opportunities to learn about the California English Learner Roadmap Policy and examine student data to better understand their language proficiencies and needs. Their initial language about responsibility was to deny that it was up to them or that they were capable of taking it on. Yet, their participation in the intervention suggests they were willing to learn more. They developed confidence and took interest in meaningfully supporting their English Learners in science once they started to understand that it is their responsibility as a matter of California policy, they understood more about their own students' proficiencies and potential and they learned more about some integrated ELD strategies they could incorporate into their teaching with some coaching.

Science teachers planned to implement strategies they were taught

Initially teachers knew very little about how strategies and practices could be maximized to support English Learners, but by the end of the study they all demonstrated understanding of

how 9 of the 12 strategies could be used to support English Learners to access science content and engage in scientific practices. The three teachers were readily able to describe various integrated ELD strategies and explain their purpose after being introduced to them during the intervention. As we saw in chapter 4, many of these strategies seemed to be learned quite readily, as teachers almost immediately began talking about efforts to integrate them into their teaching. Their lesson planning activity in professional learning showed also how readily they picked up the chance to establish a home-school connection and make the learning relevant. They also worked to practice including primary language support opportunities, multi-modal non-linguistic supports, the interactive science notebook, critical questioning, and flexible grouping as a way to respond to what they learned about students' proficiency levels and typologies. Previous studies demonstrate similar positive results.

In contrast, at the start of the study they had no prior training about how they could use specific strategies to support English learners in science. However, as previously noted, teachers learned the strategies quickly. Some even made the effort to try to adjust their current lessons right away, which relates to teachers' willingness to change being tied to their own professional ethics. In 5 weeks of learning sessions teachers could demonstrate functional knowledge of all the strategies and planned the application of all 12 strategies in their revised unit project plan, but based on their description of how they plan to implement, it is clear they still require support for some of the language support strategies such as functional language sentence frames and structured academic talk, which makes sense because those are typically strategies more typically supported by the designated ELD teacher because they involve a more specific knowledge of registers of language and coaching students to work up to speaking academically without devaluing other more informal registers to help them communicate ideas.

Professional Learning for science teachers of ELs

Research involving both in-service and pre-service teachers indicates that science teachers are not adequately prepared to meet the needs of their English Learners (Santos, Darling-Hammond & Cheuk, 2012;), but there are certain things that professional learning can address to better prepare science teachers of ELs (Banilower et al. 2018; Gutierrez & Rogoff, 2003; Ishimaru, Barajas-Lopez, & Bang, 2015; Kelly, 2014; Lee, Quinn & Valdes, 2013; Miller, Januszyk & Lee, 2015; Moll et al., 1991; Nasir et al., 2014). Most science teachers have not received adequate preparation to provide appropriate opportunities for ELs in their science classrooms to meaningfully engage in science practices (August et al, 2014; Adams & Pegg, 2012; Bunch, 2013; Darling-Hammond 2006; Harmon & Pegg, 2012). This study found that teachers were not at all aware of the strategies that could be specifically used to support ELs in science and none could remember any opportunity to learn about supporting their EL students since the roll-out of the CA English Learner Road Map. However, once they did learn about it, they embraced what they could learn from it as responsible professionals committed to learning more about serving their EL students. There are few opportunities for teachers to learn how to integrate language into science instruction or how to enhance curricula to teach science content and practices in tandem with integrated ELD practices August et al, 2014; Bunch, 2013), and more specifically, secondary teachers serving schools with large EL student populations typically lack preparation in strategies to teach science and strategies to teach science to English Learners. As a result of this, participants in this study were afforded that opportunity while learning about the CA English Learner Road Map and during sessions to practice application of strategies. Research also tells us that science teachers also do not typically approach teaching science from

an assets-based position and instead view EL students from a deficit perspective, which diminishes opportunities for ELs to meaningfully engage in science. This was initially true for the science teachers participating in the study -- even for those whose first language was not English. However, helping them to understand and relate to their students caused their perspectives to shift. Teachers also tried to think about ways to engage families in the learning or participate in community-based learning experiences with their English Learners because research indicates that it supports the development of an assets-based approach to teaching ELs. In addition, opportunities for collaboration and professional learning between science teachers of ELs and ELD teachers who are experts at integrating science with ELs during their planning and delivery of science instruction have also been proven to be beneficial. For instance, researchers have found that when science teachers and ELD teachers come together for shared professional development about how to advance ELs in science and how to collaborate and share their expertise with each other, both groups of teachers are more likely to learn knowledge and competencies that benefit ELs. There is evidence that during the study the science teachers learned from the expertise of the ELD teachers and the ELD teachers better understood the needs of science teachers and could support them to improve upon what they were already doing to better serve their English Learners.

Instructional Strategies and Practices to Support ELs in science

In reviewing the research, there are several instructional strategies that show the greatest promise for building science content knowledge, providing EL students with meaningful access to science practices, and supporting Language development in tandem with science learning (National Academies of Science, Engineering, and Medicine, 2017). The science teachers

participating in this project gained valuable skills that moved them toward learning the strategies and practices that work to build science understanding while supporting language development. This was because research demonstrates that science teachers of ELs who are more successful at meaningfully engaging their students understand that ELs learn through meaningful and active engagement with language as it relates to science practices (González, Moll, & Amanti, 2005; Tolbert & Knox, 2016). All three teachers demonstrated progress toward this type of engagement throughout phase 3 of the professional learning. They tried to include Integrated ELD strategies and practices as springboard to students' engagement in science, but still demonstrated a struggle to learn how to teach their students to write and speak like Scientists. Although they did become more comfortable preparing to teach their students that they can gather meaning, learn, and communicate that learning using a wide range of meaning making resources and modalities. The science teachers participating in this study began to demonstrate their understanding of the importance of layering strategies to support EL students in their lesson plans. The reflections built into this study aimed to foster reflective practices that would hopefully transfer into teachers' practices once they do begin to implement their planned unit.

Recommendations

The intervention enacted here was designed from best practices gleaned from prior research. These include being based at the school site, engaging ELD teachers and science teachers collaboratively, using an instructional coach to support the collaboration and introducing science teachers to policy related to the education of EL students and recommended strategies and practices to help teachers develop the knowledge about EL students' needs to

move toward meeting policy expectations. While this study was not designed to directly test the efficacy of the intervention, per se, my findings point to the following recommendations.

Overall, teachers involved in this study demonstrated that the following recommendations applied with fidelity can yield results in the following areas: teachers' confidence to teach and meaningfully engage their science students, teachers' perceptions of EL students, and teachers' intent to implement strategies to support EL students. Participants' preliminary perceptions and practices as evidenced in interviews, journals and preliminary unit plans all indicate, as research supports, that content teachers are not prepared to work with English Learners (Ballantyne et al., 2008; Gandara et al., 2005). As a result, the following recommendations will support the establishment of a community of practice that meets the needs of teachers and consequently, students.

These results provide important insights for school leaders and professional learning providers whose goal is to support science teachers to effectively teach EL students.

Establish a community of practice between science teachers and ELD teachers

While this study wasn't designed to test the efficacy of this intervention, it does show that teachers' understanding of their responsibility to ELs can be readily changed and they can easily learn ELD strategies that fit into their current views of science teaching practice when they establish a community of practice along with ELD teachers. If teacher teams were to exist at more schools, then EL students and science teachers would likely be more successful. The three science teachers who participated in this study all changed their perceptions about their role to meaningfully engage their EL students in the science classes and their sense of responsibility for addressing the needs of their EL students. They were interested in learning about different

proficiency levels and typologies and the skills and traits associated with the different levels and typologies. In that process, their confidence to address the needs of their EL students increased. They also realized that some of the strategies they previously used could be adapted and adjusted to provide integrated ELD support and worked to adjust their practice to better support students, even though they were not expected to implement the learning during the study. They also revised their lesson plans to include the strategies they were most comfortable with and tried to include the ones they were not comfortable with.

ELD teachers to coach science teachers to foster science academic talk

The science teachers made the attempt to include structured academic talk opportunities and support students' development of science academic talk by using sentence frames related to the functions of language. However, ELD teachers provided them with resources, and they did not fully understand how to use them. That was partially because in the past the process of teaching students to move from informal to formal academic registers was expected of English and ELD teachers. Some would interpret it as a function of designated ELD, which should be addressed in the ELD class. However, if NGSS and CCSS expect that students will learn to engage in science practices and demonstrate understanding of phenomena and cross-cutting concepts, they need to be able to speak the language of science (August et al, 2020). Since science teachers in the study could not specifically explain how they would implement structured academic talk or support students' use of functional language sentence frames, it would benefit them and other science teachers to watch an ELD teacher to implement those strategies with their students in a push-in model.

Examine student language proficiency data firsthand

Prior to the intervention, all three science teachers knew very little about the proficiency levels of their students because they relied on their administration or English Learner Facilitator to provide them with a list of their English Learners. However, during the professional learning intervention, teachers had the opportunity to learn about the English Learner Proficiency Examination for California (ELPAC), understand the scores and associate scores with proficiency levels and student abilities at each proficiency level. That gave teachers the understanding of students' needs and allowed them to select a strategy or group of strategies to support students to access the science curriculum. Prior to understanding this information, teachers had no idea how to support their students. Some took guesses about their students' proficiency levels and relied on generic strategies like focusing on vocabulary and translations, while others made no effort.

Explicit integration of ELD strategies within the science lessons

Knowing more about students' proficiency levels allowed the participants to integrate ELD strategies within their science lessons to support their English Learners. Understanding the ability levels associated with each proficiency level allowed teachers to more carefully integrate strategies to support their students to meaningfully engage in science. They also better understood that newcomers benefitted best from opportunities to integrate their primary language as a springboard to learning science content and as a bridge to English language development. They demonstrated understanding of how multi-modal non-linguistic supports such as charts, figures and models give students the support they need to access science content. They also

demonstrated an understanding that students who have moderately developed oral language benefit from resources to help them move from informal to academic registers when they are having a discussion and that it benefits students to have opportunities to think, write, discuss with a partner and a small group before participating in a whole-class discussion. Participants learned how to integrate ELD strategies within science instruction to better position their students for success in their classes.

Limitations

There are a few limitations to the study. Because I only planned to understand changes in science teachers thinking and intent to implement, I did not get the opportunity to observe teachers implement the strategies. As a result, I was also not able to determine whether their planned intention to implement strategies occurred.

Another limitation stems from the research questions. Including ELD teachers but choosing not to research the role they played in supporting the science teachers was a missed opportunity to further understand their influence on teachers' thinking and learning.

I also struggled at times to separate myself from the research because I was already connected to them. As a result, at times I questioned the degree to which our prior working relationship and their prior working relationship affected the quality of data collected.

Implications for Practice

Although the initial findings of this project support research that science teachers are not adequately prepared to meet the needs of their EL students, the project also supports promising

research about the effectiveness of professional learning opportunities that address the specific needs teachers have and allow for collaboration between English Language Development teachers and science teachers that provide many lessons for school leaders, teachers and professional learning providers. My recommendations are meant as advice for administrators and instructional coaches at OHS in addition to other professional learning providers and schools with similar student demographics, size and structure.

Conclusion

Effective professional learning opportunities designed to meet the needs of science teachers of English Learners should begin with an assessment of teachers' knowledge and ensure that their knowledge increases. Teachers may require more background in policy, research about educating ELs, workshops intended to help them understand their students' language proficiency levels, understanding students' competencies, support with applying strategies to help students access content or the space to ask questions, discuss or practice any of the previous topics. It is necessary to establish a structure that supports an ongoing community of practice with the support of an instructional coach that helps teachers to focus on helping teachers to provide their EL students with equal access to science by focusing on using students' assets to help them grasp science content and develop disciplinary language and literacy skills.

Appendices

Appendix A

Meeting Focus Questions

Meeting 1

1. What are some Culturally and linguistically responsive strategies that could support ELs to learn science?

2. What could those strategies look like in your classroom?

Meeting 2

1. What are some learning strategies that will support ELs to learn science?
2. What could/do these strategies look like in your in-person science classroom?
3. How did learning about the typologies of English Learners help you think about ways to adjust your practice?

Meeting 3

1. What does the current body of research say about teaching Science to English Learners?
2. What are some of the characteristics mentioned in the professional learning that you also see in your students?
3. Do you notice any overlap between the EL Roadmap and Research on Supporting ELs in Science?

Meeting 4 Guiding Questions

1. What are some learning strategies we're already familiar with? How does that strategy function in your classroom?

2. Are there any learning strategies about which we need some clarification or would like to see some examples of?
3. Are there any existing projects, lesson sequences, or units that can be improved upon by using the strategies?

Meetings 5 and 6 Guiding Questions:

1. What are some CCSS/ELD standards in this lesson that would work to foster the selected science learning goals (NGSS), while co-developing language?
2. Which are the language intensive science-related learning tasks in this project or unit that might be difficult for ELs to complete?
3. What are some strategies that were used or could have been used to support students' completion of the language intensive science tasks?
4. What are some strategies that could support language development and at the same time help students grasp science content?
5. How would the implementation of those strategies look?
6. Explain why you organized the unit/project/activities/students in such a way?
7. What are some challenges you may have implementing the selected strategies? How will you attempt to avoid those challenges during implementation?
8. Describe how the lessons will play out ideally. How will you check for understanding? How will you know that students learned?

Meetings 7, 8, (maybe 9 & 10)

1. What are the tasks, specifically the culminating tasks that students will be expected to complete?

2. What are the language intensive aspects of the task?
3. What are some challenges you might have teaching the selected concepts to ELs? How can you address them?
4. What are some strategies that could help students understand key science concepts and meet the linguistic demands of the learning tasks and goals?
5. What are some challenges you may have implementing the selected strategies?
6. Describe how the lesson will play out ideally. How will you check for understanding? How will you know that students learned?
7. Explain why you organized the unit/project/activities/studentsin such a way?
8. How, if at all, did the process of analyzing a lesson last week, prepare you to re-write (or revise) your new lesson?

Appendix B

Observation Protocol

Research Questions:

1. Does teachers' thinking about their ability to provide language support to their science students change through their participation in this project?
2. Does participation in this project increase teachers' intentions to implement language supports?

Team ID	**Observation Notes** Language that: 1. Demonstrates thinking about their ability and role/responsibility 2. Demonstrates the intent to learn strategies. 3. Demonstrates intent to implement strategies	1	2	3
	Time:			
	Time:			
	Time:			

Appendix C

Journal Questions

WEEK ONE
Meeting 1 Journal Questions

1. Based on the information discussed today, what are some student characteristics *and* needs you recognize in students in your class?
2. How would you measure or assess your current ability to respond to their needs? Explain.
3. What is your perception of the role you play in developing students' language and literacy ability in regard to scientific practices?
4. What kind of support do you think you will need to develop your practice and better meet the needs of your EL students?
5. What are some of your expectations for this process?

Meeting 2 Journal Questions

1. Based on the information discussed today, what are some of the strategies you already implement in your class? What are some strategies you would like to try?
2. What challenges might you face teaching science to EL students? How might this opportunity help you address them?
3. Of the types of language intensive tasks introduced (or re-introduced) today, what strategies would you prefer to implement to support your EL population to meet the learning goals? Why?

WEEK TWO

Meetings 3 and 4 Journal Questions*

1. Do you feel equipped to address anticipated student needs based on what you learned last week, and reviewed this week?
2. Off the top of your head, what could you think to revise? Why?
3. What were some of the criteria you used to select strategies to support English Learners for your selected lesson or unit?
4. In what way does the lesson/project/unit you chose utilize the strategies we have learned? In what ways does it not?
5. How do you anticipate the strategy(ies) selected will help your students? Do you have any concerns about how students will respond?
6. What kind of support do you think you will need to implement the selected standards and strategies?
7. What types of challenges do you anticipate, if any?

Meeting 6 Journal Questions

1. What are some challenges you faced when analyzing your unit or project?
2. Did you find that you were already supporting the language needs of English learners?
3. How, if at all, has your perception about your role in literacy development for English Learners changed?
4. Is there something more you would like to gain from this collaboration?

Meeting 8 Journal Questions

1. What are some challenges you faced throughout the process of revising your unit or project to support the language needs of English learners so they demonstrate growth in both science and language development?
2. Would you say that the collaboration process better equipped you to teach science in a way that co-develops language?
3. Did your perception of the role science teachers play in developing literacy change?
4. To what extent, if any, did this collaboration improve your ability to meet the needs of your English Learners?
5. How would you say your instruction has changed as a result of this process?
6. If you could continue with the process, how would your goals for yourselves change based on your findings?

Appendix D

Pre/Post Interview Questions

1. About what percentage of your students are ELs?
2. How much do they vary in terms of English Proficiency?
3. How much do you know about their proficiency levels?
4. Do you know anything about their ELPAC scores?
5. How many of your students have reclassified as fluent English Proficient (RFEP)?
6. How confident do you feel in your ability to support EL students to meaningfully engage in your science class?
7. If you had to rate your ability to support them on a scale 1-10, how would you rate yourself?
8. Are you currently using any strategies to meaningfully engage your science students?
9. What kind of professional learning have you had to specifically help you engage English Learners in your science class?
10. What kind of support is currently being provided to your school or District, to help you meaningfully engage English Learners in science?
11. In a perfect world, what kind of support would you like to receive?
12. Do you collaborate with science colleagues to develop strategies to meaningfully engage your English learners?
13. Do you ever talk about English learners in your data teams? And if so, what do those conversations look like, describe them?
14. Are you doing any kind of interventions?
15. Do you ever work with the ELD teachers to develop strategies to engage your English learners?

Pre Intervention ONLY

16. What are some of the ways you hope this project might affect the way you work together? Across science and ELD to meaningfully engage English Learners in Science?
17. What do you personally hope to get out of this project? What would that look like?

Appendix E

Instructional Plan Analysis Chart

Directions: Consider your project, or unit plan and identify aspects of the task below.

- ❑ **Pre**
- ❑ **Post**

Learning Task or Work Product	**Science, Literacy and ELD standards to support**	**Language Task(s)**	**Support Strategy(ies)**	**Explain how support strategy will support students' completion of the tasks?**

***Participants added rows for each task or work product**

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