A CRITICAL SYSTEMIC FUNCTIONAL LINGUISTICS APPROACH TO SCIENCE EDUCATION: EMERGENT BILINGUAL LEARNERS AS AGENTIVE MEANING-MAKERS

By

LOURDES ADELINA CARDOZO GAIBISSO

(Under the Direction of Ruth Harman and Cory Buxton)

ABSTRACT

Research on linguistically and culturally sustaining science education has recently placed increased attention on the need to rethink the field by promoting more equitable pedagogical opportunities for all students. In this dissertation, I explored and analyzed different contexts where language and science were used to promote emergent bilingual learners as agentive meaning-makers within the NSF-funded Language-rich Inquiry Science with English Language through Biotechnology project. To this end, I inquired into two contexts of language production and meaning-making. First, I focused on the classroom practices of a LISELL-B trained educator working with bilingual newcomer refugee learners. Second, I analyzed the linguistic production of Hispanic students in constructed-response assessments. Drawing on the theoretical lenses of Systemic Functional Linguistics (SFL) and Culturally Sustaining Systemic Functional

Linguistics (CSSFL), this dissertation also provides insights on the role of language as a fundamental means for human transformation.

Presented as three article-length manuscripts, the central purpose of this dissertation was to analyze contexts of enactment in which teachers and students became agentive meaning-makers. In the first manuscript, I address how Teacher Professional Learning (TPL) can function as a powerful resource in supporting culturally sustaining educational practices for multicultural and multilingual students. In the second manuscript, I investigate the classroom practices of a bilingual science teacher in the context of a program for newcomer bilingual students. In the third manuscript, I argue that the field of science assessment needs to rethink and reflect not only on how scores are generated on assessments but also on what analyses are done with such assessments to inform teacher instructional decisions. Findings from this dissertation are aimed at contributing to the science education of bilingual Latino students within and beyond the U.S. context.

INDEX WORDS: Systemic Functional Linguistics, Science Education, Middle School Education, Science Inquiry, Emergent Bilingual Learners, Teacher Professional Learning, Culturally and Linguistically Sustaining Pedagogies

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DEDICATION

To God, the driving force behind it all.

To my mother, to the memory of my father and my dearest aunt Alba.

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CHAPTER 1

INTRODUCTION: BACK TO THE SOURCE TO MOVE FORWARD

My perspectives on this research study are first and foremost influenced by my rich experiences growing up, studying, and working in urban Uruguay, as part of a Spanish-speaking monolingual setting that permeated my schooling experiences in my home country. Despite the pervasive monolingualism present in my country, my family history is one of immigration, assimilation, and biculturalism. Even though I did not grow up with a clear understanding of what this all meant, and could not predict that parts of my personal history would be intertwined with my research agenda, there is a unique strength when the personal and the academic merge. Thus, the transformative experiences I went through while conducting this research and writing this dissertation have allowed me to conceptualize my role and ethical responsibilities as a bicultural researcher both at the academic and personal level.

A transcendental part of inhabiting my new role took place when I moved to the United States, partly because it was the first time I had the opportunity to reflect on my own identity as a Latina. Never before had I been considered a minoritized person, belonging to a diverse group of people who are often discriminated against, marginalized, and made invisible in and out of schools. In fact, before I moved to Georgia in 2014 to pursue my graduate studies in Language and Literacy Education, my reality had been of working as an English as a Foreign Language (EFL) teacher for five years in my home country, Uruguay. In the process of becoming a graduate student in the United States, my own identity went through many changes, while

navigating a new role of being a Latina and an immigrant in the Southeast. As I have mentioned before, neither of those roles, Latina or immigrant, had ever been part of how people saw me before 2014, or how I would describe myself. These two characteristics, however, are the ones that have helped me build my positionality as a researcher and that initially sparked my interest to work with Latino students, who struggle with their schooling experiences, language loss, and language acquisition, as well as issues of cultural and linguistic discrimination in the American school context.

These issues, however, are not new as "the United States has long struggled with the concept of equality in public education, with race having often been a determining factor in the provision of educational services and opportunities" (Hawkins Ash & Anderson, 2013, p. 1). As a bilingual and bicultural educator, I am aware of the dangers of language and cultural loss and the hazards this can pose to minoritized students in terms of identity development. Indeed, my work as a graduate assistant at The University of Georgia provided me with rich access to and interactions with parents and students in family workshops with teachers and students at multiple secondary schools, and in my school liaison role.

As a result of these interactions and my work as research assistant, a communal and collaborative notion of research emerged. It became clear to me that research is a joint endeavor, and building research teams is the way in which I enact and honor the theoretical and pedagogical framework I discuss later in this chapter. Due to this, through this dissertation, the "we' is stronger than the "I", as educational research at large scale needs a tremendous amount of collaboration and support. In honoring and mirroring my own conceptual stance, and following on understandings developed by Akkerman, Admiraal and Simons (2012), I recognize collaboration as a means of bringing dynamism to my research. In this regard, the ultimate goal

of collaborative research is not to bring desired consensus in any given topic, but integrating diverse paradigmatical stances to inform and enhance research. Akkerman and colleagues note that, "academics and research groups with initially different ways of positioning themselves can enrich each other's work" (p. 249). Contrary to more competitive and individualistic views on research, my experience and academic production has demonstrated to me the need to combine the expertise of many, so as to take on the inevitable challenges of knowledge development. Indeed, my three studies in this dissertation were collaboratively planned and written with members of my research team. Although in each study I was the main researcher, I insist in each piece on recognizing the other members who collaborated with me through the process.

Part of developing this new knowledge meant diving into the educational context of the United States and Georgia. To do so and understand the ways in which language instruction and language policy are enacted in K-12 U.S. schools, I started looking into different approaches to language and language learning. It was not until I found the approach of Culturally Sustaining Systemic Functional Linguistics (CSSFL; Harman, 2018) that I realized the need for a theory of language that accounted for necessary inclusion of the linguistic diversity of students in the classrooms I attended, and that also acknowledged that "language choices do not have the same value and meaning in society, or for different social groups. Linguistic variation has ideological and power implications" (Achugar & Carpenter, 2017, p. 96). Thus, building on a CSSFL framework and through the data collected and analyzed in this dissertation, my research aims to contribute to critical praxis that focuses on expanding the range of repertoires students can enact in schools, so that students will neither exclusively nor passively learn school-appropriate language but, rather will engage in a multitude of equally effective meaning-making processes.

Considering this, bilingual learners who have participated in this research are active agentive meaning-makers throughout the process.

In this sense, the CSSFL approach to language knowledge that I adopted for this study was illuminating because it allowed me to develop a deeper understanding of language variation equity. But I could not simply think about theory of language without understanding language policy and its implications for the schooling experiences of Latinos. A crucial reason for my secondary focus on policy is that "in the United States, issues of belonging and entitlement or rights, are argued and exercised through language policies, and discourses about language" (Arzubiaga & Adair, 2010, p. 306).

During the past four years, I have been able to research both CSSFL praxis and language policy within the context of a National Science Foundation-funded project called the LISELL-B[1] (Language-rich Inquiry Science with English Language Learners through Biotechnology) project. In LISELL-B, I served as a research assistant, which provided me with a dynamic understanding of how university school partnerships can support bilingual learners through culturally sustaining praxis, despite the pervasive and problematic state of language policies. The LISELL-B project, implemented from 2013 to 2018, was an initiative in which teachers, students, families, and approximately 15 researchers and research assistants participated with the aim of enhancing the learning of bilingual students. LISELL-B had two main components; one, which mainly focused on enhancing teacher professional learning for middle and high school science and ESOL teachers, and a Designed-Based Implementation Research area through which

[1] The work has been supported by the National Science Foundation (award # DRL-1316398)

the research team constantly assessed the quality and impact of the implementation (Cardozo-Gaibisso & Harman, in press).

My participation and engagement with LISELL-B, is without a doubt, the unifying thread that weaves together a combination of theories, methods, and transformative practice. The three articles that I present in this dissertation have originated from and developed through this communal (teachers, students, families, research team) learning experience, which influenced the lives and educational understandings of over four thousand students and fifty middle and high school teachers in two school districts. What is more, my previous narrow viewpoint of science and science teaching with which I entered this project was expanded and challenged as my research colleagues and I sought to enhance the science learning experiences of Latino Emergent Bilingual Learners (EBLs). My new understandings, combined with my own linguistic and cultural background and identities, shaped my questions around the possibility of transforming education for minoritized students. Such considerations are especially important because research consistently has identified major deficit discourses and practices as impeding Latino students in accessing social equity and indeed permeate the educational system at large. It is no coincidence, for example, that the dropout rate of Latinos in the Southeast is double that of their White counterparts.

As a result, my research seeks to understand, explore, and analyze different contexts where language and science contributed to meaning-making through the different material conditions available, at different points in time, and within the varied contexts of the LISELL-B project. To do so I look into two contexts of language production and interaction. On the one hand, I focus on the classroom practices of a LISELL-B trained teacher working with EBL refugee learners. On the other, I examine the linguistic production of EBLs in constructed-

response assessments. In the next section I discuss the overarching research problem, shedding light on some of the contextual issues such as immigration, which are essential to comprehend when thinking of the implications of the research presented in this dissertation.

Research Problem

Think of a classroom. *Piensa en una clase*. Imagine you are a child or a teenager and someone who is in charge of your schooling speaks a language you do not comprehend. *Imagínalo.* Think about how difficult it is not to have people who look or speak the way you and your family do when talking or reading about math, history, science, language. *¿Lo comprendes?* How would it make you feel? This is a daily experience for many culturally and linguistically diverse students across the United States. In addition, statistics show that the number of immigrant students with diverse backgrounds continues to grow exponentially (U.S. Census Bureau, 2012). As a Latina educator living in the United States, I wonder how educational stakeholders are preparing for this demographic shift, or if they are preparing at all. No change can occur unless the gaps, issues, and overarching problems in the educational system are acknowledged, and if that acknowledgement is followed by action. Although I recognize that education is a complex phenomenon and that many power structures need to be challenged and revised in order to achieve change, teachers serve as the key protagonists in any educational transformation, and therefore teacher training is deeply connected to what students learn (Darling-Hammond, 1997).

The focus of this study is on teacher education and the need for culturally sustaining approaches to better support teachers and improve the teaching force. First, however, I need to analyze the current landscape. The majority of the teaching force in American schools continues to be white women from middle class backgrounds, a situation which is increasingly different

from the demographic of the student population they teach (Amos, 2010). Moreover, persistent bias in regard to what minoritized students can learn and achieve in schools is an ever-present mindset that propagates and intensifies deficit-based thinking in schools across the country (Fergus, 2017).

Nevertheless, the differences between teachers and students is not only ethnic but also comprised of social, linguistic, and cultural aspects which have not successfully been incorporated into teacher education programs and are just now being introduced into the equity education research agenda both theoretically and methodologically (Agee, 1998; Samura, 2017). The aim of understanding this demographic difference is not capricious but linked to a fundamental question that needs to be addressed systematically: How does this demographic difference between teachers and students affect their academic learning in schools? For us, teachers and researchers, understanding the complexity of the social and academic needs of EBLs requires a wider and deeper analysis of how we are framing the problem. For example, when we consider issues of access, retention, graduation, and learning, we need to account not only for what the statistics tell us, but also what is behind those numbers and how they impact the discourses that label Latinos with a deficit framework (Gutierrez & Orellana, 2006).

In this context, and although immigration has always been a salient characteristic of the U.S., today schools across the nation are receiving growing numbers of immigrant students, and in spite of the increasing body of research that shows the negative effects of English-only models of instruction, education policy-makers are still focusing on such models. Following this idea, Lee and Buxton (2013) and Garcia and Kleifgen (2010) suggest that as immigrant students navigate the American school system they are often blocked from full access to meaningful

learning experiences. Since language and culture are intertwined, "language is closely tied to its sociopolitical context and can be a powerful political source for inclusion or exclusion of particular groups, often serving as a proxy for other social factors such as race and class" (Lucas, 2011, p. 7). Consequently, educators and policy-makers need to think about how these research-based findings are incorporated into the official educational discourse, having in mind that:

> While the connection between language and schooling has implications for all students, it has special significance for ELLs. To be sure, ELLs share many experiences and challenges with other groups of students. They are often marginalized and underestimated like students from other socially subordinated groups, and they do too have to learn appropriate ways of doing school (Lucas, 2011, p.5).

This pattern is reflected in both populations of immigrant Latinos and American-born EBLs. Immigrant Latinos represent 5% of the total of individuals with a college degree; when including Latinos born in the U.S. the number climbs to 17% (Migration Policy Institute, 2014). Furthermore, individuals who are both immigrants and EBLs are more prone to live in poverty (Migration Policy Institute, 2016). The question I need to pose in attending to the context of my research is how this looks like in Georgia, a traditional non-immigrant state. Finney, Perna and Callan (2012) claim that educational policies in Georgia continue to show a sizeable gap between college attendance rates among Whites and Asians compared to Latinos. Adding to this, recent educational policies in Georgia have done little to decrease the educational disparities, and therefore, the transition between high school and college remains one of the biggest challenges for minoritized students.

To examine Latino immigration in Georgia further, I also need to consider it in terms of the new Latino Diaspora. Although the latter term cannot be unequivocally defined, this

construct of a new area for influx of Latinos gives researchers the opportunity to explore how these new communities develop and evolve (Hamman & Harklau, 2010). In my research, therefore, I define the term as a broad category, comprising individuals who are first, second, third generation-immigrants and zero generation ones. This latter term refers to those who relocated to the United States as young adults, often times following their families. While the implications of the "patterns conditioning the intergenerational succession and reproduction of transnational ties remain largely under-researched and under-theorized" (Vertovec, 2001, p. 577), it is still crucial for educators and researchers working with immigrant youth to understand the complexity of their identity construction and transnational relationship between two lands.

Thus far, I have discussed some basic notions about immigration in the U.S., its immigrant population, and schooling for minoritized students with a focus on Georgia, and have given a glimpse into what the literature says about students who are linguistically and culturally diverse. The next logical question is: Where does the science come in? Researchers have long established (e.g. de Oliveira & Willcox, 2017) that for EBL students "one of the most challenging content areas is science, as in science, students need to develop scientific reasoning skills and visual literacy as well as learn the lexical and grammatical aspects of the language of science" (p. 2). Following this idea, the existing literature and research offer some clues about science education for Latino EBLs, even though more research is needed to understand the dynamic interplay of factors that impact this student population in context. In this regard, the role of initial teacher education, in-service teacher professional learning, enacted classroom practices, and student performance in science need to be conceptualized as intertextual layers of meaning (Lemke, 1992; Short, 1992), which when studied together can provide a more comprehensive view of the phenomena.

Taking all of this into consideration, research must do more than just build understanding about what conditions may lead to improving student performance. It should also essentially build creative understandings of how best to engage in "the process of supporting diverse learners in communicative and literacy tasks that move them towards linguistic and cultural equity and that supports their emotional and social wellbeing" (Khote, 2018, p. 154). Drawing on this notion, then, in this dissertation I conceptualize teaching and learning as mediated by an assemblage of internal and external resources, these "being embodied discursive, institutional, systemic or agential, and each learning episode therefore has socio-historical roots" (Scott & Evans, 2015, p. 191). In order to understand the complexity of these discursive forces, in the next section I present the conceptual foundations of this dissertation.

Conceptual Foundations: Back to the Source to Move Forward

In this section I discuss Systemic Functional Linguistics (SFL) and its critical extension into Culturally Sustaining Systemic Functional Linguistics (CSSFL) as a conceptual foundation for my work (see Harman, 2018; Harman, Buxton, Cardozo-Gaibisso, Jiang & Bui, in press). Understanding this functional theory of language requires me not only to go back to the source (e.g., Halliday, Hasan), but also to question some of the notions about language acquisition I was exposed to in my previous educational experiences as a teacher (e.g., language is an innate capacity learned through exposure). Once I went back to basics with SFL, I was able to push through deeply entrenched ideas about language and move forward. This exercise of questioning my own biases and resistance assisted me in understating that SFL, as a foundational language theory through which educators can enact linguistically and culturally sustaining pedagogical practices, can be placed within the umbrella of Critical Theory (Prasad, 2005). Indeed, Halliday's theory of language was influenced by Marxism (Thompson & Collins, 2001).

This combination of SFL and a critical uptake on language provided me with theoretical constructs in conceptualizing, analyzing, and problematizing contemporary language-related schooling practices for minoritized students, with a focus on Latinos. The latter is particularly relevant because Critical Theory has the ultimate goal of understanding how power relations operate, with the aim of producing change. Therefore, becoming a researcher within this paradigm means that institutional and educational practices are not regarded as neutral (Prasad, 2005). In this sense, Critical Theory can be defined as a "participatory approach that engages constituents or stakeholders in a reflective and critical reassessment of the relationship between overarching social, economic, or political systems, such as capitalism or accountabilism, and everyday practices" (Freeman & Vasconcelos, 2013, p. 8).

Historically, the origins of this theory can be traced back to the 1920s, and linked to the creation of the Institute of Social Research in Frankfurt, and scholars such as Habermas, Adorno and Horkheimer. In an environment of disillusion and desolation in light of rising political and social movements such as Fascism and Nazism, social theorists became increasingly dissatisfied with the main tenets of the Enlightenment and sought a new theory around social change (Prasad, 2005). It is relevant to note that Critical Theory "refers to a wide range of diverse but interrelated traditions that are united by an interest in cultural critique" (Prasad, 2005, p. 136). Today, Critical Theory serves as an umbrella term, under which a broad set of critical lenses focus on diverse social issues, with a shared purpose of producing social changes and shifts (Prasad, 2005). In addition, conducting research from a critical stance, "requires skepticism about the innocence of social and institutional practices, however innocuous and commonplace they may seem" (Prasad, 2005, p. 153). And I add, it requires skepticism about what linguistic practices are valued over others.

This becomes relevant when working in the context of science education, in which the notion of one unique and neutral field of science is pervasive. As explained by critical theorists, the concept of instrumental reason is highly important in assisting us in understanding this. Instrumental reasoning can be understood as the reduction and limitation of reason to a mere instrument to fix a given situation. Instrumental reason has "shaped our collective beliefs about science as a completely value-neutral activity that should not in any way be contaminated by wider social beliefs" (Prasad, 2005, p. 144). A distinctive feature of science education research is about the different understandings of science as a discipline, and how this has been incorporated into teaching. That is, often times the science instruction in school has not reflected the patterns and shifts present in the scientific community. What is more, science education research has not been successful in implementing instruction that focuses on the nature of science as a culturally and environmentally-embedded phenomena as opposed to an abstract realm (Bang & Medin, 2010).

As educational settings become more and more diverse, it is not possible to adhere to this idea of science as removed from culture and experience. Additionally, in science classrooms this value neutral perspective can be seen when teachers fail to incorporate culturally diverse students' experiences into the teaching of natural phenomena (e.g., how a certain culture understands earthquakes or a volcano eruption). From a critical theory perspective, social phenomena are never seen as value neutral. Education, for instance, has often been portrayed as a neutral space on which social, political, and economic forces have no impact and in which dominant interests are not present. This clearly false idea of neutrality is reinforced by discourses that emphasize education as an inheritably altruistic activity. Very differently, as a critical scholar, I understand that school is never neutral and "facts can never be isolated from the

domain of values or removed from some form of ideological inscription" (Kincheloe, McLaren, Steinberg & Monzo, 2018, p. 237).

These problematic ideas about the neutrality and inherent goodness of education inform my critical stance on the social, political, and ideological implications of language teaching and learning. Thus, my teaching and research experiences have ultimately led me to adopt Critical SFL and CSSFL approaches to meaning making (Christie, 1998; Gebhard, Harman & Seger, 2007; Harman & Zhang, 2015; Hasan & Williams, 1996; Harman, 2018; Khote, 2018). Hence, my inquiry is guided by the idea that it is not possible to arrive at pedagogical implications of a theory of language without reflecting on language as a powerful means for human transformation. Researchers have already established that language production is bound to a purpose (Eggins, 1994). From a critical theory perspective, (a) language is a complex tool that serves social cohesiveness and operates to control and shape the distribution of the meaning-making potential of linguistic resources, and (b) language is ultimately bound to economic and social conditions (Bourdieu & Thompson, 1991).

Theorists such as Halliday (1978, 1996, 2004), Firth (1957) and Voloshinov (1994) add to this ideological perspective arguing for the role of language in the construction of reality, and the possibility it affords individuals to communicate about that reality. In the construction of that reality, language has the power to function as a mostly invisible and implicit mechanism of the system of symbolic force, perpetuating the unequal distribution of linguistic and semiotic meaning-making resources, or alternatively as a transformative tool that contributes to its fair distribution (Martin & Rose, 2004). But how does an unequal distribution of linguistic resources take place? Mainly, this happens through the intangible ideological approaches to language teaching and learning, embedded in institutionalized schooling, which assume that students can

learn language and metalanguage implicitly, rather than explicitly. These approaches also overlook the fact that the language students learn at home, and through which they engage in learning at school, has an impact on their academic development (Nieto, 2004; Schleppegrell, 2004). By not acknowledging them in school, the educational community is hindering emergent bilingual student learning opportunities and negating their agency as creative meaning-makers.

If we recognize the need for the redistribution of linguistic resources through education, then education becomes a crucial space for students to reflect, think, and take action to build a more equitable society (Adams, Blumenfeld, Castaneda & Hackman, 2000; Cochran-Smith, 2004). But the possibility of doing so "is very much a matter of opportunity, so that a primary responsibility of schooling will be to teach children to be able to make such choices" (Christie, 1989, p. 161). SFL and CSSFL then have the potential of offering students the linguistic meaning-making resources to access, challenge, critique, and question social practices as they engage with language, text, and context (Donohue, 2012).

On this subject, SFL becomes suitable for understanding language from at least two different yet complementary angles: from within, how linguistic features are realized through grammatical and discourse structures, and from beyond, how language is connected to and shaped by cultural and situational contexts. Martin and Rose (2004) maintain that ultimately, one of the most valuable contributions of SFL has been to provide a new way of conceptualizing pedagogical practices and questioning why linguistic resources are unevenly disseminated.

To return to the primary discussion of why I chose this approach, SFL is a theory of language developed by Michael Halliday (1978, 1996, 2004) concerned with analyzing the real expressions of human interactions not as isolated products of human communication, but as contextualized ones. SFL then is a descriptive language theory which is concerned with language

in use, that is, the communicative patterns humans enact rather than a theory that prescribes how people should use language to make meaning (Eggins, 1994). As explained by Halliday (2004), SFL is concerned with the study of language as a semiotic or meaning making system. Although language is ultimately articulated through material functions (speech, body language, graphics), what language does and the meanings it conveys can neither be reduced nor defined in material terms, but rather in both material and semiotic ones. That is, language is not only the phonemes or graphemes comprising it, but the meanings it makes.

To understand Halliday's theory of SFL it is important to compare it with other linguistic theories that are popular, both in linguistic and educational realms. SFL views language as a symbolic system through which individuals make meaning, and in which function and form interweave. In contrast with cognitive approaches to language and language development, (e.g., Chomsky, 1986), which posit no relation between language structure and purpose, SFL is concerned with analyzing the system of structures (form) and their use (function) as a continuum rather than as separate linguistic entities (Painter, 1996). In this regard, "what is distinctive to systemic linguistics is that it seeks to develop both a theory about language as social process and an analytical methodology which permits the detailed and systematic description of language patterns" (Eggins, 1994, p. 23). This characteristic makes SFL theoretically unique and distinct from other linguistic theories in that it aims at understanding the relationships between linguistic structures and linguistic functions (Halliday, 1978). The process of language learning from an SFL perspective, is then inherently social and environmentally-mediated; humans develop language, as a semiotic system embedded in the context in which it is encoded (Halliday, 1978). Eggins (1994) clarifies this by saying that:

> language users do not interact in order to exchange sounds with each other, not even to exchange words or sentences. People interact in order to make meanings: to make sense of the world and of each other. The overall purpose of language then can be described as a semantic one, and each text we participate in is a record of the meanings that have been made in a particular context (p. 11).

As Eggins states, the ability to create meaning is ecological. That is, although individuals are biologically equipped with the capacity to learn language, it is the individuals' actual and concrete environmental conditions that will shape and determine the cultural and linguistic choices an individual will enact. The ecological approach to meaning making in SFL supports educators in seeing register and genre variation as always equitable – depending on the context - as opposed to traditional theories of language that promote binary understandings of standard versus nonstandard use (Harman, 2018).

Within a context of situation (i.e., register) three meta-functions make meaning simultaneously: field, tenor, and mode. Field is the topic raised in the situation; tenor entails the relationship of those individuals taking part in the situation, mediated by the multiplicity of roles they enact; and mode is concerned with the way in which the language of the interaction is being used (Eggins, 1994; Halliday & Matthiesen, 2004). Field, tenor, and mode then operate as "sets of related variables, with ranges of contrasting values. Together they define a multi-dimensional semiotic space – the environment of meaning in which language, other semiotic systems, and social systems operate" (Halliday & Matthiesen, 2004, p. 34). Linguistically, the three meta functions are realized through three meaning systems: ideational, interpersonal, and textual. The ideational and interpersonal meaning systems involve experiential sense-making processes, whereas the textual metafunction is concerned with the organization or flow of what an

individual is trying to communicate. That is, language realizes these meta-functions by creating two meaning-making steps. First, an interfacing one in which "experience and interpersonal relationships are transformed into meaning" (Halliday & Matthiesen, 2004, p. 25) and second, a step by which the meaning an individual is trying to communicate becomes text, either written or oral.

To this point I have explored some terms relevant to SFL. Next, I explicitly discuss what SFL theorists do with language. At large, theorists who adopt a systemic functional approach to language are concerned with the functional aspects of language on two levels: (1) language in use and (2) how language is structured for use. To understand language in use, SFL theorists look for authentic oral or written linguistic interactions enacted in a social context at two levels: register and genre. To understand how language is structured for use, researchers on SFL are concerned first with language as a semiotic meaning-making resource mediated at an encoded lexico-grammatical level. This lexico-grammatical level is hierarchically and dynamically positioned to realize different meanings through choice. Thus, to realize and communicate meaning, the writer/speaker enacts three levels of strata: two that express content (discourse-semantics; lexico-grammar); and one that realizes that meaning or expression (phonology/graphology) (Eggins, 1994; Halliday & Matthiesen, 2004).

However useful, understanding the object of SFL study as either language in use or how language is structured for use can be, I assert, reductionist. The complexity of SFL rests (or resides) in the fact that each speech act or linguistic interaction is dynamically and reciprocally related to a function. Consequently, every textual interaction takes place within a certain context of culture (genre). That context of culture is embedded in a context of situation (register). That context of situation, or register, will realize a specific metafunction through the three levels of

strata previously discussed: discourse, lexico-grammar, and phonology/graphology. While the context of culture can be described as a fairly stable one, usually defined within a set of societal and institutional norms, the context of situation is highly variable. For example, the context of culture of this research is defined by the educational policies of the state of Georgia, which are regulative, whereas the context of situation of each study is defined by the setting, school, participants, teachers, and students, and these are much less stable.

Finally, SFL theorists study language both as a system and as a text. This means that while the object of SFL study is language as a system of functions, those functions cannot be studied until they are instantiated in an actual text. As explained by Halliday (2004), the system of language has fundamental meaning-making potential. That meaning-making potential is instantiated or realized through a text. That text can be anything from something written on a sticky note, to teacher classroom discourse. In the two empirical studies I have conducted, language is instantiated in multiple forms: through interviews, student assessments, and classroom practices and instruction captured by videos.

As mentioned previously, my research is informed by a culturally sustaining SFL praxis (CSSFL). Accordingly, and drawing on the pedagogical framework developed by Paris (2012), the studies presented in this dissertation are inspired by the idea that recognizing the varieties and diversity of knowledge that minoritized students bring to the classroom is a central aspect of cultural and linguistic sustainability and agency. However ideal, the previous statement can be seen as ambitious in a climate dominated by accountability discourses and practices, in which teachers are constrained and under constant pressure. Due to this, the possibility of integrating SFL with a culturally sustaining lens, can become a rich space to explore how to produce changes that teachers enact in their classroom practices (Harman, Buxton, Cardozo-Gaibisso,

Jiang, Bui, in press). As literature and current research proposes "integrating SFL into teacher professional development can have an important influence on advancing teachers' knowledge of language and enhancing teachers' ability to design instruction that fosters academic literacy development of bilingual learners" (Harman, 2018 p. 7).

As a closing remark to this section, I understand the combination of SFL and CSSFL as a suitable theoretical framework for my studies. First, because it helped me to analyze language beyond language itself, that is, understand language embedded in context, as a sociocultural-mediated construct, and as dynamically conditioned and constrained by the material circumstances surrounding it. As Halliday (2003) claims: "meaning needs matter to realize it; at the same time, matter needs meaning to organize" (p. 3).

Second, SFL analyzes language within, how speakers make meaning through the available sets of linguistic resources (Butt, 1996). Third, it seeks to understand the relationship between these two systems of form and function with the understanding that "language is what it is because of what it has to do" (Halliday, 1978, p. 19). In short, the way in which language is structured is a consequence of the evolutionary needs of humans. Structures are not merely an abstract construct but are shaped by the actual needs of the real, and not ideal, speaker (Eggins, 1994). Following on this, in the next section I analyze how cultural and situational forces shape the linguistic choices speakers make.

Context of Culture and Context of Situation

In SFL and CSSFL theory, context is a complex construct that can be realized at two levels. To elaborate further on those two levels, this section will expand on the theoretical notions of genre (context of culture) and register (context of situation), and how members of any given community can navigate and shift their discursive practices through choice. It is important

to acknowledge that genre and register are closely interrelated. In a sense, genre can be conceptualized at a more abstract level than register. What is being realized through language cannot be understood except in the context in which it is embedded.

The context of culture is related to (a) the overarching meanings a given community shares and (b) what they can potentially mean in cultural terms. It is important to state that the context of culture can be realized through semiotic, or multimodal systems such as body language, facial expressions, and voice volume (Halliday & Matthiesen, 2004). I will explore this in my second paper: Newcomer Youth in American Schools: Exploring an Alternative Model of "Languaging" in the Sciences. According to Eggins, genre can be defined as "the general framework that gives purpose to interactions of particular types, adaptable to the many contexts of situation that they get used in" (1994, p. 32). For Knapp and Watkins (2005), however, genre is a more complex term as it is considered a dynamic social process, in which texts are influenced by ideology, ultimately determining who has access, and is able to produce, certain genres.

The contextual adaptation or context of situation is realized through register (Schleppegrell, 2004). Register is the "configuration of meanings that are typically associated with a particular situational configuration of field, tenor, and mode" (Halliday & Hasan, 1989, p.39). According to Eggins (1994) field expresses "what the language is used to talk about"; mode expresses "the role language is playing in the interaction"; and tenor expresses "the roles relationships between the interactants" (p. 52).

To better understand the connections between the contextual variables, meta-functions, and language, it is important to go back to SFL's object of study. As I stated earlier, SFL is concerned with the linguistic choices individuals make, not as isolated and abstract language

acts, but as contextual mediated choices. In this regard, different registers correspond to one of the three meta-functions, which are expressed through a set of linguistic resources. That is, the function a speaker is trying to accomplish (ideational, interpersonal, or textual) is enacted through a series of available linguistic choices. Next, with the aim of explaining how I articulate theory and methods in the study, I provide an overview of the methodological framework.

Overarching Methodological Framework

The three papers I present in this dissertation have the aim of capturing and exploring contexts of enactments in which teachers and students can become agentive meaning-makers. The first paper analyzes how in-service teacher education can provide a significant space for transformative action in educational practices in and out of schools. In my second paper, I investigate how a bilingual and bicultural teacher uses linguistic, cultural, and experiential repertoires of newcomer EBLs to enhance science learning. In my third paper, I analyze students' performance in assessments looking at alternative ways of understanding their written production through a multidimensional analysis model.

As explained in the introduction of this dissertation, the process of data collection and research conceptualization for the studies can be traced back to 2014, although I was unaware that this process had begun at that time. Since then, I have had the opportunity to explore different paradigms, methodologies, and designs. Through collecting and analyzing multiple data sets (interviews, assessments, videos, and pictures) I ended up working under what Maxwell (2013) calls a less structured approach. With the purpose of understanding this notion, and in contrast with structured approaches, a less structured one helped me "focus on the phenomena being studied, which may differ between individuals or settings and require individually tailored methods" (p. 88). Adding to this is the fact that the studies I have conducted use multiple data

collection methods, with the objective of achieving what Greene (2007) calls complementarity and expansion. These two constructs have helped me develop studies, which through complementary data sources and methods, provide a comprehensive gaze of the multifaceted phenomena which I have been actively studying, informed by contiguity-based relations (Maxwell & Miller, 2008). Contiguity-based relations, as explained by the authors "involve juxtaposition of time and space, the influence of one thing or another, or relations among parts of a text; their identification involves actual connections between things, rather than similarities and differences (p. 462). In addition, SFL and CSSFL function as both a theory and a series of interdisciplinary methods for data analysis that have also informed my research process and data analysis.

Framing the Studies

The onset critical questions that guided my dissertation research were: How are languages viewed and valued in the context in which the studies I conducted take place; and how do I, as a bilingual educator and researcher, see language? To explore these questions, I borrowed the classification developed by Ruiz (1984) that was subsequently expanded and challenged by Flores (2017). For Ruiz, language, especially second language, and particularly Spanish in the southeastern United States, can be seen and interpreted from three different perspectives: First, it can be viewed as a problem that minoritized students bring into the schools; second, as a resource that some people will benefit from; and third, as a right that all individuals have, regardless of their legal or immigrant status, either assigned or perceived. Adding to this idea, Flores (2017) brings another level of meaning to this classification, when he views language as a struggle for recognition. That struggle can become a source of inspiration that can

energize communities to plan and develop transformative action (Allexsaht-Snider, Buxton & Harman, 2012).

Earlier I proposed that an SFL approach to language teaching and learning acknowledges the "dynamic nature of the virtual/actual interference of context and text. In other words, actualized through the range of dynamic variables at play in the contexts of their production" (Knapp & Watkins, 2005, pp. 19, 20). For the studies I conducted, this means that data cannot be analyzed as abstract texts, but as socially and institutionally situated meaning-making resources, an idea that is also explained by the contiguity principle I have mentioned in an earlier section.

Given the frameworks I am using, I am compelled to answer the following questions: What are the context of culture and the context of situation in these studies? The context of culture can be placed at a macro level, within the overarching discursive practices and patterns enacted in the southeastern United States, specifically those that focus on EBLs, and their linguistic and learning abilities. A brief, illustrative look at the US legislation gives us some hints about how discourse is constructed. For example, as I have pointed out, according to the No Child Left Behind Act, EBLs are students "whose difficulties in speaking, reading, writing, or understanding the English language may be sufficient to deny the individual ability to meet the States proficient level of achievement on State assessments" (NCLB Act, 2001). From that statement, I can infer two key elements. These students are perceived as facing two challenges: a) they are required to learn academic content in a language which they have not yet fully acquired (English); b) they must navigate an educational system that values monolingualism, and discards heteroglossic perspectives around native language preservation and development (Engman & King, 2017). The context of situation of this dissertation, as I have mentioned before, is a National Science Foundation-funded project, LISELL-B.

The conceptual and empirical studies that I present in this dissertation have the aim of understanding, exploring, and analyzing different contexts where certain aspects and practices of LISELL-B were enacted. Following the line of inquiry outlined in this chapter, the overarching theoretical and methodological framework is a combination of SFL and CSSFL. Table 1.1 shows the most relevant characteristics for each study.

Table 1.1. Outline of Studies

Study	Research Questions	Methods	Data Sources
Preparing In-Service Teachers to Work with Linguistically and Culturally Diverse Youth: Lessons Learned and Challenges Ahead	1) What is the relevance of Linguistically and Culturally Sustaining Pedagogies in the current sociopolitical context? 2) Can In-service Teacher Professional Learning serve as a means to challenge and transform educational practices for EBLs? If so, how?	Qualitative inquiry Ethnographic approach	Recent literature on the topic. Observations and engagement with the scenarios described in the paper.
Newcomer Youth in American Schools: Exploring an Alternative Model of "Languaging" in the Sciences	1) How did a bilingual Mexican teacher enact a CSSFL approach to teaching science to newcomer bilingual students? 2) How does the focal teacher conceptualize and talk about the findings we observed in the videos?	Qualitative case study, ethnographic approach participant observation, thematic analysis. SFL-MDA, follow up interviews. Memos. First stage: thematic content analysis of data and categorization of emerging themes identification of critical moments in data related to CSSFL Identification of moments of Translanguaging, multimodality and register shunting and science inquiry.	Classroom Videos Follow up semi structured interview with the focal teacher.

Study	Research Questions	Methods	Data Sources
		Second stage: SFL analysis of interaction, the ideational and interpersonal meaning systems enacted in their joint construction of text.	
Thinking Beyond the Score: Multidimensional Analysis of Student Performance to Inform the Next Generation of Science Assessments	1) What student performance information cannot be captured by RBA scores exclusively? 2) Can any of the alternative and complementary analyses help us understand why students score higher or lower in specific questions?	Mixed-methods SFL analysis of lexical and textual features Textual Analysis through LDA	For the SFL analysis: 131 Pre-assessments and 140 Post-assessments For the LDA analysis: 293 Pre-assessments and 267 Post-assessments

Abstract for each Study

Chapter 2: *Preparing In-Service Teachers to Work with Linguistically and Culturally Diverse Youth: Lessons Learned and Challenges Ahead*

Teacher professional learning (TPL) can function as a powerful resource in supporting culturally sustaining educational practices for multicultural and multilingual students. However, as this chapter discusses through a detailed description of the literature, the design of current TPL initiatives often leads to a perpetuation of top down discourses about the role of teachers and bilingual learners in K-12 contexts. To speak to these challenges, our chapter provides readers with a detailed account of a bilingual National Science Foundation (NSF)-funded model of professional learning that could serve as an alternative culturally sustaining model for TPL. Specifically, the goal of the NSF initiative was to position in-service ESOL and science teachers of English as agentive and culturally responsive in their work. The systemic functional linguistic

paradigm that undergirded the initiative placed emphasis on incorporating students' linguistic and experiential repertories in co construction of knowledge. This chapter concludes with recommendations for the field.

To appear as Cardozo-Gaibisso & Harman (in press). Preparing In-Service Teachers to Work with Linguistically and Culturally Diverse Youth: Lessons Learned and Challenges Ahead. In Keengwe, S. *Handbook of Research on Engaging Immigrant Families and Promoting Academic Success for English Language Learners*

Chapter 3: *Newcomer Youth in American Schools: Exploring an Alternative Model of "Languaging" in the Sciences*

Informed by a Culturally Sustaining Systemic Functional Linguistics (CSSFL) framework, this article investigates the classroom practices of a bilingual science teacher in the context of a program for newcomer bilingual students; it also contextualizes the case study within a larger National Science Foundation multilingual project that took place over several years in the southeastern United States. The paper first discusses the CSSFL theoretical framework (Harman, 2018; Halliday, 1994; Paris, 2012). It then discusses findings from a discourse analysis of classroom videos, teacher interviews, and students' work. Findings support the authors' claims that a CSSFL approach sustains students' linguistic and cultural repertoires and supports science knowledge development. Limitations include the highly felt pressure of teachers due to high stakes testing, lack of bilingual teacher education, and low budget. Implications are discussed including the importance of register shunting among every day, specialized, and reflective domains (Macken, 1996) and multilingual meaning making in science classrooms.

To be submitted to: *Journal of English for Academic Purposes*

Chapter 4: *Thinking Beyond the Score: Multidimensional Analysis of Student Performance to Inform the Next Generation of Science Assessments*

Conventional assessment analysis of results, referred to as rubric-based assessments (RBA), has placed emphasis on scores as a way of communicating information to teachers about their student learning. In this light, rethinking and reflecting on not only how scores are generated but also what analyses are done with them to yield results, is of outmost importance.

Informed by SFL and LDA approaches, by utilizing LISELL-B's innovative bilingual (Spanish-English) constructed response assessment of science and language practices for middle and high school students, this study seeks to perform a multilayered analysis of student responses on these assessments in order to explore multiple ways for looking at students' performance through their writing in assessments; and to provide insights into the variability of student responses and explore some possible reasons for it derived from our data sources. Findings from this study suggest that we need to use a multidimensional model that deploys complementary ways in which we can interpret student performance. This new understanding leads us to think that research in the field of assessment would benefit from an approach which analyzes student performance as a multi-layered phenomenon.

To be submitted to: *Journal of Research in Science Teaching*

The dissertation ends with a concluding chapter that explores implications, conclusions, and a series of recommendations for researchers and educators interested in pursuing and enacting similar work in diverse educational contexts.

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CHAPTER 2

PREPARING IN-SERVICE TEACHERS TO WORK WITH LINGUISTICALLY AND CULTURALLY DIVERSE YOUTH: LESSONS LEARNED AND CHALLENGES AHEAD[2]

[2] Cardozo-Gaibisso, L. & Harman, R. Submitted to the *Handbook of Research on Engaging Immigrant Families and Promoting Academic Success for English Language Learners*, July 2018

Abstract

Teacher professional learning (TPL) can function as a powerful resource in supporting culturally sustaining educational practices for multicultural and multilingual students. However, as this chapter discusses through a detailed description of the literature, the design of current TPL initiatives often leads to a perpetuation of top down discourses about the role of teachers and bilingual learners in K-12 contexts. To speak to these challenges, our chapter provides readers with a detailed account of a bilingual National Science Foundation (NSF)-funded model of professional learning that could serve as an alternative culturally sustaining model for TPL. Specifically, the goal of the NSF initiative was to position in-service ESOL and science teachers of English as agentive and culturally responsive in their work. The systemic functional linguistic paradigm that undergirded the initiative placed emphasis on incorporating students' linguistic and experiential repertories in co-construction of knowledge. This chapter concludes with recommendations for the field.

Introduction

As the U.S. school landscape continues to grow more and more diverse, the challenges teachers face often place them under the microscope as their performance in the classroom is perceived as the key component to achieving student learning. If this is the case, then teacher professional learning, usually known as professional development, becomes a crucial component for teacher change. However, for this in-service learning to be achieved, many stakeholders, both inside and outside schools, need to actively participate in the co-construction of learning experiences that are participatory, context relevant, and sustainable over time (McComb & Eather, 2017; OECD, 2009).

How can the gaps in teacher professional learning be addressed to advance the profession and improve instruction? A large and growing body of literature has investigated this topic. A recent report on teaching practices around the world (Burns & Darling-Hammond, 2014) identifies teacher professional learning (TPL) as one of the practices that can advance the quality of teaching and learning in diverse contexts, more specifically for culturally and linguistically diverse students. For decades, researchers have identified the importance of teacher knowledge as not only an issue of social justice (Darling-Hammond, 1997), but also as a crucial component to enhance student learning and success (Lee, Luykx, Buxton, & Shaver, 2007).

Despite this consensus on the importance of TPL, in the Country Background Reports, McKenzie and Santiago (2005) concluded that although the notion of ongoing learning is accepted in many professions, this is often not the case for teachers. Adding to this critique, Boyle, White, and Boyle (2004) found that professional development activities often presented in one-time workshops do not adequately sustain changes and shifts in teaching practices, as educators often feel they are being condescended to and not actively engaged. The weak nature

of many TPL initiatives is doubly an issue because of the increasing need for teachers to work with diverse students in complex 21st century disciplinary discourses without their having the expertise to do so. In many states, particularly the southeastern United States, where the authors of this chapter developed their research and teaching agenda, the non-English speaking immigrant population of students continues to grow (U.S. Census Bureau, 2012), with teachers feeling highly challenged in knowing how to teach an increasingly culturally and linguistically diverse student body. Additionally, Lee & Walsh (2017) state that:

> despite the nearly ubiquitous rhetoric around diversity, multiculturalism, and culturally relevant pedagogy, immigrant youth today, like those from previous generations, continue to encounter assimilative policies and practices that are premised on deficit perspectives of immigrant cultures and languages. (p. 191)

To counter these challenges, research highlights how teacher learning needs to speak much more effectively to practitioners by creating contextual and longitudinal TPL initiatives that address the needs and sociocultural characteristics of the population it is attempting to serve. Indeed, there is much room for further progress in determining which type of in-service professional learning for teachers optimally can serve Emergent Bilingual Leaners (EBLs) and produce sustainable change in teacher practices and beliefs.

Our chapter first describes current challenges in TPL initiatives for pre-and in-service teachers. It then explores how an NSF-funded model of professional learning developed for in-service ESOL and science teachers could respond to these current challenges because of its successful acknowledgement and support of teachers as agentive decision makers in their work with bilingual students. Informed by a culturally sustaining SFL theoretical framework (Harman, 2018), the NSF model incorporates students' linguistic, semiotic, and experiential

repertoires as integral elements of knowledge generation. After discussing how this model met the needs of a group of teachers and students, the chapter concludes with suggestions and recommendations for taking action and theorizing about new possible models for in-service teacher professional learning that are longitudinal, contextual, and culturally relevant.

Linguistically and Culturally Sustaining Pedagogies: What they are and why they Matter

In this chapter, we will use the terms *culturally and linguistically sustaining pedagogy* and *multicultural teacher education*. We understand that language and culture are deeply intertwined, informing each other, and thus cannot be separated. The decision to include the term linguistically sustaining was based on our focus on immigrant students as they bring their own languages and cultures to the classroom. The terms *sustaining* and *relevant* are often used interchangeably in the literature and, thus, for the sake of brevity no such distinction will be made in this chapter.

When educators encounter culturally and linguistically diverse students, many of whom fall into the category of EBLs, it is necessary for them to develop an approach that goes beyond deficit. Educators and policy-makers need to develop an approach based on the strengths that their students bring to the classrooms, leveraging their languages and cultures (Garcia & Kleifgen, 2010; Khote, 2017). Even though we recognize that diversity extends beyond the immigrant population, our focus in this chapter is on EBLs, and they also comprise the student body of the teacher professional learning model described later in this chapter. EBLs can be defined as "those students who speak other languages other than English and are acquiring English at school" (Garcia & Kleifgen, 2010, p.1). The No Child Left Behind Act (2001) defines these students as "those whose difficulties in speaking, reading, writing, or understanding the

English language may be sufficient to deny the individual ability to meet the States' proficient level of achievement on State assessments" (Sec. 9101(37)).

According to Ladson-Billings (1995), culturally and linguistically relevant pedagogy is based on three important things: helping students succeed academically, helping students to develop cultural proficiency, and helping them to question established social structures. Furthermore, culturally sustaining pedagogies move beyond deficit and assimilationist approaches that are based on an "expected outcome that students would lose their heritage and community cultural and linguistic practices if they were to succeed in American schooling" (Paris, 2012, p. 94). Gay (2001) defines culturally responsive teaching as "using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively" (p. 106). Nevertheless, more often than not teachers have limited and superficial information about what cultural diversity is. Current literature on TPL, indeed, highlights three main areas of weakness that need to be addressed in the way that educators are being prepared to work with a linguistically and culturally diverse student population. The section below discusses how the literature conceptualizes these concerns.

Teacher Education in Socio Political Context: The first concern is linked to the need for a stronger agenda focusing on social justice beyond the classroom. This literature frequently addresses issues of inequity, deficit thinking, and hegemony, placing emphases on the need for development of teacher education programs that analyze societal issues of access and discrimination. This line of research tends to ask TPL and teacher educators to go beyond the common idea of preparing pre-service teachers to respect their students' cultures and the integration of superficial traits in their daily practices. An example of this is given by Valdés and Castellón (2011), who suggest that teachers should focus on seeing who their students are,

instead of just focusing on what they as teachers are doing in terms of teaching practices. In this sense, the authors feel it is important that teachers pay attention to their students as a diverse population and "become familiar with their backgrounds, their communities, their histories and their culture" (p. 30), putting emphasis on the need for teachers to go beyond what takes place inside the classroom. Culturally and linguistically sustaining pedagogies, in other words, are seen as necessarily situated in a wider social context, not just reduced to the confines of the classroom.

Likewise, Gorski (2009) makes a significant claim about the need to link culturally and linguistically sustaining teacher education to broader social structures and political issues. When discussing teacher education programs, the author makes a marked critique to what he calls a frequent othering language of educators that position diverse students and teachers as deficit and different. For example, many teacher education syllabi refer to culturally diverse populations as other cultures or co-cultures. Gorski claims this language "helps maintain hegemony, attaching negative value to identities or ideologies that differ from the hegemonic norm" (p. 313). In addition, he finds that teacher education syllabi tend to homogenize non-dominant populations, meaning that all students considered diverse are grouped together with the same deficit discourses, even though they may come from completely different backgrounds.

In line with this idea of social justice, Lenski, Crumpler, Stallworth and Crawford (2005) critique stand-alone teacher education courses that focus on cultural relevance and multicultural education. They assert that these stand-alone courses have limited impact on the overall outcome of teacher education programs. Instead, they suggest that it is the job for all teacher educators and pre-service teachers to question and reflect on their cultural assumptions and preconceptions in their courses and teaching contexts. They insist on this reflexivity especially because teacher

preparation for multicultural classrooms often follows predictably normative patterns of teaching and learning, whereby the curriculum is centered around the dominant culture, a curriculum that acts as if inequities and differences do not exist, and a curriculum that incorporates some of the superficial aspects of cultures, food and celebration as a way of addressing cultural diversity. This normative approach is inadequate in preparing teachers to work in a multicultural setting. In addition, the traditional approach fails to support new teachers in thinking about how to sustain the cultural and linguistic repertoires brought to schools by these students.

Diversity of Teacher Educators. The second issue emerging from research on teacher education is the need to re-conceptualize the role of faculty and teacher educators in their work with pre- and in-service teachers. Research has shown that teacher educators can have great impact on the professional trajectory of future teachers and highlights how it is imperative to consider who is teaching and participating in these programs, especially given the extent that teacher educators influence pre-service teachers' practices and ideas. Lucas and Villegas (2011) also place strong emphasis on the role of the teacher educator and the teaching education curriculum, including the importance of diversifying the future teaching force. Sleeter (2001) highlights how "students of color tend to bring richer experiences and perspectives to multicultural teaching than do most White students, who dominate numerically" (p. 94). The issue of diversifying pre-service teacher programs is a pivotal concern, as issues of multicultural education and diversity in the classroom tend to become hidden under what are treated as more urgent issues such as class management and testing. Consistent with this observation, Sleeter (2001) proposes two different, although not opposite, lines of action: to diversify pre-service preparation programs by bringing in candidates and faculty from culturally and linguistically

diverse backgrounds; and to create an awareness of multicultural equity issues among the existing White-dominated potential teaching pool.

Multicultural Language Education Preparation for All. The third issue raised in the research calls for the need for all teachers to be prepared to work with culturally and linguistically diverse students. Researchers state that the notion of specialized teacher preparation for bilingual students is no longer a relevant paradigm for an increasingly linguistically and culturally diverse landscape. Consequently, they argue that it is time to prepare all teachers to work with an increasing multicultural student population, and to abandon professional development models that prepare only ESOL and special educators for teaching of sheltered instruction. Compartmentalizing teacher preparation programs is seen as no longer serving the reality of diverse classrooms. In this vein, Lucas (2011) states that the fragmentation of teacher preparation into mainstream and specialized teacher education hinders the preparation of future educators for inclusive classrooms. Adding to this idea, de Jong and Harper (2011) claim that all teachers, not just those that choose to work in ESOL programs, must be prepared to work with linguistically diverse students. The authors advocate for a design of teacher education programs with a focus on curriculum content, program structure, and program coherence that pose the following question: Why do we prepare only specialist teachers, rather than all teachers, to work with diverse students when such students are becoming a majority in mainstream classrooms? Lucas (2011) also critiques the ways in which teacher education programs tend to perceive reform of current practices as happening through an additional course or two that focus on teaching of diverse students rather than the need for reconceptualization of the programs themselves. Others have advocated for certain language prerequisites for student teachers or even for additional certification. But for Lucas (2011), teacher education programs should think

not only about those issues, but also about reinventing themselves, which may also mean hiring new faculty who could possibly bring the changes needed.

Thus, a central idea recurrent in the literature is the need to prepare all, and not just some, teachers to work with culturally and linguistically diverse students, as mainstream American classrooms become increasingly diverse. Following this idea, Gort and colleagues (2011) mention how difficult such preparation is, when teacher educators do not possess the knowledge and skills themselves. The question is, then, how can we expect a shift in teacher education programs if those in a position to be the main generators of that change do not act? The authors suggest that this can be achieved if teacher educators are trained not only on cultural and linguistic diversity, but also on critical and reflexive analysis of the teacher education programs wherein they teach. Buxton, Allexsaht-Snider, Suriel, Kayumova, Karsli, and Aghasaleh (2016) claim that for equitable teaching to take place, teacher educators with experience working with minoritized populations need to play a key role in sharing and expanding that knowledge among pre-and in-service teachers. They add that "universities are the settings in which such preparation of both teachers and teacher educators is most likely to occur" (p. 91).

In summary, what does the literature say about teacher education for linguistically and culturally diverse students, and how does this inform our chapter? One issue that consistently arises is that a shift in language use about diversity does not necessarily imply a shift in teacher education practices. This means that just by adding words such as "diversity" or "multicultural" to a teacher education program, it does not automatically mean that this will be reflected in the practices of those involved in the course. Institutional policies and practices embedded in higher education teacher preparation programs are far from providing a consistent and coherent framework for preparing teachers to work with culturally and linguistically diverse students. A

sizable portion of the literature makes a call for action to diversify the teaching force, claiming that the homogeneous characteristics of pre-service teachers represent a barrier when working with culturally and diverse populations.

Bearing the discussion in this section about the major issues for teacher education in mind, what we propose is that time is needed to create spaces where teacher education programs can be reconceptualized thoroughly for 21st century diverse classrooms. In the meantime, however, teacher educators can focus efforts on improving teacher professional learning of educators who are already in the classroom. With the aim of exploring the current state of affairs for in-service professional learning programs, we explore the research on their affordances and limitations in the following section.

In-service Teacher Professional Learning: The Underexplored Niche?

Based on our work as teacher educators and recent research, we believe that in-service teacher professional learning initiatives can become a rich space for opening up reflexive dialogue among educators. However, for this robust reflexivity to emerge, we suggest that certain characteristics of what is now accepted as standard practices in teacher professional development need to be questioned and modified.

In line with this idea, twenty years ago Darling-Hammond and McLaughlin (1995) already recognized limitations that are still prevalent today in teacher professional learning programs (TPL). Such limitations include a lack of teachers' input and ideas when developing TPL programs, an absence of contextualization and limited time in conducting TPL, and a lack of cooperation and network development among university and school stakeholders. Despite these limitations highlighted frequently in research, governments around the world invest extensively in professional learning programs for teachers. One key challenge in making changes

to TPL is that often there is a lack of adequate assessments of the initiatives and their impact or lack thereof on teaching and learning (Day & Sachs, 2004; Garet, Porter, Desimone, Birman, & Yoon, 2001). Taking these issues into consideration, this section explores the different TPL models and how they are, and have been, implemented in order to understand and assess how in-service teachers can develop culturally and linguistically sustaining pedagogies in their classrooms.

To understand the field of TPL, it is important first to look at how the literature conceptualizes it and if there are some shared understandings of what it entails. In general, TPL is constructed as an activity that is done *to* teachers, rather than something done *with* teachers, and is an activity that occurs for a relatively short period of time despite evidence suggesting that short-term interventions are usually unsuccessful (Garet, Porter, Desimone, Birman & Yoon, 2001). In addition, the literature discusses the most consistent model of TPL of being one that is externally mediated by either instructional coaches within the school (Feighan & Heeren, 2009; Gross, 2010; Munoz & Guskey, 2009), or specialists and/or university researchers (Buxton, Allexsaht-Snider, Kayumova, Aghasaleh, Choi, & Cohen, 2015; Konza & Michael, 2010; Richardson & Janusheva, 2012; Bansilal, Goba, Webb, James & Khuzwayo, 2012; Fisher, Lapp, Flood, & Moore, 2006). Across the literature, these top-down approaches that position teachers often in deficit passive ways are discussed as emerging from a combination of economic, student performance, and school accountability factors.

Variations in TPL implementation could be potentially explained in many cases as conditioned by external factors such as funding (or lack thereof), or contextual features such as country, school location, and population. The literature demonstrates that although teachers are rhetorically considered key agents of student learning and school change, they do not have a

prominent role in such instances. In synthesis, TPL is generally conceptualized as an external-mediated, formal, and planned initiative which aims at improving student learning by modifying classroom practices through teacher reflection, changes in their instructional practices, or both.

When it comes to a focus on agency, autonomy, and decision-making opportunities, the literature is scarce. Generally, traditional models of TPL conceptualize it as an activity that "seek{s} to update, develop and broaden the knowledge that teachers acquired during initial teacher education and/or provide them with new skills and professional understanding" (McKenzie & Santiago, 2005, pp. 121-122). This perspective, which sees TPL activities as an external agentive mandate aimed at changing teacher practices, is consistent across the literature, with a few exceptions. In general, the literature presents TPL as an intervention that is implemented, designed, and developed by outside agents such as university researchers, experts, or mentors. In most cases, these initiatives come from either state-level or school administration. Although there are varying degrees of teacher involvement and agency, it is surprising to see how TPL initiatives, which are meant to be centered on teachers, are seldom originated or led by them. This is a highly problematic positioning of teachers as Borko & Puntman (1995, p. 60) highlight:

> Teachers themselves must make the design changes. To do so, they must acquire rich knowledge of subject matter, pedagogy, and subject specific pedagogy; and they must come to hold new beliefs in these domains (p. 60).

The fact that most TPLs are top-down initiatives without consideration of teacher agency is counterintuitive, given that the literature shows that the more teachers feel involved in an intervention, the better they tend to value and appropriate it (Rivard & Gueye, 2016; Styslinger, Clary, & Oglan, 2015; Watson, 2013). On the contrary, when teachers had less executive

decisions and presented top-down approaches, they were less embracing in their response (Gross, 2010; Konza & Michael, 2010; Patterson, et al., 2010).

Two specific studies about TPL (Buxton et al., 2015; Thibodeau, 2008) refer to and acknowledge the role of teachers as central. Buxton and colleagues (2015) propose an alternative conceptualization to the traditional model. They propose the notion of teacher engagement, with a multiplicity of enactments, and discuss how the TPL intervention they designed and implemented was based on the understanding that teachers exert choices in their professional learning (engagement) and in the ways they appropriate or not these new strategies in their own classrooms (enactments). In addition, the authors recognize that the content of the TPL intervention may not be translated or applied in just one way, but that teachers make choices when they transfer their understanding to new contexts (multiplicity of enactments). Hence, the authors recognize that regardless of the professional learning interventions teachers attend, they have agency and enact a central agentive and ownership role, as they are the ones making choices about what they will appropriate and use in their classrooms.

Similarly, Thibodeau and colleagues (2008) document a TPL initiative which they define as a "job-embedded approach" (p. 54). This initiative consisted of eight teachers organizing and participating in a teacher community through a literacy study group. This group had the aim of creating instructional resources and discussing teaching methods. The impact of this TPL intervention was successful because

> teachers were closely involved in shaping their own learning experiences. They were instrumental in determining the structure and operation of the group to meet their needs. This gave them a feeling of ownership and control that led to a sense of responsibility to one another and to one another's students (p. 63).

Similar to the study by Buxton and colleagues, the researchers found that autonomy and agency supported much higher investment among teachers.

Another finding in our literature search was related to the lack of reference to teacher learning theories in the research. In some cases, the literature makes careless parallelisms between pre-service and in-service teacher learning programs, showing the latter as an extension of the first. A consistent trend of the literature is to present models of TPL interventions as courses designed to retrain teachers (Bansilal, Goba, Webb, James & Khuzwayo, 2012). The majority of the studies about TPL do not provide an explicit framework nor a distinction of how teacher learning within in-service settings is different from other contexts. As a result, many articles provide only implicit hints about in-service teacher learning.

Having identified some of the main issues that may hinder in-service teaching, learning. and subsequent changes in teacher practices, we now explore how those implementing and studying TPL interventions discuss the role of language, culture, and literacy. In other words: what message are teachers receiving, whether explicit or implicit, about the role of literacy in their classrooms, and how it is constructed? When focusing on the way in which TPL interventions frame literacy, a common understanding across the literature is that literacy is linked to content in a synergic association, which cannot be developed unless explicitly taught. Studies which address literacy present distinctive approaches. A first group defines literacy as instrumental; that is, they describe it as a skill which is taught to students and can be used across all content areas (Munoz & Guskey; Styslinger et al., 2015; Thibodeau, 2008). A second group acknowledges that literacy is discipline-specific (Fenwick, 2010; Gilles et al., 2013; Rivard & Gueye, 2016), and that each subject has a set of discursive norms to which readers and writers need to adhere in order to understand and communicate knowledge. The third group adhere to

the notion of literacy as inquiry (e.g. Greenleaf et al., 2011). This emergent trend expands the notion of literacy to add an inquiry component, as it claims that literacy does not only encompass language, but also inquiry (Lee & Buxton, 2013; McMahon & McCormack, 1998; Stoddart, Pinal, Latzke & Canaday, 2002).

A fourth group offers an ideological and critical perspective on literacy which positions dominant forms of literacy as a possibly racist construct. Gross (2010) claims that through literacy students have the potential to challenge existing academic obstacles which are sustained by cultural and political hegemony. Consistent with this idea, Tolbert (2015) recognizes that literacy and the language practices of minoritized communities are usually seen as less academic and as potential barriers for academic learning. She claims that "racism in classrooms is enacted by teachers who either consciously or dysconsciously maintain differential expectations for minoritized students versus White middle-class students" (p. 1327). In this regard, teachers who reproduce racialized visions of language will unintentionally hinder minoritized students learning opportunities. TPL interventions, then, are not just opportunities for teachers to learn about literacy instruction, but they have the potential to become powerful spaces for ideological reflection about the role of languages, cultures, and literacies, constructs which are otherwise regarded as neutral. Similarly, Watson (2013) distinguishes between two literacy paradigms. One, which she calls the autonomous paradigm, is conceptualized as "a universal technical skill that is the same everywhere" (p. 389). The second paradigm understands literacy as ideological, embedded in a social and political context within a community. This paradigm is the one which informs our work with teachers and students.

The ideas proposed by the fourth group of authors are part of a recent scholarly movement which focuses on analyzing literacy, language, and culture as not only arbitrary

constructs, but as potential tools for racial oppression and segregation, especially of minoritized students (Flores & Rosa, 2015). From this analysis, it is relevant to note how these four different visions and interpretations of literacy coexist and guide professional learning programs for teachers across the country and the world.

What has become clear from looking at the current research is that TPL, in agreement with Day and Sachs (2003), can be implemented and enacted in a multitude of ways and settings, and that it can engage many stakeholders, not just teachers and experts. Nevertheless, the traditional notion of TPL needs to be challenged by newer understandings of how it is constituted. Borko, (2004), for example, points out that teacher professional learning occurs ubiquitously within formal contexts and in daily interactions with colleagues and students. This newer vision of TPL can fundamentally challenge not only the normative conceptual fabric, but also what counts as professional development and how it is measured, evaluated, and reported in research studies.

Context of Culture and Context of Situation of a Culturally Sustaining TPL Intervention

This section explores the theoretical and practical underpinnings of a TPL intervention that we believe can serve as an example of a new paradigm for teacher professional learning. When working with teachers and teacher educators in our design of TPL, we take into account that an SFL conceptualization of language teaching and learning acknowledges the "dynamic nature of the virtual/actual interference of context and text. In other words, actualized through the range of dynamic variables at play in the contexts of their production" (Knapp & Watkins, 2005, pp. 19-20). The logical question that follows as we approach the description of our TPL model is: What is the context of culture, and the context of situation, in our work with teachers? To understand this, we need to acknowledge that the context of culture can be placed, at a macro

level, within the overarching discursive practices and patterns enacted in the southeastern United States, specifically those which focus on multilingual and multicultural diverse youth, and their linguistic and learning repertoires. Within an increasingly draconian set of immigration policies and practices in the southeast, bilingual youth experience racialized school systems where English is the expected language and racial profiling is a common experience for all communities of color.

The context of situation of this intervention is an NSF-funded project called Language-rich Inquiry Science with English Language Learning through Biotechnology Project (LISELL-B). This project has two components: a TPL and a K-12 domain where Science and ESOL teachers participate in multiple professional learning activities such as student writing analysis workshops, family workshops, a summer institute, and a teacher-run student academy; and a Designed-Based Implementation Research domain, where a research team conducts data analysis with the aim of changing the models and testing several iterations. In the next section of the chapter, we focus on describing the multifaceted model of TPL, through which teachers experience a wide variety of learning experiences with different methodologies in diverse settings, and in which colleagues, student and family interaction play a key role in developing culturally and linguistically sustaining practices.

The LISELL-B Framework: Multiple Scenarios, Multiple Opportunities

The LISELL-B TPL model is built on the idea that teacher learning is a co-constructed endeavor in which multiple learning scenarios and interactions can help teachers develop a deep understanding of ELLs, their cultures and languages, and the role that their families have in enhancing their learning. The model has been built in a way which allows participating teachers

to experience a wide range of learning experiences, not limited to the traditional top-down ones we have previously mentioned in this chapter.

The LISELL-B TPL model, which was implemented from 2014 to 2018, offered participating teachers four main learning opportunities: Steps to College Family Workshops; Exploring Student Writing Workshops; Student Summer Academy; and Teacher Institute. Teachers who participated in this program were Science or ESOL ones, although Math and English Language Arts teachers would sometimes join our program. The aim of this program was to sustain a stable cohort of teachers who would participate in our activities throughout the duration of the intervention, and the majority of teachers did so. In the following section, we will describe each of these four learning contexts.

Steps to College Family Workshops

In order to introduce the Steps to College Family Workshops model, it is important to mention the notion of cultural capital (Bourdieu, 1973). This concept supports the idea that all families can bring their own culture to the schools, and that there is no superior nor inferior culture. Lewis (2001) reaffirms the concept of a pedagogical model based on the possibility of building relationships within and beyond the classroom, and in which participants are given the possibility of exploring and enacting different roles. In the LISELL-B Family Workshops, parents and students negotiate their roles as experts in the different fields: linguistic, scientific, academic, and cultural. It is in, and through, these unfixed roles that we find an incommensurable richness and exchange of cultural and linguistic capital. That capital, which is informed by the history of each family, becomes a fund of knowledge for teaching and learning (Gonzales et al., 2005). Connected to this idea, one of the key elements of the LISELL-B family workshops is the notion of knowledge and power being distributed freely among participants so

that everyone can learn from each other and each participant becomes an agency promoter. As one of the principal investigators of the project stated below:

> (…) the teachers are positioned as participant observers, Spanish language learners, and advocates for their students; the researchers are positioned as facilitators, listeners, and learners across both organized and impromptu learning experiences; the students are positioned as bilingual learners engaged in authentic science practices and on a path to academic success; and the family members are positioned as active learners and teachers fully engaged in their children's academic success (Allexsaht-Snider et al., p. 206).

The practical execution of this model of TPL and teacher-student-family engagement is conducted through a sequence of sessions. There is a science experiment workshop where parents, siblings and students work together, and where disciplinary and everyday language use is integrated. A key component of this segment is that all previous knowledge is validated, and parents, teachers, and students position themselves as learners who care in their collaboration with each other. Another key component of family workshops is the idea of bringing together Latino college students to provide a wide variety of information to students and parents and to serve as models for the children. The information about high school and college options is not exclusive for students; parents also benefit from it and often show interest.

Another key component of the LISELL-B Family Workshops is legitimation of the students' home languages. This gives teachers the opportunity to reflect on the importance and potential that home languages can have in schools and classrooms, in spite of the hostile climate that surrounds them. Consequently, using families' and students' previous experiential knowledge as a means of conducting any type of instruction is central to this project. In this way, we do not only promote the use of the home language for both conversational and academic

purposes, but we also aim to bring our participants' ideas, thoughts, and knowledge into the conversation with the belief that:

> Educators must develop radical pedagogical structures that provide students with the opportunity to use their own reality as a basis of literacy (…) It is of tantamount importance that the incorporation of the students' language as the primary language of instruction in literacy be given top priority. It is through their own language that they will be able to reconstruct their history and their culture (Freire and Macedo, 1987, p. 151).

Informed by Freire and by research on the importance of acknowledging the linguistic and cultural repertoires of all participants, our TPL generates knowledge wherein students and their communities make meaning alongside teachers and university faculty. This breaks away from the deficit constructs of students and teachers and instead perceives them as active agents in their learning and teaching processes.

Teacher Institute and Student Summer Academy

These two other TPL initiatives, while different, are linked together. They take place during the summer and give teachers the opportunity to plan, practice, and reflect in a safe space outside of school constraints. During one week, teachers come together to what is called "The Teacher Institute", a series of workshops aimed at presenting key pedagogical ideas, modeling of inquiry lesson plans and inquiry activities; it also provides a space for peer reflection and informed creativity. In this context, educators work collaboratively with their peers designing a wide range of teaching resources and language activities to use during the Summer Academy. Once the Teacher Institute planning week comes to an end, the teachers and LISELL-B team welcome over 100 students, for two consecutive weeks, and put into practice all of what they

have prepared. Teachers work in pairs or small groups and have the opportunity to share the instructional experience with colleagues from other schools or counties.

Exploring Students' Writing Workshops

These student workshops focus mainly on analyzing, discussing, and reflecting on the written expression of EBLs. Teachers explore their own students' writing and reflect on the way in which that writing is perceived. With a focus on EBLs, many teachers experience a shift in their thinking and start to recognize and change their deficit positioning of the students. After the workshops, many teachers claim they now see the multilingual expression in their student writing as a strength rather than as problematic, and they also feel better equipped to assist them in developing their thinking and writing.

Implications and Challenges Ahead

The purpose of this chapter was to explore how teachers in the United States are being prepared to work with linguistically and culturally diverse students, as well as to introduce a model of teacher learning which offers multiple scenarios for teacher learning. In discussing the LISELL-B model, we placed emphasis on the importance of thinking not only about TPL in terms of classroom instruction, but also in relation to the role of students' home languages, previous experiences, and relationship-building with their families. These experiences with in-service teachers have important implications for developing spaces that provide a comprehensive perspective on teacher instructional change over time.

In our model, we worked to dismantle the usual top-down professional development approaches and chose, instead, to build a model in which teachers, facilitators, families, students, and researchers constantly collaborate "to co-construct knowledge and resources that can be used to address the needs of diverse student populations" (Buxton, Kayumova, & Allexsaht-Snider,

2013, p. 9). This is particularly relevant for EBLs, as they have historically fallen behind in school achievement (Valdés & Castellón, 2011).

In sum, our understanding of TPL draws from sociocultural perspectives of teaching and learning, which includes recognizing "the historical, the linguistic, the semiotic, and the cultural" (Lemke, 2001, p. 297) domains of working with linguistically and culturally diverse student and teacher groups. Overall, in our experience working with teachers, we believe that this TPL framework has been key in engaging educators in robust and meaningful professional learning, which will have an impact on linguistically and culturally diverse youth. We believe that such a reconceptualization of teacher education is a necessary step toward true recognition and validation of the cultures and languages of our dynamic K-12 student body and also in recruiting more diverse teachers.

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Appendix

Appendix 1.1 Key Terms and Definitions

Emergent Bilingual Learners (EBLs): This term refers to those students who are learning the dominant language, but who, nevertheless, have already mastered their home language. The combination of the two linguistic resources implies a richer and more complete repertoire to learn.

Culturally and Linguistically Diverse Youth: In the school context, this term refers to those Middle and High school-aged students whose home cultures and linguistic practices are different from those of the dominant groups.

Teacher Professional Learning (TPL): The learning experiences teachers have access to and are exposed to inside and outside of their classrooms and schools. This includes non-traditional professional development activities.

Multilingual Teaching Practices: It encompasses those practices that comprise the use of students' whole linguistic and cultural repertories including but not limited to language.

Ideological Reflection: The ability to reflect on the core set of values and beliefs that an individual in a society adheres to. It implies the possibility of questioning and challenging long-standing beliefs and constructs such as ethnicity, power, and social structure.

Literacies: The ability to critically express oneself through reading, writing, and other nontraditional forms of expression such as visual representations.

CHAPTER 3

NEWCOMER YOUTH IN AMERICAN SCHOOLS: EXPLORING AN ALTERNATIVE MODEL OF "LANGUAGING" IN THE SCIENCES[3]

[3] Cardozo-Gaibisso, L. & Harman, R. To be submitted to *Journal of English for Academic Purposes*

Abstract

Informed by a Culturally Sustaining Systemic Functional Linguistics (CSSFL) framework, this case study investigates the classroom practices of a bilingual science teacher in the context of a program for newcomer bilingual students; it also contextualizes the case study within a larger National Science Foundation multilingual project that took place over several years in the southeastern United States. The paper first discusses the CSSFL theoretical framework and then addresses findings from a discourse analysis of classroom videos and a focal teacher interview. Findings support our claims that a CSSFL approach sustains students' linguistic and cultural repertoires and supports science knowledge development. Limitations include the extreme pressure experienced by teachers from high stakes testing, lack of bilingual teacher education, and low budgets. Implications are discussed including the importance of register shunting among everyday, specialized, and reflective domains and multilingual meaning making in science classrooms.

Introduction

In recent years, the number of immigrant bilingual learners in the United States has grown exponentially; yet instruction in disciplinary areas such as science and social studies remains largely monolingual and text oriented (Harman & Smagorisnky 2014; Flores & Schissel, 2014). Thus, very little focus is placed on fostering disciplinary knowledge through dynamic inquiry, multimodality, and translanguaging practices (Garcia & Wei, 2014). Indeed, teachers are successful in fostering scientific knowledge in bilingual classrooms to the degree to which they incorporate and validate the linguistic and cultural repertories of their students (Harman, Ahn & Bogue, 2016; Flores & Schissel, 2014) While reductive monolingual practices in schools are not unintentional, they function as a form of symbolic violence (Bourdieu, 1973; Bourdieu & Thompson, 1991), wreaking havoc on potentially robust multilingual school communities.

Informed by a Culturally Sustaining Systemic Functional Linguistics (CSSFL) framework, in this article two university researchers investigate the classroom practices of a bilingual science teacher and his newcomer bilingual students while also contextualizing the case study within a larger National Science Foundation multilingual project that took place over several years in the southeastern United States. The paper first addresses the CSSFL theoretical framework (Harman & Khote, 2018; Halliday, 1978; Paris, 2012), and then discusses findings from our discourse analysis of classroom videos, a teacher interview, and student-teacher interactions. Findings support our claims that a CSSFL approach allows the possibility of sustaining students' linguistic and cultural repertoires and supports science knowledge development by drawing on their cultural capital. Limitations include the high pressure experienced by teachers from high stakes testing, lack of bilingual teacher education and support,

and low budgets independent from what the university team could provide (e.g. lack of science kits, bilingual teachers, science laboratories). Additionally, limitations like with any case study, include also the issue of replicability, since each educator would need to take into account his or her specific context to enact similar practices. Implications are discussed at the end of the paper, including the importance of register shunting among everyday, specialized, and reflective domains (Macken-Horarik, 1996) and multilingual meaning making in science classrooms with newcomer youth.

Context of Situation

Diversity Meets Georgia

The demographic changes in the Southeastern United States, explained by the increased demands of the manufacturing industries, especially meat packing (Guzmán & McConnell, 2002), have resulted in an increasing number of immigrants arriving to the southern state of Georgia. During the second semester of 2014, Georgia, a traditionally non-immigrant state (Portes & Salas, 2015) also started receiving a rising number of unaccompanied underage youth. These students arrived mostly from Central America and had an extensive and diverse background in terms of schooling, English and Spanish language proficiency, and what is usually known as formal academic knowledge. As a response to this large and unexpected influx of newcomer students, the initial state decision was to place the students in various Middle and High School institutions across counties. After noticing that these students were facing academic challenges, the county decided to create a pilot program based on a model of sheltered instruction at a Charter School. Throughout this article, we will call the program RiseUp.

This RiseUp program for newcomer students, predominately from Mexico, Honduras, Guatemala, and El Salvador, provided them with life skills, ESOL, and science lessons. However, since having unaccompanied minors coming to the state of Georgia in large numbers is a new phenomenon, although prevalent in historically large immigrant states such as California, Texas, New York, Florida, Illinois and Arizona (OELA, 2008) there is little information regarding what curriculum design and consequently what educational practices best benefit these emergent bilingual students in this context. Consequently, the district communicated with a group of senior researchers and graduate students who were already working with EBLs across the state through the LISELL-B (Language-rich Science Inquiry with English Language Learners through Biotechnology) project. After the initial meetings with the classroom teacher, a team of three to five researchers, including graduate assistants, designed and co-taught lessons with the newcomer students. Over the course of four semesters, the team attended and developed a shared "interest in gaining a deeper understanding of the newcomer students [they] were teaching and the pedagogical approaches that would support their learning" (Cardozo-Gaibisso, Allexsaht-Snider & Buxton, 2017, p.10).

There is a considerable amount of research (e.g., Bauman, 2013; Brown & Bean, 2006, Rodriguez, 2018; Rumbaut, 2011) that has addressed issues of migrating youth and the difficulties they face when entering a new country, and thus, a new way of being. That way of being is also accompanied by the hegemonic perspective that situates migrant youth as an inconvenience to be assimilated as soon as possible. The idea that assimilation is the desired pathway to success jeopardizes the identity and culture that newcomers bring to school. However, because American mainstream schools are permeated by the assimilation rhetoric, both practices and discourses function as mechanisms to further assimilation. When schools fail

at their assimilative attempts, the blame is placed on the newcomers rather than on the monoglossic structure that has racialized and limited the holistic development of newcomer youth. In this context, the importance of this study is two-fold: on the one hand, it sheds light on the urgent need for teachers and administrators to understand how interrupted schooling and migration trauma has affected students; on the other hand, it calls for a comprehensive understanding of culturally sustaining pedagogical approaches that attend to the cultural, experiential and language needs and interests of emergent bilingual newcomers.

Language and Immigration

The intersections between language and immigration are not new (Peters, 2013). In fact, "linguistic enactments of political borders are continuously reproduced in contemporary language practice among white English-speaking monolinguals in the United States" (p. 578). In this context that continuously pushes immigrants towards assimilation, enacted primarily through English language learning, newcomer youth in American schools feel an additional layer of pressure not only to learn a new language, but to do so in order to show social cohesion. Although the notion of learning the language of the new nation to blend in is not new, historically language assimilation has been perceived as a unidirectional progression; that is, minoritized groups learn the new language with the expectation that they will stop using their mother tongue (Tran, 2010).

Newcomer students, then, arrive to the schools and are faced with the expectation to become proficient in English, rather than bilingual. This significant difference, which does not acknowledge the complexity of their linguistic repertoires, can greatly hinder their schooling experiences, as well as reproduce discriminatory practices.

In the next section, we present the theoretical framework that informed our research, taking into consideration the contextual factors we have mentioned.

Conceptual Framework

In the previous section, we made reference to the context of situation of newcomer students. Likewise, for this study, we draw on the understanding of language in context. By this we mean that there is a connection between language use and the access to linguistic resources that students experience, and the political and economic paradigms within a given society. This connection can help us understand processes of exclusion of certain groups, and how "language plays a central role in regulating an individual's access to the production, distribution, and consumption of resources" (Del Percio, Flubacher & Duchene, 2017, p. 69).

We propose that a CSSFL pedagogical stance that places emphasis on supporting student linguistic, cultural, and experiential repertoires is essential for newcomer youth learning. This also goes hand in hand with the idea of a humanizing pedagogy (Huerta, 2011), in which educators take into consideration the contextual intersections of the sociocultural and political context with those of their students. With use of CSSFL and humanizing approaches to teaching newcomer youth, educators understand the importance of sustaining students' repertoires as well as giving them access to the resources of normative educational discourses. To further understand this idea, we draw the understanding that educators can enact culturally and linguistically sustaining practices that will lead them to ultimately challenge the repetitive cycle of oppressive educational policies present in schools (Freire, 1970; Nieto & Bode, 2008). Opportunities for this to occur are dependent on developing an understanding that CSSFL is not

only about supporting linguistically minoritized students to develop effective science or other disciplinary literacy, but also to challenge and transform normative practices.

In developing the theoretical stances that inform CSSFL, we have also adapted the subdivisions outlined by Nocone and Cole (2009) to understand the connections between the concepts we will be introducing throughout the article: SFL, culturally and linguistically sustaining, and literacy. In order to deploy a comprehensive view of CSSFL as researchers we propose the need to perform or adopt:

a) A socio-cultural, historical, political, and economic analysis of the contexts in which the concepts have evolved, and how they permeate how they are seen in schools;
b) An intra-literacy perspective which helps us view different visions of literacy in the field; and
c) An ideological perspective on cultural and linguistic diversity.

With those three parameters to guide our work, the conceptual framework we draw from in this study are SFL and CSSFL. In figure 3.1 we illustrate the main components of our pedagogical model, which will also guide our analysis. Firstly, we focus on multimodality given the multi semiotic nature of science discourse (e.g. graphing, drawing, experimenting). Secondly the embodied nature of science inquiry. Thirdly the need in newcomer contexts for a pedagogy of translanguaging, and finally the idea of register shunting (e.g. need to orchestrate moves from face to face negotiation to formal presentations, embodied understandings).

This idea becomes particularly relevant as we introduce the concept of science inquiry as a pedagogical practice that allows students to explore and use experience to seek scientific knowledge, instead of reproducing it. Translanguaging informs our framework as it is a

pedagogical approach that validates and supports bilingual learners in constructing meaning through dynamic borrowings from available linguistic repertoires (García, 2009). Register shunting posits that learning consists of the ability to move, or shunt, across the register demands and discourse domains (Macken-Horarik, Devereux, Trimingham-Jack, C., & Wilson, 2006). The notion that "when people whose linguistic backgrounds minimally overlap come into contact, they deploy semiotic repertoires which include a wide range of signs for making meaning" (Blackledge & Creese, 2017, p. 255) has also informed this research. In other words, it is essential to attend to all available semiotic resources in supporting knowledge generation among emergent bilingual newcomers in middle and high school years.

In sum, a CSSFL framework allows educators and bilingual learners to cultivate a third space where everyday registers, dialects and languages are leveraged to jointly produce new idiosyncratic and scientific knowledge (Harman & Khote, 2018).

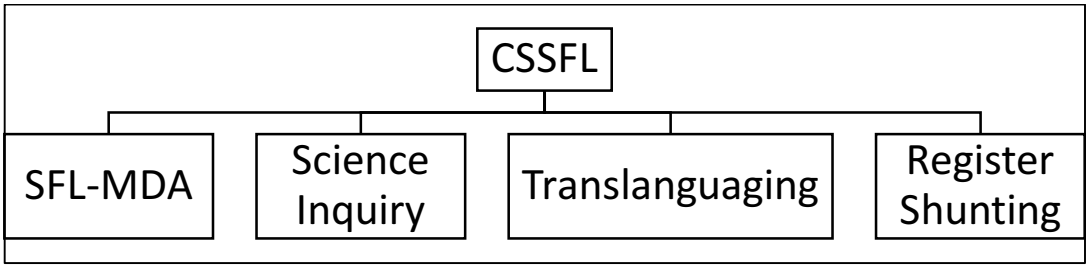

Figure 3.1 CSSFL Model

In teaching science within a CSSFL framework, educators and bilingual learners co construct a permeable curriculum space, where a range of registers, dialects and languages are leveraged to make scientific knowledge (Harman & Khote, 2018). The language of science (LoS) provides emergent learners with a distinct challenge because of its frequent use of grammatical metaphor (e.g. nominalizations), lexical density and passive voice (Fang &

Schleppegrell, 2006). Indeed, as Lemke (1990) stated: "what makes the language of science distinctive is primarily, but not exclusively its semantics, the specific relationships of scientific meanings to one another, and how those relationships are assembled into thematic patterns" (p. 21). Overall, a CSSFL approach, informed by cultural sustaining pedagogies (e.g. Paris, 2012) and SFL-informed genre pedagogies is an approach that supports students and teacher to co-mingle their congruent, specialized and reflective knowledge domains to jointly construct scientific knowledge.

All in all, Halliday's model of language celebrates the "eco-social" nature of language that shifts to accommodate variation in social register and cultural context (Lukin, Moore, Herke, Wegener & Wu, 2011). Meaning making potential emerges from all available semiotic resources (e.g. different linguistic repertoires, modes) Thus, creating a space where students draw from all their semiotic, cultural and multimodal repertoires can support them in appropriating and challenging disciplinary discourses; while also problematizing their positioning within a racialized educational system (Rosa & Flores, 2015; Hasan & Williams, 1996; Paris & Alim, 2014).

Methodology

Participants and Classroom Setting

Participants of this research study are twelve students who are known to the school system as newcomers, and a bilingual Mexican teacher, from now on referred to as Jerónimo. Jerónimo has lived in the US interruptedly for the past ten years, and has now permanently relocated in the US. The students, who we have conceptualized as newcomers or unaccompanied minors are those who have recently arrived in the United States and are currently

living with extended family or older siblings. Students arriving under this condition usually do so by crossing the border. A small portion of the students are American citizens who were born in the U.S. but who returned at some stage to their home country with their families. According to one of their teachers, 75% of the students work either at a restaurant or at the chicken plant in the county. Teachers have mentioned that sometimes students fall asleep during class, but they do not call their attention as they understand they are tired. According to their teacher, students work between 6 to 8 hours and come to school after that.

In terms of the setting of this study it is, of course, a classroom. However, this classroom is not your typical one, as it represents a bilingual space, full of signs in Spanish and English, which are naturally embedded in the walls and teaching resources. A salient characteristic of this classroom is the bilingual academic vocabulary cards which are at all times in display for the students to use as guidance. This classroom is a space different from other rooms in the school in that it allows students to negotiate meaning across both languages, Spanish and English, express their ideas multimodally and find language support in their peers though their own translations, or through translations devices.

Data Collection

Data collection included video recordings of the weekly teaching sessions, an in-depth interview with Jerónimo, the teacher, and field notes collected over the course of fall 2015. The camera was usually placed at the back of the room, on a tripod, and although some students seemed reluctant at first, they became used to it. Videos were taped once a week, on Mondays, at a Charter School located in a rural area of the state in which the research team was invited to collaborate with teachers during the 2014-2105 and 2015-2016 academic years.

A unique characteristic of the data collected for this research is that it is bilingual, in Spanish and English. Both languages are used by the focal teacher, Jerónimo, and students to jointly construct understanding of scientific concepts. Students were actively encouraged by Jerónimo, and their peers, to use the language they feel more comfortable with, to take risks when using English, to translate, and to shunt across registers. When writing, students were encouraged to use whatever means of expression they believe will better help them convey their ideas, including multilingual resources. This means some students drew, wrote, or both.

Data Analysis

Data analysis included two phases, and was comprised of two different data sets that were analyzed intertextually. In the first phase of qualitative analysis, intertextuality was used as an analytic tool to explore connections between the classroom discourse, field notes and follow up teacher interview (Harman, 2013). The first stage also included a thematic content analysis of the videos and a categorization of emerging themes with the aim of identifying critical CSSFL moments. Analysis in the second stage was conducted through an in-depth SFL exploration of selected data: this entailed exploration of critical moments in the data collected, exploring specifically how the ideational and interpersonal meanings were enacted by the teacher and how the students responded to this pedagogy through their oral interactions. Our guiding question was the following: How did Jerónimo, a bilingual Mexican teacher, enact a CSSFL approach to teaching science to newcomer bilingual students? Our second data set consisted of an in-depth teacher interview, in which Jerónimo was asked to reflect on some key aspects related to the practices enacted in the videos. Our guiding question was: How did Jerónimo conceptualize and talk about some of the findings we observed in the videos?

In order to analyze Jerónimo's interview, we performed a thematic analysis. To achieve this purpose, we looked at thematic patters as they emerged in the interview, and contrasted them with what was captured on video, and observed during lessons. For the purpose of data analysis, we conducted a Critical Thematic Analysis (CTA), adding to the idea that "the purpose of data analysis is to search for important meanings, patters and themes in what the researcher has heard and seen" (Ruona, 2005, p. 236). We also aimed at critically situating Jerónimo's perspectives in wider social contexts. CTA, then, is an approach to interview analysis which seeks to unpack data based on a critical and situated perspective of emerging themes. CTA is critical because in creates "alternative ways of representing, being and interacting in the world with the goal of creating a society free of oppression and domination" (Rogers, 2011, p. 5). It is situated because "language has a certain meaning potential (…) a range of possible meanings that the word or structure can take on in different contexts of use" (Gee, 2015, p. 109). We found especially meaningful to make connections between what we were able to capture from the videos where Jerónimo is teaching, and his narrative accounts.

CSSFL supports science teachers by using hands on inquiry, register shunting and multi semiotic resources. (Harman & Khote, 2018; Harman, 2018). In integrating our second data set which consisted of an in-depth teacher interview, in which Jerónimo was asked to talk about some key aspects related to the practices he enacted in the videos we wanted to explore how Jerónimo conceptualized and understood the practices observed in the videos, and what were his underlying understandings that guided his practices.

Findings from the Video Analysis and Jerónimo's Perception

Key Strategies in CSSFL Practice

As illustrated in Table 3.1 below, our study found that the key elements of Jerónimo's teaching practices with newcomer bilingual students included frequent shifting among specialized and everyday registers, frequent use of multimodality and translanguaging in Spanish and English, and a dynamic use of his body and gestures to make meaning. Items coded and described emerged from Jerónimo's teaching practice and will be explored in depth later in this paper.

Table 3.1 Coded Themes and Descriptions

Coded Theme	Description
Scaffolding scientific concepts ("variables" and "potential) and negotiating science talk	Jerónimo supported understanding of scientific concept variable through use of everyday language. Once the students understood the concept, he introduced the specialized term.
Use of multimodal features to expand understanding of science talk	Jerónimo uses both verbal and multimodal resources to expand student understanding of science concepts. He used: ✓ Multimodality ✓ Everyday language ✓ Students' personal experiences Transition from technical vocabulary to everyday language.
Practices that include students' full linguistic repertoires through translanguaguing	Jerónimo encouraged students to express their ideas in Spanish, English and multimodally. Students combined these resources to make meaning.

The sections below discuss the findings outlined in the Table above.

Scaffolding Scientific concepts and Negotiating Science Talk

In a representative episode of Jerónimo's science discourse, there were several instances in which negotiation of science talk arose. In this negotiation, the use of everyday language supported students in contributing to and articulating an understanding of key scientific concepts. In such cases, the focal teacher usually enacted the scientific talk and co constructed student understanding, such as in the following discursive exchange. Note that those participating in this exchange are either Jerónimo (J), or students (S).

J: I am gonna draw two different examples and you tell me which one is kinetic, well there is always kinetic and potential. But tell me when there is the maximum of potential and when is the maximum when is the maximum of kinetic. *Entonces yo voy a dibujar dos ejemplos y ustedes me van a decir cuales en donde están el máximo de energía potencial y el máximo de energía cinética.*

Este es el uno (…) Now, here the individual is just sitting there. *Aquí nada más el individuo está parado no se está moviendo y aquí…*

S: *Coge velocidad*.

J: *Está echando. Exacto.* ***Tiene velocidad ahí el muchacho.*** *Entonces* ***aquí está en movimiento*** *y* ***aquí no está en movimiento.*** *Aquí las dos están pero en una en una vale cero, en una la cinética vale cero y en otra la cinética vale máximo. ¿Cuáles está en movimiento?* **Which one is in motion?** Cinética, this one is movement. *Aquí está en movimiento. Es la energía en movimiento, la energía cinética es la energía en movimiento. Y la energía potencial es la energía que no está en movimiento pero tiene potencial de convertirse en movimiento. Por eso cuando tú por ejemplo alguien te dice tú tienes potencial de ser un buen arquitecto o tú tienes potencial de ser (0.4) no sé qué te gustaría ser cuando trabajes?*

Jerónimo co-constructed ideational understandings (i.e. building student knowledge) by drawing on their everyday understandings and through contextualized references to his simple drawings on the board. For example, he stated, "**Tiene velocidad ahí el muchacho**. Entonces aquí está en movimiento y aquí no está en movimiento." The participants, processes and circumstances are realized through use of Spanish terms such as "muchacho" and simple relational processes (e.g., ahi **está** en movimiento)." Thirdly he used parallel simple clauses to highlight how the figure in the drawing were either in movement or not.

As illustrated in the except below, Jerónimo continued to support students' conceptual understanding of the abstract notion of potentiality versus actuality by drawing on concrete everyday examples in English and Spanish before moving back into discussion of the scientific concept in Spanish:

J: Tú tienes potencial de ser un buen deportista: ¿que significa eso? Que todavía no eres, pero puedes llegar a ser. When someone tells you you have a great potential of being an architect or being an (0.4) engineer. For example, what you wanna do when you grow up? When you get a job, what you wanna do? What would you like to do? Being an architect, an engineer, a physician…

S: I haven't decided yet

J: You haven't decided. Ok. For example when someone tells you, you have a great potential of being a physician. It means you are not a physician yet, but you have the characteristics to become one, that's when you have a potential. So for example here when you are standing right here (points to whiteboard) you have a potential energy meaning that when you go to when you slide you are in motion, you are in movement. Entonces cuando

alguien aquí está parado tiene energía potencial que quiere decir que se puede convertir en energía en movimiento.

When Jerónimo introduced new vocabulary, he did so by providing several contextual clues to assist and scaffold students' understanding. When asked about the notion of scaffolding, Jerónimo mentioned the importance of students' experiential knowledge as a starting point to scaffold science learning. In this sense, Jerónimo saw value in incorporating students' previous knowledge and experiences into their teaching of science. Jerónimo expressed a detailed understanding of how students already knew about science as they had experienced it in their daily lives:

> They knew about science, what they didn't know is the language of science so they all have cooked a meal, they all have used … cars for example, … but the thing is to use that scientific perspective to talk about what's going on in their lives, that's the challenge, some of them very few had some knowledge on some concepts, hypothesis, cause and effect … but the majority didn't, although they had experienced science in their lives.

His narrative also shows his positioning of scaffolding as a fundamental resource to enhance science meaning-making with newcomers as shown in the excerpt that follows:

> Ah, well scaffolding, that's Bruner's definition and it's like a parallel concept of zone of proximal development so you have to, that's what we did in the … project in 2014 with these kids. We start interviewing them to know their backgrounds in education and in other areas too so we can use that information to design activities that are meaningful to them so, you're not gonna use amount and snow to teach about the water states, anyway,

> so you get the idea, ice and liquid water and vapor and all that so if you use amount it's not something they are related to, I mean maybe they are but most of them come from tropical zone, where you cannot find snow in that so anyway, by using a river let's say it's more familiar to them and many of them have not been to the sea, so if you, I don't know if you remember I used an example, I don't remember who it was ah, of the sea and many students had not been to the sea so by doing that you can either use that to engage them and interest them in that topic but if you are using the sea as your base knowledge to then talk of something else I think that's not the best way to plan your activities. The goal is to engage in different … scaffolding process(es). We used and it worked with language and experiences from their home countries in education and other areas … to engage them in so the activities will be meaningful.

For Jerónimo, as illustrated by his explanation above, an effective pedagogical approach to newcomer students takes into consideration the diverse backgrounds that they bring into the classroom. In other words, when thinking about how to enhance newcomers' learning experiences, it is essential to make the content relevant, instead of generalizing or making assumptions about their previous lived experiences.

Use of available social semiotic resources to expand understanding of science talk

As mentioned before, SFL is a theory of meaning making initially applied to language; and more lately through SF-MDA (Systemic Functional Multimodal Discourse analysis) to analyze not only verbal but all available semiotic resources in a communicative context. SF-MDA supports investigation of "semiotic systems other than language and their interaction with each other and with language in semiosis" (Harman, 2018, p. 73). Researchers classify

modalities such as drawings, gestures and movement according to their realizations of ideational, interpersonal and textual meanings (e.g. Martinec, 2000, 2001, 2004 and Hood, 2007, 2011). In Jerónimo's teaching, our analysis showed that his use of gesture, movement and white board drawings served to co construct the ideational meanings of the concept; in the representative lesson, we discuss in this paper, for example, he used indexing, drawings and his body to convey the scientific understandings with an expanded range of semiotic resources. In the images below, for example, the drawings provide simple visual elaborations of what he discussed in his verbal negotiations of science talk with the students. Yet, they serve as another way of meaning representation.

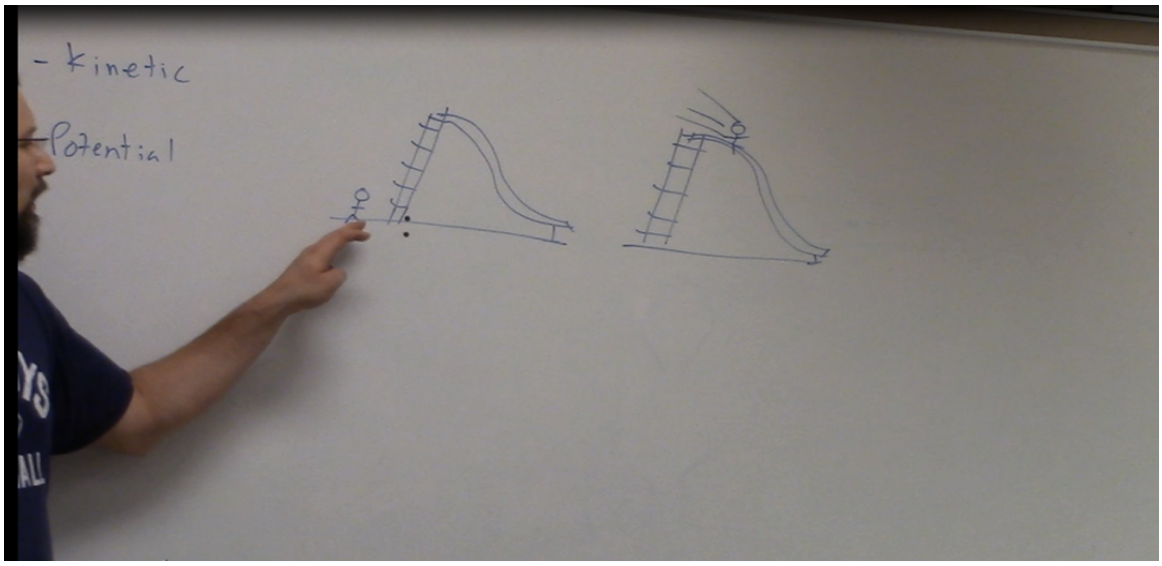

Figure 3.2 Jerónimo multimodally explains the concepts of kinetic and potential energy

Represented above in Figure 3.2 is the image of the static figure at bottom of steps and the figure sliding down the slide. Accompanying the image, Jerónimo used deictics (e.g. this boy) to bring students' attention to the difference in the two images and his gestures also showed what he was indexing in the drawing.

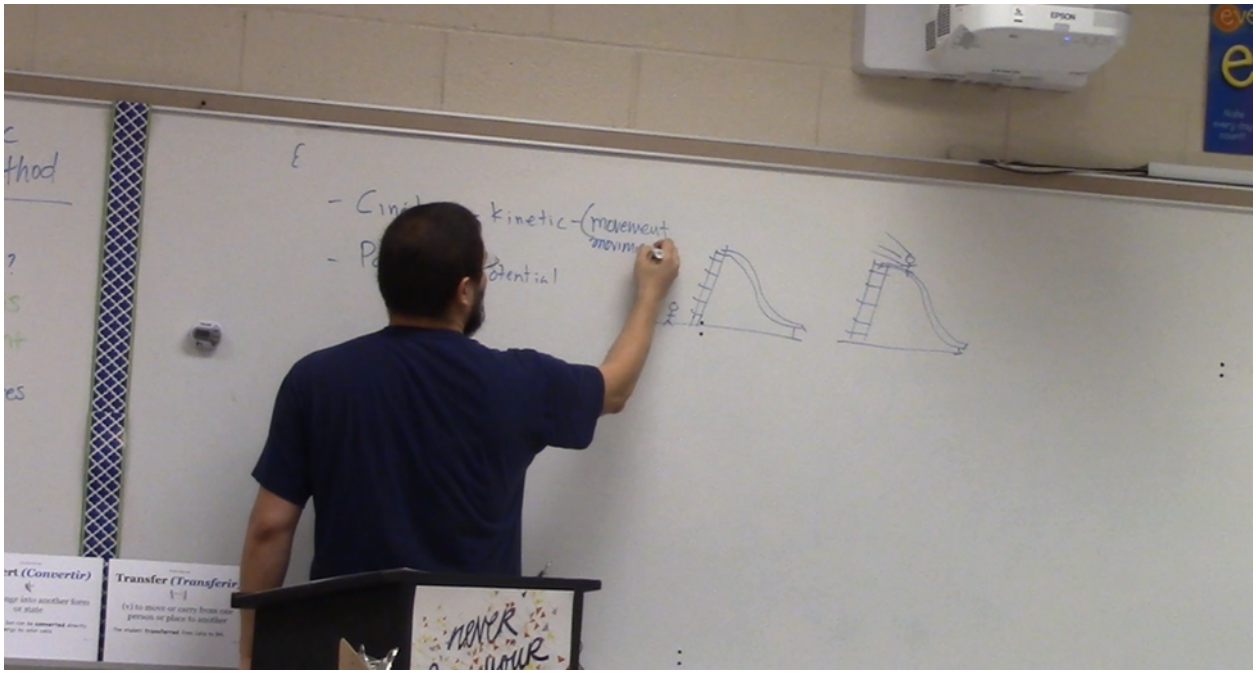

Figure 3.3 Jerónimo used everyday language to explain the concept of kinetic energy

To support student understanding of the concepts, Jerónimo also accompanied each of his drawings with scientific and everyday explanations of the terms in English and Spanish. In figure 3.3 he highlighted what he had said and drawn by adding the verbal to the visual representations. In this approach, the verbal and visual modes were used interactively to expand students' understanding.

Jerónimo's multimodal approach also included small experiential studies drawn from everyday life to support the class in co-constructing their understanding. In this way, the teacher activated students' funds of knowledge in co-constructing scientific concepts. As Lemke stated, indeed, students need to be encouraged to "construct the essential meanings in their own words, and in slightly different words as the situation may require" (1990, p. 170). When students are encouraged to write down and use specialized scientific terms, that does not mean they have grasped conceptual understanding. Students, instead, were encouraged to show their understanding

of scientific concepts by expressing and enacting their meaning linguistically and multimodally. Later in the focal episode, for example, the teacher made sure that all students had a few coins to play with. Jerónimo then posed a question about their predicting how far the coin would go. Students started mentioning the different elements that would affect the trajectory of the coin. The transcript excerpt below highlights how they understood the concept of a 'variable' without using the specialized terminology. After he had activated their understanding of the field (topic of variables), he introduced the specialized term.

J: Antes de que vayamos allá afuera quiero me predigan que tan lejos pueden hacer esto y que se vaya una moneda y aquí lo voy a hacer, pero eso lo vamos a hacer en el piso entonces y cada uno tiene dos. Each one of you has two coins, two chances so what I want you to do is to predict how far you can flick a coin. *Entonces yo bien a escribir, yo creo que la puedo eh que le puede hacer así y la moneda se va a ir cinco metros.*

S1: *Pero también depende la fuerza que uno le de*

J: *Claro*

S2: *Y el terreno o el (0.4)*

J: *Muy bien↑, entonces aquí estamos hablando de variables.* We are talking about variables here so Angel, you were saying, what can affect how far I can flick a coin? *Que puede afectar o que está variando cuando yo le hago así una moneda. Ángel dijo que tan fuerte estoy yo.*

S1: *Esta fuerte*

J: *La fuerza, ¿tu dijiste que?*

S1: *El terreno,* el place, *el lugar*

J: How do you say that? Mandy, the ground?

R.A: Yeah, the ground

J: *El piso, que otra cosa, entonces que tan fuerte soy yo, las condiciones del piso*

S1: *La distancia*

J: *Eso queremos medir↑, eso lo vamos a medir hasta lo último, ese es el resultado, pero está bien.* What else? What can you think of? (0.8)

J: *Alguien más. Bueno, estas son variables. ¿Por qué se le llaman variables?* Why are we calling them variables↑

S1: *Porque podemos hacer las cosas diferentes.*

J: *Porque están cambiando, muy bien, porque pueden ser diferentes cada vez. Muy bien, entonces escriban,* you have white paper, so make a prediction… (Jerónimo shows them on the board an example of the potential wording of their statements).

When talking about the use of multimodality, Jerónimo mentioned the need to add different layers of linguistic interaction between people and material objects. In this specific case, he mentions how multimodal resources were available in the classroom, assisting students in the development of their science understanding and knowledge building:

> … we try to use the concept, the explanation of that concept, the description, using, the content cards, that we display on the classroom walls, so they have that knowledge available, is not that they have to open their notebook every time they have a question,

it's like they just turn their heads and see what the concept is, the definition, and how it can be used, so by doing that.

When the teacher asks the students for a concept and how to use it, they need to turn their heads and see their definition on the classroom wall, take a look at the content card or a language frame poster and they embody the learning in this way repeatedly, constantly in different classes, different periods, over a week, over a month.

Practices that include students' full linguistic repertoires through translanguaguing

In Figure 3.4 below we see how a pedagogy of translanguaguing (Garcia & Kleifgen, 2012) was used to enhance understanding, while students got ready for the science class. The teacher always posed a general question in Spanish and English to spark an informal discussion. Students could use any of those languages they speak to express their answers. In this opportunity, the teacher asked the students what they would like Americans to know about themselves and their families.

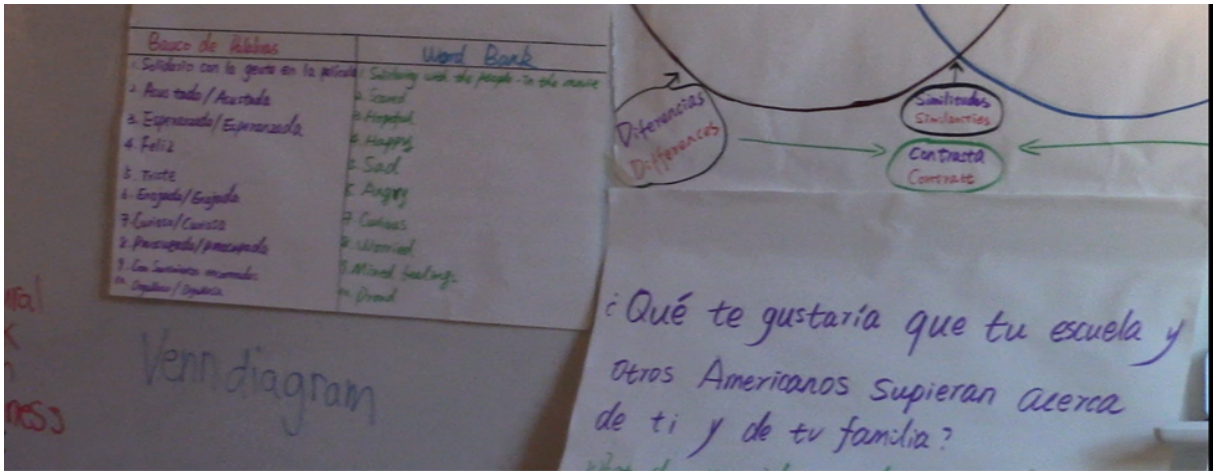

Figure 3.4 A pedagogy of translanguaguing

Jerónimo validated students' answers either with gestures (see Figure 3.5 below) or words. Instruction was carried out bilingually in Spanish and English, and he moved back and forth between the two languages. When the students provided answers in Spanish, the teacher validated those answers and switching register, incorporated their knowledge in his scientific explanation on the board, sometimes reframing the main idea in technical language. He purposefully used cognates when possible. Cognates are "important ways in which emergent bilinguals make sense of a new language" (Garcia & Kleifgen, 2012, p. 64). In Figure 3.6 it can be seen how the teacher used the cognates variables and force (*variable* and *fuerza* in Spanish).

Figure 3.5 Jerónimo's use of gesture to validate a student's idea

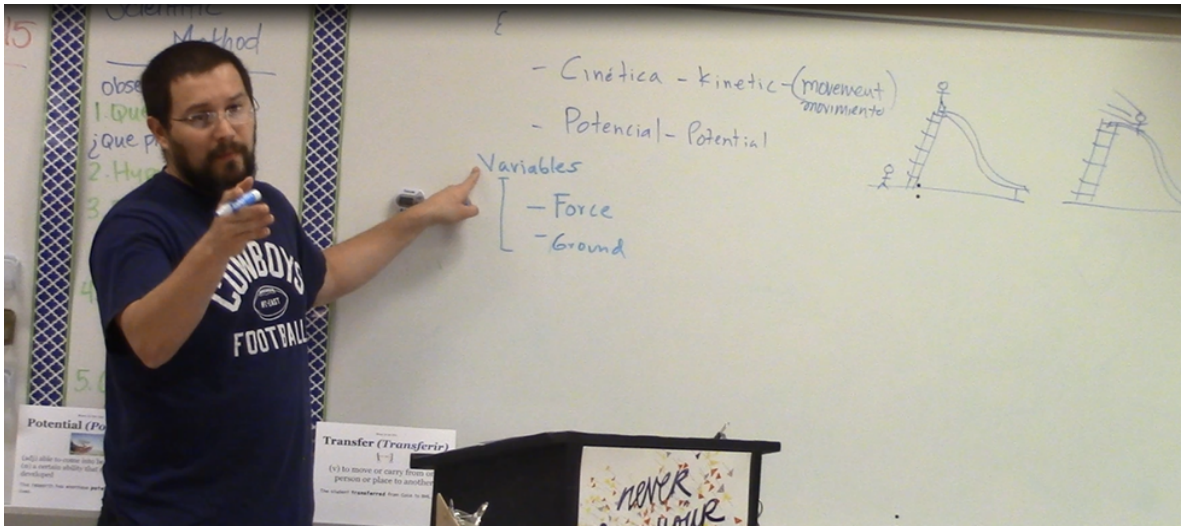

Figure 3.6 The use of Cognates

Research suggests that integrating home languages, colloquial expressions and specialized vocabulary (Garcia & Kleifgen, 2012) is crucial to enhance EBLs content understanding. Jerónimo's explanations of his teaching in the post interviews revealed a careful and purposeful planning and integration of semiotic repertoires and domains into his instruction. Specifically, Jerónimo discussed what he called the scaffolding process:

> At the beginning of the program we spoke Spanish most of the time and we tried to complement Spanish, using a little bit of English, some words now and then.

When discussing how to use students' repertoires Jerónimo claimed that it was a continuous process in which:

> you have to repeat it, use a different activity with the same language, the same language a different activity so … they have to repeat and repeat but it's not like a mechanical action. *It's engaging in different activities and that build their knowledge of about their*

new goals, their use of language, their backgrounds, and the new environment they are in, so, English and Spanish and their goals in life, the academic institution, the institutional goals so it's, many things, …mixed in those activities, and it's difficult to keep track on those, so you, *by using the least amount of academic concepts or scientific concepts and building on those concepts … that helps a lot.*

For Jerónimo, what was important was the notion of enacting similar linguistic and inquiry practices repeatedly, but differently to create multiple opportunities for learning. In addition, he mentioned not only the importance of learning in the classroom but also learning autonomy. As seen in the transcript excerpts above, newcomer students had the opportunity to plan and reflect on their learning goals.

What have we learned? A CSSFL framework for Science Teaching for Emergent Bilingual Leaners

Through the tools of discourse and multimodal analysis, the key elements of a teacher's innovative model of science teaching and learning for Emergent Bilingual Learners were discussed in this paper. What follows is our suggested dynamic model that includes three general principles that can guide teachers in working with newcomer students. After working with, observing and analyzing the teaching practices of a bilingual educator with newcomer students, we draw from the culturally sustaining approach he adopted to make some suggestions for science instruction of emergent bilingual learners should try to develop:

1 Designing lessons that require students to apply their own knowledge and experience in exploring concepts that might be new to them. Exploration of concepts can be co constructed dialogically in oral or written form.

2 Scaffolding challenging content and challenging disciplinary language, rather than using basic language and content. In doing so, teachers guide students in understanding and expressing their conceptual understanding through different means (for example, multimodal, linguistic). Teachers support scaffolding students' language by using their everyday vocabulary to enhance meaningful understanding.

3 Teaching and Learning in languages available to students, and taking advantage of the cognitive benefits of translanguaguing, which encourages a greater abstract understanding and enhances disciplinary understanding.

Limitations

There are multiple limitations to this study. First, because we focused on a specific program, RiseUp, bounded to one geographical region, student population and educator, findings of this study cannot be generalized, although they can be adapted to serve as a guide to educators and researchers working in diverse contexts. A second limitation is connected to the data collected, as videos were only able to capture a specific moment, and the interview was based on perceptions of the teacher. Thirdly, because students' voices are not represented in this study, their ideas and perceptions about the efficacy and CSSFL framework of the program may differ from the ones presented in this study.

Implications and Further Discussion

New Diaspora Latino regions such as the Southeast of the United States are settings in which the cultural voices and interests of predominantly Mexican, El Salvadoran and Guatemalan newcomer groups have not been incorporated into institutional discourses (e.g. Alexsaht-Snider, Buxton & Harman, 2013; Gallo & Wortham, 2012). This is despite the fact that the Latino population in the U.S. Southeast region has increased dramatically in recent years, with a 103% increase in Georgia between 2000-2010, making it one of the top ten Latino-populated states in 2011 (Pew Research Center, 2013). To respond to these challenges, the purpose of our study was to explore how a CSSFL praxis, such as the one developed by Jerónimo in the context of a large NSF-funded professional development initiative, can validate and encourage bilingual students, predominately from Mexico, Guatemala and El Salvador but also from Vietnam and Burma to engage in academic learning in multilingual, imaginative and critical ways.

More specifically, the purpose of this study was to explore how a Mexican bilingual educator enacted science teaching practices for newcomer students. As shown in the video analysis and the interview's narratives, Jerónimo had a theoretical and ideological positioning that helped him recognize the importance of students' home language, previous experiences, and the advantages of register shunting for science meaning-making with newcomer youth. Overall, the main findings of this study point us to the benefits of cultivating culturally sustaining spaces *with* students in order to engage them in using expanded semiotic and cultural repertoires to make meaning in disciplinary discourse. Finally, the notion of challenging anti-immigration and internalized hegemonic discourses which hinder newcomer and immigrant youth schooling and learning experience is at the center of our work.

The study presented contributes more generally, to work in the field of Latino education, still an under researched field (Gandara, 2015). Specifically, this research aimed at contributing to the still limited body of research about Science literacy for newcomer students who are challenged to learn English and academic content simultaneously.

Teachers and administrators across the country can plan and develop learning programs for newcomer students which are accessible (not simplified) in terms of language and science content. While not all teachers will be willing to learn Spanish, they can use strategies such as translating materials or having a community member translate certain expressions (Garcia & Kleifgen, 2012). Further exploration between the intersections of knowledge, power, language and racialized discourses in disciplinary instruction is essential. Future research is needed exploring the connections between knowledge, power and language, uncovering the uneven distribution of some meaning-making resources (Martin & Rose, 2003) for all students, science being one of them. The learning curve for teachers and researchers in developing a culturally sustaining SFL praxis is steep. However, within the current era of virulent anti-immigration discourses globally, we need to step up to the task. Newcomer immigrant students will thrive when the education system learns to acknowledge the complexity of their linguistic repertoires, their bilingual schooling experiences and their dynamic meaning making systems.

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Appendices

Appendix 1

2:36

J: Now ↑ (0.4) it is rainy outside so we are not going outside today for the science activity

S: Que triste ↑

J: We were supposed to kick the soccer ball as far as you could and then measure how far the ball went, but instead we are doing a (0.2) indoors activity. We are not kicking anything but (.) we are flicking (turns and looks at the American teachers for confirmation of word). That's the word, flicking. *Entonces en vez de ir allá afuera y hacer la actividad de soccer cuando no este lloviendo otro lunes lo vamos a hacer que consistía en patear una pelota de soccer lo más fuerte que ustedes pudieran y después medir que tan lejos se fue para ver quién del salón patea más fuerte. Eh (0.2) quien creen de ustedes de ustedes que aquí de este salón que patea más fuerte?*

S: Yooooo

J: Who you think kicks the ball the hardest, the strongest?

S: (Talking to this peer) () El que patee más fuerte

J: So instead of doing that we are going to the hall and we are gonna flick a coin. I'm gonna. But before we do that lets remember some of the concepts that we review (0.2) two weeks ago. *Antes de que vayamos allá fuera y revisemos y hagamos la actividad vamos a revisar algunos de los conceptos que que vimos hace dos semanas. ¿Quién recuerda los conceptos?* We talked about energy. Do you remember that?

S: Energia sintética

S1: Noooo

S2: Cinética

J: Cinética ↑ muy bien ↑, muy bien ↑**.** Potencial

T: Muy inteligente

S3: Muy orgulloso ↑ (Students laugh)

5:50

J: I am gonna draw two different examples and you tell me which one is kinetic, well there is always kinetic and potential. But tell me when there is the maximum of potential and when is the maximum when is the maximum of kinetic. *Entonces yo voy a dibujar dos ejemplos y ustedes me van a decir cuales en donde están el máximo de energía potencial y el máximo de energía cinética.*

Este es el uno (…) Now, here the individual is just sitting there. *Aquí nada más el individuo está parado no se está moviendo y aquí…*

S1: *Coge velocidad*.

J: *Está echando. Exacto. Tiene velocidad ahí el muchacho. Entonces aquí está en movimiento y aquí no está en movimiento. Aquí las dos están pero en una en una vale cero, en una la cinética vale cero y en otra la cinética vale máximo. ¿Cuáles está en movimiento?* Which one is in motion? Cinética, this one is movement. *Aquí está en movimiento. Es la energía en movimiento, la energía cinética es la energía en movimiento. Y la energía potencial es la energía que no está en movimiento pero tiene potencial de de convertirse en movimiento. Por eso cuando tú por ejemplo alguien te dice tú tienes potencial de ser un buen arquitecto o tú tienes potencial de ser (0.4) no sé qué te gustaría ser cuando trabajes?*

S: Ay no sé, que fuerte

J: Tú tienes potencial de ser un buen deportista, que significa eso? Que todavía no eres, pero puedes llegar a ser. When someone tells you you have a great potential of being an architect or being an engineer. For example, what what you wanna do when you grow up? When you get a job, what you wanna do? What would you like to do? Being an architect, an engineer, a physician…

S: I haven't decided yet

J: You haven't decided. Ok. For example when someone tells you, you have a great potential of being a physician. It means you are not a physician yet, but you have the characteristics to become one, that's when you have a potential. So for example here when you are standing right here you have a potential energy meaning that when you go to when you slide you are in motion, you are in movement. *Entonces cuando alguien te aquí está parado tiene energía potencial que quiere decir que se puede convertir en energía en movimiento.*

9:52

J: Antes de que vayamos allá afuera quiero me predigan que tan lejos pueden hacer esto y que se vaya una moneda y aquí lo voy a hacer, pero eso lo vamos a hacer en el piso entonces y cada uno tiene dos. Each one of you has two coins, two chances so what I want you to do is to predict how far you can flick a coin. *Entonces yo bien a escribir, yo creo que la puedo eh que le puede hacer así y la moneda se va a ir cinco metros.*

S1: *Pero también depende la fuerza que uno le de*

J: *Claro*

S2: *Y el terreno o el (0.4)*

J: *Muy bien↑, entonces aquí estamos hablando de variables.* We are talking about variables here so Angel, you were saying, what can affect how far I can flick a coin? *Que puede afectar o que está variando cuando yo le hago así una moneda. Ángel dijo que tan fuerte estoy yo.*

S1: *Esta fuerte*

J: *¿La fuerza, tu dijiste que?*

S1: *El terreno,* el place, *el lugar*

J: How do you say that? Mandy, the ground?

R.A: Yeah, the ground

J: *El el piso, que otra cosa, entonces que <u>tan</u> fuerte soy yo, las condiciones del piso*

S1: *La distancia*

J: *¿Eso queremos medir↑, eso lo vamos a medir hasta lo último, ese es el resultado, pero está bien What else?* What can you think of? (0.8)

J: *Alguien más Bueno, estas son variables. ¿Por qué se le llaman variables?* Why are we calling them variables↑

S1: *Porque podemos hacer las cosas diferentes*

J: *Porque están cambiando, muy bien, porque pueden ser diferentes cada vez. Muy bien, entonces escriban,* you have white paper, so make a prediction… (Teacher shows them on the board an example of the sentence)/.

Appendix 2

Transcription Conventions used for Conversational Analysis

phrase/word underlined word or phrases shows speakers' emphasis

↑ indicates higher pitch

() indicates time lapse

italics indicate use of Spanish language

CHAPTER 4

THINKING BEYOND THE SCORE: MULTIDIMENSIONAL ANALYSIS OF STUDENT PERFORMANCE TO INFORM THE NEXT GENERATION OF SCIENCE ASSESSMENTS[4]

[4] Cardozo-Gaibisso, L., Kim, S., Buxton, C. and Cohen, A. To be submitted to *Journal of Research in Science Teaching*

Abstract

Student conventional assessment analysis of results, referred to as rubric-based assessments (RBA), has placed emphasis on scores as a way of communicating information to teachers about their student learning. In this light, rethinking and reflecting on not only how scores are generated but also what analyses are done with them to yield results is of outmost importance. Informed by SFL and LDA approaches, this study seeks to, by utilizing LISELL-B's innovative bilingual (Spanish-English) constructed response assessment of science and language practices for middle and high school students, perform a multilayered analysis of student responses. We aim at exploring multiple ways of looking at students' performance through their writing in assessments and provide insights into the variability of student responses and explore some possible reasons for it derived from our data sources. Findings from this study suggest that we need to use a multidimensional model which deploys complementary ways in which we can interpret student performance. This new understanding leads us to think that researchers in the field of assessment need to develop a new approach that analyzes student performance as a multi-layered phenomenon.

Introduction

Conventional analysis of student assessment results, referred to as rubric-based assessments (RBA) henceforth, has placed the focus on scores as the defining way of communicating information to teachers about their students' learning. Further, these assessment scores are also used as the centerpiece of teacher accountability and control (Alzen, Fahle & Domingue, 2017). In this light, rethinking and reflecting on not only how scores are generated but also what analyses are done with them to yield results is of utmost importance. The current demographic, cultural and linguistic changes in the U.S. student population (U.S. Census Bureau, 2012) further complicates the question of how teachers and administrators should understand and interpret student learning (Nieto, 2017).

As most states have adopted or adapted some version of the Next Generation Science Standards (NGSS), there is a call for a change in assessments, recognizing the difficulties that this poses. Little has been said, however, about the implications of the next generation of assessments, such as how they will be used for teacher accountability purposes. According to The National Academies Report Developing Assessments for the Next Generation Science Standards (2014), the information obtained from such tests has the potential to either help or destabilize student performance in the schools. For this reason, it is important not only to evaluate the design of new assessments, but also how they are being studied and analyzed to better inform teacher instructional practices.

One challenge of designing and using new assessments is that they must be equitable for all learners, including emergent bilinguals. Educators in the Southeastern U.S, where this study takes place, typically have had little experience working with emergent bilingual learners (EBLs), yet over the past few decades, the influx of a new Latino diaspora (Wortham, Murillo &

Hamann, 2002) has resulted in many teachers facing classrooms with half or more first- and second-generation immigrant students, many of whom speak a home language other than English. Current educational policies in the Southeast, which largely promote English-only instruction, have been unsuccessful in utilizing students' cultural and linguistic resources and repertoires as a means to scaffold content-area learning (Garcia & Kleifgen, 2010). Thus, EBLs are typically placed in general education content classes with little or no language support, placing great importance on teachers' understanding of how their classroom instruction and assessments can better support all learners. However, "while there is growing evidence on the value of studying bilingual learners' writing for supporting their science learning, there is less evidence about how best to support these students' science writing on either formative or summative assessments as part of that process" (Buxton, Allexsaht-Snider, Kim & Cohen, 2014, p. 2).

Thus, science teachers must simultaneously address shifting student demographics and a new vision of science based on the NGSS (Achieve, 2013; Lee, 2017). NGSS presents a three-dimensional model of science learning highlighting an integration of disciplinary core ideas, science and engineering practices and cross cutting concepts. In this new context, greatest attention is given to what students do with science as they engage with and attempt to make sense of phenomena. The National Science Foundation-funded Language-rich Inquiry Science with English language learners through Biotechnology (LISELL-B) project was developed to study the intersection of these two changes in science classrooms. The primary aim of the project was to support teachers, students and families in dynamically integrating science investigation practices with the use of the language of science (LoS). The data presented in this study are part of that broader project which included 4000 students, 50 teachers (Science Teachers and ESOL

teachers) and 10 schools (8 treatment and 2 comparison). Schools were located in two counties in the Southeast United States. The LISELL-B Professional Learning Framework for teachers uses several intervention activities such as family workshops, teacher institutes, summer academies and classroom observations to enhance classroom instruction and student learning. Outcome measures for the project included the administration of pre-and post-assessments which are the focus of this paper.

One goal of the LISELL-B project was to work collaboratively with teachers to support the development of strategies to expand their EBLs conceptual and linguistic understandings of scientific practices. We did this in part by valuing the language of science (LoS) as a disciplinary discourse, while also nurturing critical language awareness and incorporating students' "everyday language" registers and experiential knowledge. Our understanding of the fundamental characteristics of the LoS was informed by Systemic Functional Linguistics, and one of the means through which we intended to evaluate the impact of the LISELL-B intervention was through an innovative bilingual (Spanish-English) constructed response assessment of science and language practices for middle and high school students (Buxton, et al., 2014).

The development of these assessments was informed by an SFL approach, which has been described in previous research (Buxton, Allexsaht-Snider, Kim & Cohen, 2014; Kim, Kwak, Cardozo-Gaibisso, Buxton & Cohen, 2017). This current study seeks to perform a multilayered analysis of student responses on these assessments to a) explore multiple ways for looking at students' performance through their written assessments, b) provide insights into the variability of student responses and some possible reasons for it. In other words, the questions we attempt to answer are: What useful information about student learning cannot be captured by RBA scores

exclusively? Can additional analyses help us understand why students score higher or lower on specific questions?

These purposes will be achieved by discussing the potential contributions of using three different sources to measure and interpret student performance in bilingual assessments: RBA scores, Systemic Functional Linguistics, and Latent Dirichlet Allocation (LDA) analyses. Our hypothesis is that by combining quantitative and qualitative methods, researchers can obtain complementary layers of meaning, balancing information about students, adding dimension to, and challenging some of our own understandings and considerations within the field.

Both the contextual features connected to assessments for EBLs, as well as our theoretical orientation led us to the following overarching question: What can we learn by combining three sources of analysis to understand student assessment performance?

Background and Rationale

As we have established in the previous section, in the LISELL-B project, bilingual constructed response assessments were designed with the aim of supporting all students, including EBLs, in science meaning-making and disciplinary knowledge. As new assessments based on the NGSS emerge, implications for teacher education and what teachers need to do to be able to prepare students for these assessments also arise as a new space for research.

This question is particularly important as we try to understand how to assess the learning of EBLs in a language that they are not yet proficient in. This leads us to reflect on what science traditionally means and how science learning has been conventionally evaluated and measured, usually by multiple choice tests. In the context of the LISELL-B project, our assessments aimed at much higher goals in terms of what we wanted students to do with and know about science. Indeed, we wanted students to understand science, not as body of facts but as a dynamic way of

thinking about the world. Ultimately, we wanted students to know the science content, perform the scientific practices, and communicate their ideas scientifically, all aligned with the NGSS. However, we faced the challenge that we have not yet developed effective ways of measuring and understanding students' science learning as envisioned in NGSS through assessments. In the LISELL-B project we developed an assessment that focused on assessing what students know and can do with science, rather than how many scientific facts and definitions they can remember. In this sense, we followed Cowie (2013) in believing that "the emphasis on scientific inquiry in contemporary science education has seen a shift from perceiving science as an activity focusing on exploration and experiment to one that construes argumentation, model building, and explanation as central to learning and knowing science" (p. 474).

In analyzing student growth using our constructed response assessment, we were not able to see significant student growth in terms of scores between pre-test and post-test. Initially we developed several hypotheses to try to understand this. First, our project assessments were significantly different from what students are used to seeing, as ours were multimodal and bilingual. As educators, we understand that anything new to students will be challenging. Second, students knew that the LISELL-B assessment did not count for their overall school grade, and as a result they were not extrinsically motivated. Third, a pre-post design only captures those two brief moments, at the beginning and at the end of the year, when students are usually overwhelmed taking tests. However, we still wanted to understand student performance.

In trying to comprehend the impact of the intervention, we realized that many participating teachers did not enact the LISELL-B pedagogical model on a regular basis. In a way, as shown by other data collected such as teacher interviews and classroom observations, LISELL-B did not transform teaching practices as effectively as it did transform teacher thinking. This leads us to

think that even though we consider the treatment to be robust, it was not enough to cause significant change in teacher enactment, and this was evidenced in student performance as shown by the RBA scores. Given this challenge to our hypothesis that enactment of the LISELL-B intervention would correlate with student growth on the project assessments, we started thinking beyond those two variables, and focusing on how the students' responses on our assessments were being evaluated and measured. In the next section, we present some key concepts that have shaped and informed our research.

Weaving Science Literacy, Writing and the LoS: An Integrated View

Although much has been said about the need to scaffold students' academic writing, this is still one of the practices which teachers devote the least time to (Enright & Gilliland, 2011). Recent reports in the US (Perie, Grigg & Donahue, 2005) show a majority of secondary school students do not possess the literacy skills that are necessary for learning advanced content. While literacy development is important in all levels of schooling, it becomes crucial in secondary schools as the texts students need to access are radically different from those they encounter in primary schools, due to their high structural complexity (Fang & Schleppegrell, 2010).

The literacy field has long debated whether or not to consider content literacy as one unique literacy which is applicable across all academic disciplines. That is, literacy is a generalized concept that once mastered is enough to comprehend history, math and science likewise. This understanding remains widely used today in schools, but there is an increasing push to replace this concept with the one of disciplinary literacy. As explained by Fang, Sun, Chiu and Trutschel (2014) "reading instruction in content areas should move away from the traditional emphasis on applying generic strategies and skills to a focus on building an understanding of how knowledge is produced in the disciplines" (p. 55). The configuration of lexico-grammatical and discourse

semantic features of each discipline are unique, not just the specific lexicon that needs to be explicitly taught to students (e.g., high lexical density, low appraisal in science texts). A conceptual article by Fang and Coatoam (2013) claims that experts in the area of disciplinary literacy call for "literacy instruction anchored in the disciplines and advocate explicit attention to discipline-specific cognitive strategies, language skills, literate practices, and habits of mind" (p. 627).

The LISELL-B project pedagogical model and related bilingual constructed response assessments were the result of observing that many students who are not yet fluent in English, but are literate in their home language, do not have sufficient opportunity to engage in rigorous science learning nor to demonstrate their everyday and academic understandings. One particular example of this are school assessments in which students have to read and respond in a language in which they are not yet proficient. Science assessment for EBLs pose a challenge of legitimacy in terms of scores and equity (Siegel, 2007) as students are assessed in a language they are still learning. In this sense, Kieffer and colleagues (2009) argue that language accommodations for EBLs, such as providing them with bilingual dictionaries, are not effective because content knowledge is bound to language and literacy development, and the connection between these is not simple. Consequently, our LISELL-B bilingual constructed response assessments were designed to support Latino students in science meaning-making and disciplinary knowledge.

Shifting our focus to the language of science, researchers agree that the language of science taught at schools or presented in textbooks is not exactly the language used by the scientific community (Fang, 2006; Reif & Larkin, 1991). However, the language used to access and to produce scientific meaning in school still displays some characteristics of expert science discourse. As Halliday (2004) argues, although science texts and discourses tend to be packed

with a significant amount of technical vocabulary, this vocabulary is not the main difficulty for students. Rather, he claims, it is the lexicogrammar structure, the way in which utterances are constructed. This creates two challenges for students: On the one hand, the highly complex LoS requires students to learn its vocabulary and grammar so as to be able to produce it, and on the other hand it creates the need for students to develop an understanding of both lexical items and structures so as to access such language. Access to and production of the LoS is critical to produce equitable learning opportunities for all students. This can be achieved by explicitly teaching the complexities of the LoS and helping students understand how this discourse is a different way for expressing ideas.

The value of this academic discourse is largely arbitrary, and it's worth lies in a social discursive practice that values this language over others (e.g., the language the students bring from home). Nevertheless, if students are not equipped with the metalinguistic tools to understand the LoS, they will have limited resources to access this domain of academic and technical knowledge. Halliday (2004) claims that we should seek alternative ways of constructing scientific meaning, so that its access is not limited to only a few, but open and available to all.

From this study's contextual and theoretical lens, teachers of an increasing minoritized student body receive only limited information about their students' performance as shown by mandated standardized assessments. Research about assessment increasingly shows that teachers need information in order to make decisions regarding instruction. In this light, we now know that "it is not enough for students to participate in state assessments; students' participation must lead to valid inferences about their achievement" (Kieffer, Lesaux, Rivera & Francis, 2009, p. 1169).

In this sense, writing in the science classroom serves two purposes. On the one hand students write as a means to enhance their learning. On the other hand, they do so to make that learning visible and available for teachers (Cowie, 2013). In order for teachers to take advantage of the information made available from students' assessments, that information has to be reliable and timely. In other words, any information that teachers receive in terms of student performance (e.g., scores, reports) should provide information that helps teachers enhance their instruction and make the necessary changes to provide a fruitful learning experience to all students. However, many times educators obtain contradicting information about what students can and cannot do. This can be the result of students being assessed by many different testing sources (Schneider, Egan & Julian, 2013), but also by receiving confusing interpretations on the same assessments.

Understanding and interpreting student performance is also a matter of validity. However, the idea of validity stems not only from the assessment itself, but also from the interpretations that emerge from those assessments (Cronbach, 1971). Nevertheless, the interpretations being made about students' performance cannot be seen as an objective and direct result of measuring their performance. Distinct from traditional postpositivist psychometric approaches to interpretations of students' assessment performance, new understandings in the field are interpreted from a socio-constructivist epistemology (Bonner, 2013; Brookhart, 2003; Moss, 2003). According to Bonner (2013) "these perspectives focus on the interpretations, values, and uses given to assessment information, within that context rather than a fixed meaning ascribed to scores by external authorities" (p. 90). As noted by Hogan (2013) there is a need for research which specifically focuses on the relationships between student performance according to test format and their characteristics (e.g., gender, ethnicity, sociocultural characteristics).

Keiffer and colleagues (2009) argue that an effective testing accommodation will look to control those peripheral factors which may have a direct impact on scores. That is, a science assessment for EBLs will give students the opportunity to show their learning in their home language or multimodality. As we will see below, however, reducing student performance to what can be measured in a score is not always enough to offer educators a comprehensive understanding of what students have learned in terms of content, inquiry practices, and the linguistic forms which they use to communicate certain functions.

Conceptual Framework

Drawing from Halliday (1978, 1996, 2005), and Schleppegrell's work (2004), we use Systemic Functional Linguistics (SFL) to understand and connect the diverse entry points that inform this study: EBLs, LoS, and assessments in order to understand the linguistic practices of students within the LISELL-B project. In contrast with cognitive approaches to language (e.g., Chomsky, 1986), SFL affirms that reading and writing shape our experiences with the world and so do linguistic forms. As claimed by Halliday (2005) "human experience is extraordinary rich and varied, mediated through different senses on various levels; what the grammar does is to transform that experience into meaning" (p. 63). This means that the grammatical features of a given language shape not only forms but also functions. In this sense science has specific linguistic features that far from being arbitrary, convey certain functions. Such is the case of "grammatical transformation into linguistic classes" (Buxton et al., 2014). Because SFL sees language as a "set of options available for construing different kinds of meanings" (Schleppegrell, 2004, p. 7), our aim was to look for specific linguistic features that are essential for science writing within school contexts. More specifically we looked at three linguistic features in students' writing: technical vocabulary usage, lexical density and nominalization or

grammatical drift. In our study, and following Buxton and colleagues' (2014) classification, technical vocabulary is comprised of those words that are specific in science (e.g. radiation, insulator), and those words that have the potential of conveying an everyday or scientific meaning (e.g. cause, conduct). Lexical density is a measure of the proportion of content words, those which carry the meaning of a sentence, and function words, which are those lexical features that by themselves do not convey meaning. Grammatical drift or nominalization denotes "movement along the continuum from less stable classes such as circumstances and processes, to more stable linguistic classes such as qualities and entities" (Buxton et al., p. 15, 2014). A more detailed description of each item and examples is provided later in this paper.

Our conceptual framework was also informed by Text Analysis (TA). TA, specially using statistical models "have been conducted across a number of disciplines to extract meaningful textual-based information from documents" (Kim, et al., 2017). The idea of using text as data can be applied to assessment analysis, but certain principles should be taken into consideration. According to Grimmer and Stewart (2013), quantitative models of language can be useful as long as they are 'evaluated based on their ability to perform some useful social scientific task" (p. 270). In addition, TA is a valuable tool particularly when it is used to complement other means of analysis, and not as the only one. Moreover, the notion of using complementary analysis is connected to issues of validity. Within TA, the statistical model selected as part of our analysis of the LISELL-B assessments was Latent Dirichlet Allocation (LDA; Blei, Ng & Jordan, 2003). LDA is a statistical model used to identify latent themes in a given corpus (Kim et al., 2017). When students write a lot, as researchers trying to understand their practices, we need to find ways to summarize text using topics. LDA summarizes large samples of text through latent themes in order to extract relevant information and to synthesize student answers. In

addition, LDA also gives information about topic proportions, that is what the dominant topics are for each student in the assessment. This, as we explore later in this paper, will help us analyze and understand patterns in the data.

Methods

In order to address the research questions we had initially posed (i.e., What information cannot be captured by the scores exclusively? and Can any of these analyses help us understand why students score higher or lower in any given question?) we conducted a mixed methods study. Our motivation for doing so, comes from the need to triangulate the data analyzed through the integration of both quantitative (TA-LDA) and qualitative (SFL) analyses. Interpretation of these findings helped us answer our questions and posed provoking new ones. A reason for selecting mixed methods approach to frame our study was the notion of data integration (Fetters, 2016). This means that rather than having two separate results emerging from the qualitative and quantitative analyses, we aimed at increasing our understanding of student assessment performance by combining both. Moreover, this mixed methods approach afforded the potential for uncovering details that would have been lost by conducting solely a qualitative or quantitative study. In this specific case, integration of the two analyses was fundamental to explain and expand our understanding of the results (Bryman, 2007). In Figure 4.1. below we illustrate the connections between different data sub-sets, including sample sizes.

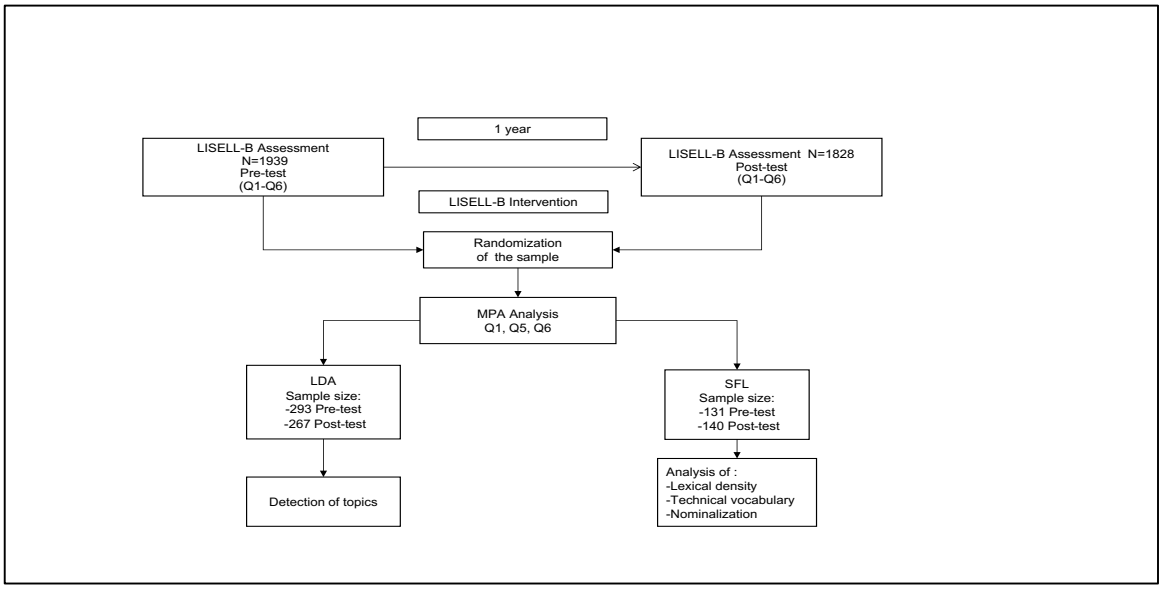

Figure 4.1 Relations among data sources

Corpus Description and Sampling

The corpus used for the analysis referred to here as a Multidimensional Assessment Performance Analysis (MAPA) as conducted in this study consisted of a sample of the LISELL-B assessment data from one of the two parallel forms of the assessment. Both the blue form and a second form, the pink form, were administered during the 2015-2016 academic year. Students were administered one form on the pretest and the other form on the posttest. This was done to decrease the likelihood of memory effects. For this study, the blue form was analyzed using two text data analysis methods, LDA and SFL. For the LDA analysis, 293 and 267 students were randomly selected from the pretest and the posttest, respectively. For the SFL analysis, Hispanic students' answers were taken from the LDA sample: 131 students from the pretest sample and 140 students from the posttest sample. That is, the SFL sample is a subset of the LDA sample composed of all the Hispanic students from the LDA sample.

As we have mentioned before, assessments were collected at the start and the end of each school year as part of the LISELL-B project with the aim of measuring students' written production of knowledge of scientific inquiry skills allowing them to write in English, in English and Spanish or in Spanish only (Buxton et al., 2014).

Multidimensional Assessment Performance Analysis (MAPA) Findings

As we have established, this study seeks to test whether a multidimensional analysis of student performance can provide complementary information that could potentially inform teacher instruction as well as assessment development, to enhance student learning. In other words, we are trying to uncover whether the SFL and LDA analyses correlate with standardized student performance measurements (RBA). The tables below demonstrate that there is significantly different information that can be obtained from these approaches. RBA shows certain growth but not as much as SFL, and not with respect to the same characteristics of writing. Thus, if SFL had been the only analytical tool used, then student growth in certain linguistic features such as lexical density or technical vocabulary would have been seen. Adding LDA helps us understand the difference between SFL and RBA. LDA helps us to see question completion and how it affects RBA scores. In other words, the more rubric specific answers students provide, the better score they receive. However, as shown below, the RBA measurements provide different information about the individual text of students' answers.

In this regard, SFL and LDA helped us see beyond the score, with SFL capturing student performance as shown in language use and LDA serving a different but complementary purpose of helping us understand the linguistic practices of students in terms of question completion and word/cluster production. Thus, for RBA, the overall score is informed by the average of the number of points for each question answered by the students. Research shows, however, that

when tests have a time limit, then students are sometimes less likely to answer the final items on a test. Further, when doing so, the amount of text produced will be less, thus affecting the number of points students receive for their answers (Goldhammer, 2015).

This leads us to reflect on what each analysis is measuring: either the number of points received for answers or the quality of writing, but not both. RBA scores are not painting the whole picture, despite these scores being used to inform curriculum and teacher practices. We argue that teachers cannot make the best instructional decisions if the information they are getting from assessments is partial and does not provide a complete picture of student learning. What we mean by this is that RBA scores by themselves do not typically capture either the richness or quality of students' answers. As it can be seen through the SFL analysis, there was significant growth (e.g., Question 5 shows a 500% increase) in linguistic features use from pretest to posttest. When drilling down into different aspects of the answers using a MAPA analysis, teachers and researchers can get a comprehensive overview of student performance. Similar to RBA, SFL scores give an average number and a standard deviation. What makes these two analyses distinctive is that SFL works with what student have produced as text, and not with what is missing. Next, we present a detailed analysis of the assessments according to each analytical approach.

a) Student performance as captured by RBA scores

Mean and standard deviations of student scores are presented in the table below for the pre-and post-tests for each question. The data indicates some growth between pre-and posttest, but this growth is inconsistent across questions. That is, students performed better on some pre-test questions, even though the overall measure shows 0.7 increase from pre-to post RBA scores.

Table 4.1 Summary of Statistics of the 2015-2016 LISELL-B Assessment (Blue Form)

Item	Score Range	Pretest (N=1,939)		Posttest (N=1,828)	
		M	***SD***	***M***	***SD***
Question 1	0-11	7.14	2.74	7.10	2.78
Question 2	0-9	5.59	2.10	5.32	2.32
Question 3	0-9	4.69	2.23	4.35	2.53
Question 4	0-11	4.11	2.41	4.88	2.92
Question 5	0-11	4.84	3.04	4.95	3.28
Question 6	0-10	3.85	2.97	3.70	3.04
Question 7	0-10	4.28	2.79	4.21	2.89
Inquiry (1-7)	0-25	9.86	4.90	10.33	5.25
EVLan (1-7)	0-14	10.87	3.38	10.69	3.60
ACLan (1-7)	0-28	8.68	4.55	8.23	4.48
Content (1-7)	0-14	5.61	2.70	5.96	2.95
Total (overall)	0-71	35.03	13.93	35.20	14.89

b) Student performance as captured by SFL Analysis

SFL was used to conduct a second layer of the MAPA. An SFL approach is conceptually suitable, as it helps to understand "the language of science as having unique qualities in terms of how the grammar of student responses is constructed" (Buxton et al., 2014, p.). Moreover, "SFL considers the relationship between linguistic form and social context in school settings, focusing on specific linguistic choices that influence and are influenced by different purposes and audiences" (Bunch, 2013, p. 309).

Knapp and Watkins (2005) propose a model of language assessment which focuses on generic, structural and grammatical features of written discourse. For the purpose of this study, our SFL analysis focused on the generic features of the written language of science, as we argue, which include the components that are usually overlooked by teachers. These generic features include: genre, theme, structure, rhetorical and language features, and vocabulary. While genre

and theme assess successful task completion, structure, language features and vocabulary are concerned with appropriateness of language structure used by students.

The methods presented next have been used in a previous study by Buxton and colleagues (2014) and are described in this study with some minor modifications. Reiteration of the coding categories and procedures conducted by Buxton and colleagues are presented here and supported by the categories elaborated by Knapp and Watkins (2005).

Table 4.2 Explanation of SFL codes and examples

Item Coded (Knapp & Watkins, 2005)	**Item Coded (Buxton et al., 2014)**	**Description**	**Examples from Data Coded**
Structure and Linguistic Features	Grammatical Drift/Nominalization	Identifies language that moves "from less stable linguistic classes, such as circumstances and processes, toward more stable linguistic classes, such as entities and qualities that have increased persistence" (Buxton, et al., 2014, p, 9).	*The nail is metal and metal is a conductor of electricity. Different plants need different light. A cactus doesn't need as much water than a rose.*
Vocabulary	Technical Vocabulary Usage	Constitutes vocabulary which is exclusive to scientific writing. It includes both scientific words and everyday vocabulary satisfactorily used in science contexts.	Technical Vocabulary: increase, decrease, temperature, electricity. Non-Technical Vocabulary: nail, large, colors, fast, small.
	Lexical Density	Measures "the ratio of content words to grammatical words in any given text" (Buxton, et al., 2014, p.11).	Response with high lexical density: *When the rubber band connects, it completes the circuit and allows electricity to flow through and let the light bulb light up.*

	Response with low lexical density: *She would have to use the same sunlight and the same amount of water if not will die.*

Coding was conducted for each of the 271 assessments and was performed for 3 of the student responses (questions 1,5 and 6), for each pre-and post-assessment, yielding a total of 813 responses analyzed. The 271 (271 = 131 + 140) students' responses for Questions 1, 5, and 6 were analyzed for the following linguistic features: lexical density, technical vocabulary, and nominalization. Table 4.3 shows the means and standard deviations of lexical density, technical vocabulary, and nominalization scores for the pretest and posttest. The means of lexical density and technical vocabulary scores increased from pretest to posttest for the three questions. The means of nominalization scores, however, decreased from pretest to posttest for Questions 5 and 6.

Table 4.3 SFL Analysis Means and Standard Deviations of Lexical Density, Technical Vocabulary and Nominalization

	Lexical Density Mean (SD)		Technical Vocabulary Mean (SD)		Nominalization Mean (SD)	
Question	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
1	48.63 (7.39)	51.62 (6.22)	3.64 (2.52)	3.80 (2.54)	0.25 (0.44)	0.40 (0.49)
5	35.87 (26.77)	52.88 (11.05)	0.34 (0.72)	1.96 (1.79)	0.21 (0.41)	0.11 (0.32)
6	35.05 (26.77)	59.07 (10.69)	0.58 (1.29)	0.60 (0.90)	0.30 (0.46)	0.21 (0.41)

c) Student performance as captured by LDA Analysis

The 560 (560 = 293 + 267) students' answers were analyzed using the LDA model. Before we conducted the LDA analysis, the software was set to convert words in students' answers to

their basic roots, and words that appeared less than 10 times were removed. For example, misspellings and typos were corrected, proper nouns were not capitalized, and plurals were changed to singular. These changes were done in the software only and not in students' original answers. Thus, the actual text of the students' answers was not affected. In addition, stopwords, which do not have significant meaning (e.g., "a", "the", "and", etc.), were also removed before the LDA analysis. In the end, these 560 documents consisted of 394 unique words with an average document length of 79.32 words for the pretest and 78.66 for the posttest words (SD). Students tended to give longer and more complete answers to Question 1 than to Questions 5 and 6 (see Table 4.4). In part, this may be due to students not having time to finish these last two questions on the test. It may also reflect the fact that the test was difficult and students may not have been as motivated to complete these last two questions. Whether due to lack of time, lower motivation, or simple fatigue at the end of the test, it was clear that the answers to these two questions were shorter than for Question 1.

Table 4.4 LDA Analysis. Average Number of Words for Answers to Each of the Questions

	Pretest		Posttest	
Questions	***M***	***SD***	***M***	***SD***
1	45.51	19.63	42.63	17.64
2	21.47	11.81	22.21	11.63
3	20.17	10.41	19.04	10.79
4	26.14	15.87	23.83	13.88
5	21.63	13.42	19.67	12.53
6	20.09	16.08	18.42	14.04
7	18.70	15.64	18.68	15.03

Note. M=mean, SD=standard deviation.

A Gibbs sampler was used to estimate the LDA model parameters. This technique assisted us in the production of "random variables from a (marginal) distribution indirectly, without having to calculate the density" (Casella & George, 1992, p. 167).

The number of topics in documents needs to be specified for any LDA analysis. After exploring the 560 students' documents, we determined that three topics were enough to characterize students' answers. The three topics obtained from the LDA analysis are described in Table 4.5. Words in the Topic 1 column are mostly related to Questions 1 to 3, words in the Topic 2 column are mainly related to Questions 4 to 7, and words in the Topic 3 column are mostly related to everyday language.

Correlations between topic proportions used by each student and the sum of inquiry scores for each student were calculated. For Topic 1, the correlation was -0.20 for the pretest and -0.23 for the posttest.

For Topic 2, the correlation was 0.70 for the pretest and 0.70 for the posttest. For Topic 3, the correlation was -0.48 for the pretest and -0.53 for the posttest. These results suggest that students with high Topic 2 proportions were more likely to obtain high inquiry scores on the total assessment whereas students with high Topic 3 proportions were more likely to obtain low scores. By examining students' responses that had extreme topic proportions, we found that 1) students who had Topic 1 proportions higher than 0.7 tended to answer Questions 1 to 3 only. That is, they did not generally answer questions 4 to 6. 2) Students who had Topic 2 proportions higher than 0.7 tended to answer all questions with good quality, and 3) students who had Topic 3 proportions higher than 0.7 tended to have lower quality answers, that is, they tended to get lower scores on the total assessment. Figure 4.2 shows question completion average scores for pre-and post-tests.

The means of topic proportions for students who took the pretest were 0.32, 0.31, 0.37, for Topic 1, Topic 2, and Topic 3, respectively. The means of topic proportions for students who took the posttest were 0.35, 0.37, 0.28, for Topic 1, Topic 2, and Topic 3, respectively. These

mean topic proportions suggest that topic proportions in students' answers differed between pretest and posttest. Students in the posttest group had larger Topic 1 and Topic 2 proportions in their answers than students in the pretest group. Using Topics 1 and 2 in this way suggests that students' answers reflected the positive effects of the LISELL-B intervention. Table 4.5 shows the words used by the students.

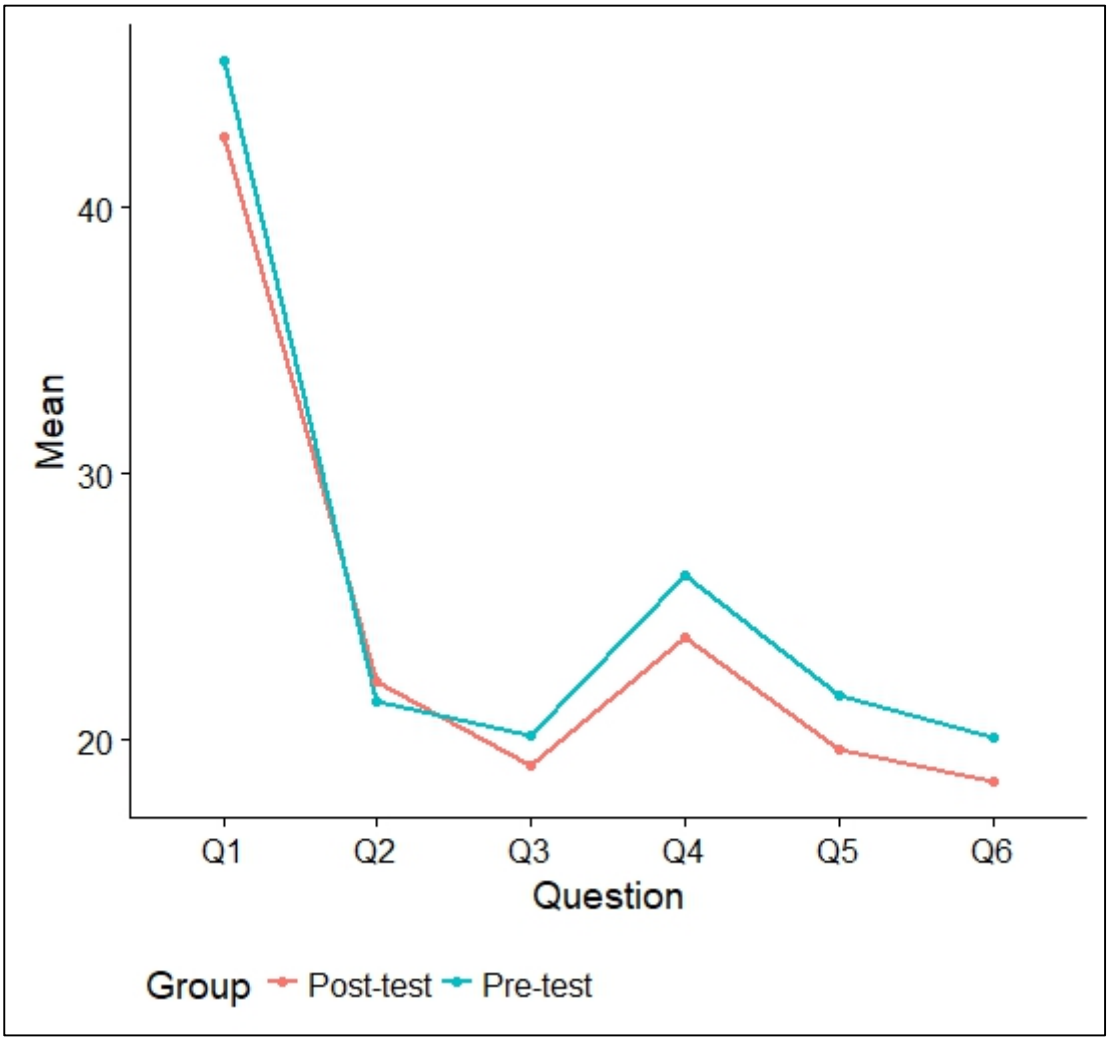

Figure 4.2 Average Number of Words per Answer in Pre-and Post-Tests

Table 4.5 Top 30 Words Having the Highest Probabilities

Topic 1 Q1-3	Topic 2 Q4-7	Topic 3 Everyday Language
Nail	because	because
energy	use	make
cause	lipstick	if
electricity	energy	get
effect	color	need
rubberband	plant	put
bulb	type	work
up	electricity	color
dough	stain	hot
flow	wax	plant
circuit	different	use
because	lipgloss	rubberband
connect	beeswax	what
yeast	flow	water
make	nail	sun
use	heat	up
stain	palm	lipgloss
maria	rubberband	soap
add	make	lipstick
variable	amount	grow
through	bulb	much
soap	than	wear
turn	black	out
type	up	like
bread	clothe	hard
metal	dough	all
expand	soil	nail
stone	soap	think
slingshot	dark	see
potential	yeast	one

Discussion

Throughout this paper, we discussed how RBA scores alone are of limited help to teachers if the score is the only feedback they receive about student performance. As Hogan (2013) notes, “more research is needed on exact ways in which teacher use externally prepared tests” (p. 288). This becomes even more relevant when the information teachers are receiving

about student performance is partial, and in that sense, not sufficient to inform their instructional decisions.

In this sense, findings from this study suggest that we need to capture more information from students' answers. Information, for example, which can be obtained using the multidimensional model described here. That is, a model which deploys complementary ways in which we can interpret student performance on assessments. For example, if we claim that SFL analysis is interested in understanding the quality of the writing, and that the RBA scores are looking at the content of such writing (e.g., content learned by the student) we can then say that those two-different analyses are expanding on and looking at things that the other approach misses. We argue that SFL can be used to support a new way of understanding student performance as a multi-layered phenomenon. These different analytical tools give us different information about how students perform and suggest the usefulness of additional assessment information to classroom instruction and to research, as we are seeking to understand the connection between content learning and language learning.

In sum, the aims of study were twofold as expressed by our two research questions. First, we sought to establish whether the LISELL-B intervention had an impact on student performance based on RBA scores. Results indicated that the RBA scores only showed a slight improvement from pre-to post test. In this regard, an answer to the following question remains: What information cannot be captured by the scores exclusively? Secondly, we wanted to understand what additional information might be contained in students' performance on the assessments in addition to the scores. Results suggested that additional information was present about student writing practices. In particular, the SFL and LDA analyses provided additional potentially useful information with respect to the following question: Can any of these analyses

help us understand why students score higher or lower on any given question? Beyond answering these research questions, we also aimed to propose a comprehensive analytical framework to better understand student growth as measured in constructed response assessments.

In terms of the information that cannot be captured by the scores exclusively, results of this study suggested that additional analyses of student performance, including but not limited to SFL and LDA, can help teachers understand the written scientific meaning-making practices of their students. Regarding whether or not the multi-dimensional analysis framework, MAPA, can help us understand why students score higher or lower in any given question, it could be that question completion is related to question order rather than complexity. Kim and Cohen (2017) suggest that speediness was detected in constructed response items. In addition, Sheppard and Vernon (2008) note that, although speediness in item assessment completion cannot be directly correlated to intelligence, this issue is still regarded as possible on tests in different educational contexts. This pervasive look at student performance related to time poses a challenge to the assessment field that cannot be overlooked. In this regard, the assessment field as a whole needs to rethink the way in which assessments are constructed, operationalized and scored to capture student performance as comprehensively as all instruments available allow.

That is why, in describing the comprehensive analytical framework to better understand student growth as measured in constructed response assessments, it is essential that as researchers we acknowledge the challenges in scaling up such a complex and laborious model of analysis. The MAPA framework is unlikely to be implemented at classroom level by teachers given its complexity and that it is labor intensive. However, as shown by our findings, the MAPA framework holds promise in being implemented at large scale by test developers and researchers as a means of generating information that teachers can use in the classroom.

In pursuing the aims we have described, the present study showed that there is a need to assess student written performance using several analytical methods in order to capture the complexity of student performance. If "students' written production has always been a central part in the assessment of student's linguistic competence", (Gregori-Signes & Clavel-Arroitia, 2015, p. 555) and if this idea becomes even more important and challenging in the context of the NGSS, it is essential to challenge models of student assessment performance description that do not provide sufficient information to improve science instruction for all students.

The research in the study has implications for the design of assessment items as well as for the interpretation of student responses. Traditional models of assessing student performance do not themselves fully serve to assess the NGSS, because they do not provide enough information about "peripheral" patterns which influence performance. It would be useful to focus future research on the connections between assessment development and its possible interactions with the RBA scores. In terms of SFL, for example, research can ask if certain features are related to reliability. Said another way, if we focus on constructing tests with certain SFL features, does that influence the scores, the reliability of the scores, the difficulty of the questions, or the kinds of themes latent in the students' answers?

In terms of educational change in assessments, it is necessary to develop an assessment agenda that is concerned not only with its production, but also to its analysis. This seems particularly timely as changes in instruction to meet the NGSS are being developed. Thus, expanding on models such as the MAPA could be useful to help us think beyond the score to get more of the information present in students' writing.

One question that our study raises is whether pre-and post-testing serves as a reliable way to track and measure the relationship between instructional effect and student performance.

Based on our experiences with the LISELL-B project, we would argue that analyzing pre- and post-test scores along may not be the most useful for understanding the relationships between students' sense making and their language use in science. One approach that might be useful would be to administer embedded assessments, that is, assessments embedded in the course of instruction. In this sense, embedded assessments are a type of assessment which takes place during the school year with the objective of providing teachers and administrators with current and timely information about student learning (Kumar, Myers, Aytug, & Preiser-Houy, L, 2018). Embedded assessments have the additional characteristic of giving teachers agency in terms of teaching and learning, student performance interpretation as well as opportune curriculum and instructional changes (Gerretson & Golson, 2004).

Ultimately, the questions we should ask are what types of text we want students to produce, what constitutes quality text, and how can we assess it in a way that is informative for teachers. The results of this study are bound to a specific context. It would be useful to replicate the MAPA model in other contexts, with different types of assessments, and with different methods for analyzing student performance. In a climate of change, especially influenced by the NGSS, traditional models of assessing student performance need to be re-examined. As instruction changes to meet the NGSS (Achieve, 2013; Lee, 2017) so do methods of assessing learning need to change.

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CHAPTER 5

CONCLUSIONS AND MOVING FORWARD

This dissertation examined three distinct scenarios where language was enacted to convey meaning in science by Emergent Bilingual Learners (EBLs) and their teachers; it also explored how these students created meaning through deploying multilingual and multisemiotic resources. In achieving this purpose however, I encountered unanticipated tensions which led me to new possibilities for analyzing the implications of my work within and beyond the US context where my research took place. Using Systemic Functional Linguistics (SFL) and Culturally Sustaining Systemic Functional Linguistics (CSSFL) theories as my conceptual framework, in my three articles I observed how forces shape and constrain disciplinary learning and teaching in science for immigrant students, and their teachers, taking into account agency as a powerful means of enacting transformative change (e.g. Allexsaht-Snider, Buxton & Harman, 2012; Harman, 2018). In this sense, a CSSFL theoretical stance served as a means to conceptualize the need for a theory of language that accounted for the linguistic and cultural diversity that students bring to the classroom, and how student experiences can be valued as powerful learning resources, rather than perceived as a problematic issue.

The tensions became especially relevant in the current US school climate which places emphasis on literacy and language development for all students (Fang & Schleppegrell, 2010). Within this context, teachers undoubtedly have a key role in explicitly mentoring students to unpack the wide-range of discourses present in the classroom so as to enhance their academic

learning (Nieto, 2004; Schleppegrell, 2004). However, as this dissertation shows, there is limited research available which explains how pre-service and in-service teachers can better develop an understanding of the practices of functional language. Due to this, incorporating an explicit component of language that goes beyond the traditional notions of linguistic awareness programs in teacher education can bring light to the dynamic relationship between disciplinary knowledge and disciplinary literacy. In addition, the findings of this study highlight the potential of a CSSFL framework being tailored specifically for a socio-political context, such as this dissertation grounded specifically in the educational practices of the southeast United States. The political, administrative and societal context, as well as the rapid demographic shifts, vary significantly from other regional contexts (OELA, 2008; Office of Refugee Resettlement, 2016), and the framework of CSSFL helps teachers and researchers understand how to acknowledge and work with the languages and culture embedded in their context.

In this research, I have sought to identify and explore opportunities where teachers and students could support each other, and be supported by other agents, as in the example of the LISELL-B project team. All of this with the aim of expanding not only their linguistic and cultural repertoires, but to do so with the purpose of challenging and transforming their own experiences with the aim of producing shifts towards a more culturally and linguistically sustaining education.

To this end, Chapter 2 served as a starting point to identify how existing gaps in pre-service and in-service teacher professional learning can be addressed in order to advance the profession and improve instruction for EBLs. Subsequently, Chapters 3 and 4 empirically explored how teachers and students can create, learn and negotiate meaning-making processes in science through oral, multimodal and written discourses. In other words, both empirical chapters

explored the discursive processes of EBLs with their teachers, challenging hegemonic and pervasive views of classroom instruction and assessment understanding. In the next section, I discuss the major findings and implications for classroom instruction and student performance assessment analysis.

Findings and Implications for Classroom Instruction

The findings for classroom instruction of this dissertation highlight the need to plan lessons that require students to apply their own knowledge and experience in order to explore concepts that might be new to them and the importance of scaffolding them into use of challenging content and challenging academic language, rather than presenting emergent bilingual students and newcomers with basic language and content. Additionally, guiding students in understanding and expressing their conceptual understanding through different means such as linguistic and multimodal resources is essential to enhance learning. To achieve this, using all linguistic repertories that students bring to the classroom holds great promise to enhancing abstract understanding and facilitating academic communication.

In terms of recommendations there are multiple which emerge from the data gathered and analyzed in this dissertation. However, these cannot be comprehensive unless they take into account the current state of teacher education and teacher professional learning as addressed in the first manuscript of this dissertation. As discussed in Chapter 2, the monolingual practices of teaching science, and other disciplinary content areas is still very common in many schools across the US (Garcia & Kleifgen, 2010; Lee & Buxton, 2013). In Chapters 2 and 3 this idea was challenged through both current literature and the empirical study presented in Chapter 4. First, by exploring how teachers in the United States are being prepared to work with linguistically and

culturally diverse youth, I discovered persistent gaps which hinder student learning such as the lack of cultural and linguistic components and the lack of diversity in the teaching force.

In this context, the LISELL-B project appeared as a model which provided multiple scenarios for teacher learning in and out of classrooms and schools. Because teacher and student learning cannot be solely constrained to the school walls, the LISELL-B model was designed with the understanding that to produce change it is important that teachers reflect and learn beyond schools, and that in doing so they can develop agency by making choices about which professional development activities to attend, and what practices to enact. In doing so, educators who took part in the LISELL-B project participated in many pedagogical activities such as family workshops, teacher institutes, summer academies and workshops, all of which assisted them in developing new understandings about EBLs written practices. These pedagogical activities helped teachers in gaining more autonomy and the agency to decide what they needed to develop and modify in their instructional practices While there is robust literature that shows that teacher participation is key for any in-service professional learning intervention (e.g., Day & Sachs, 2004; Garet, Porter, Desimone, Birman, & Yoon, 2001), there is still a tendency to provide teachers with top-down approaches that show teachers what to do instead of enacting a dialogical attitude. This tendency has proven ineffective for producing sustained and meaningful teacher pedagogical change (Gross, 2010; Konza & Michael, 2010) To the contrary, the LISELL-B model understood that teacher agency is necessary for the sustained and meaningful recognition and validation of the cultural and linguistic repertories of the increasingly diverse K-12 student body.

Second, through the means of a case study in Chapter 3, I zoomed into a newcomer EBL classroom to explore what culturally and linguistically sustaining practices looked like within the

project. To achieve this purpose, I studied the classroom practices of a Mexican bilingual science teacher, who participated in the LISELL-B pedagogical model and was familiar with the science and language practices enacted in the project. This study took place in a particular geographical setting: a novel program for newcomer bilingual students, and had the aim of exploring both the practices of the focus teacher and his own perception of such practices. In order to achieve this, two data sets were analyzed intertextually. They included the thematic analysis of classroom videos identifying key practices and how both ideational and interpersonal meanings were enacted by the focus teacher; and a follow-up teacher interview in which the teacher expanded and shared his understandings about his teaching practices. This study shed light on some of the key principles and challenges that teachers need to take into consideration when working with newcomer and immigrant students. Nevertheless, it must be noted that in asking teachers to enact some of these practices, I recognize that a support system is needed, and that further research in terms of professional learning opportunities, school leadership and climate must be addressed before placing all responsibility on educators, individually or collectively.

The suggested dynamic model which emerged from Chapter 3 is comprised of three principles that can guide teachers in working with immigrant and newcomer youth. The first principle involves incorporating student experiences into the science curriculum as a way of activating prior knowledge, making the content and inquiry practices more relevant, and valuing learners' previous experience in their home countries. The second principle highlights the importance of scaffolding both the language and the content without simplifying it. In doing so, teachers can help students use their multisemiotic resources and repertories (Harman & Khote, 2018; Harman, 2018). This model emphasizes that English is no longer the only valid means to communicate and produce meaning. This leads the discussion to the third principle which is

enacting classroom instruction in all languages that students may bring, based on Translanguaguing (e.g. Garcia & Wei, 2014) which allows for a more significant understanding and promotes communication.

Implications for Multilayered Assessment Performance Analysis

The purpose of studying how assessments are analyzed and what type of feedback teachers receive in regard to student performance was to uncover whether rubric-based assessment analysis can provide enough information for teachers to make timely and effective instructional change. Although the focus of this dissertation is on EBLs, this topic is relevant for all students and teachers as testing remains of great importance in the school context both to assess student learning but also for teacher accountability purposes (Alzen, Fahle & Domingue, 2017). Overall, this study uncovered some of the challenges and limitations of using a one-dimensional model to interpret student performance. Following on this, the study suggests that a multidimensional model which implements complementary ways to interpret student performance can provide educators and researchers with additional tools to improve instruction and assessment quality. On the one hand, this study argues that Systemic Functional Linguistics and Latent Dirichlet Allocation approaches can serve as a means to produce new understandings of student written performances. However, additional tools not explored in this study could potentially serve a similar purpose, thus opening a new line of inquiry. On the other hand, this study poses the question of whether a pre-and post-assessment model is reliable enough to measure and interpret student written performance and ultimately understand learning. As a result, this study advocated for classroom embedded assessments as a means to provide teachers and administrators with timely and accurate data about student learning (Kumar, Myers, Aytug, & Preiser-Houy, L, 2018).

In sum, developing new and more comprehensive models such as the Multidimensional Assessment Performance Analysis (MAPA) can be worthwhile in helping teachers and researchers to analyze student performance beyond the score to get at the fundamental characteristics of student written practices with the aim of improving teacher instruction.

Moving Forward

To conclude, research in the United States was influenced by my experiences in my home country, and the unique and transformative process I went through as I began my doctoral studies in the United States. These experiences created a space for me to reflect on and work toward an ethical stance regarding culturally and linguistically diverse schooling practices. Part of the next steps of this journey, will consist of uncovering new ways in which I can implement this research in other contexts, find new lines of inquiry, and attempt to contribute to a more just and equitable pedagogical and research agenda in science education for all students.

The experience of working with a diverse group of people, teachers, students and administrators as part of the research experience has allowed me to incorporate and develop skills that are meaningful in many contexts within and beyond the US. As educational researchers, when we become aware of the crucial role factors such as social class and immigration status play in education and when we connect those issues with ongoing and pervasive processes of inequity, we realize how different structures of power affect the quality of life of students. This intrinsically changes the way we build relationships with students and how we work to enhance their learning experiences. From that moment onwards, as educators we can no longer seek to reproduce the status quo, but we start seeking to enact the kinds of transformative actions that have been discussed in this dissertation. (e.g. through classroom practices that value students' linguistic and cultural repertoires). Although transformative change

is usually easier said than done, and I acknowledge that educators cannot change everything at once, there is a lot in terms of pedagogical practice that can be accomplished when we plant the seed of possibility in the classroom (Lemley, 2014).

When educators engage in dialogical practices that support their understanding of pedagogy that uses embodied and discursive practices together, they also help others pose questions about their contexts. Not because they are giving the power to others but because they are helping others to make their own choices. This is crucial when discussing critical education as it refers to "actions taken by individuals or groups aimed at changing aspects of society that may perpetuate injustice" (Cadenas, Bernstein, & Tracey, 2018, p.2). Critical educators then have a responsibility to actively participate in "the process of supporting diverse learners in communicative and literacy tasks that move them towards linguistic and cultural equity and that supports their emotional and social wellbeing" (Khote, 2018, p. 154). To achieve this purpose, and to promote transformative change, both pre-and in-service teachers need to create contextually relevant and sustained programs which address learning from a sociocultural standpoint to produce sustainable change in teacher practices and beliefs.

To add to this complexity, international dissemination of CSSFL adds another layer of difficulty: the barrier of cultural and linguistic differences. When it comes to education and teaching, a highly sensitive social issue, it is crucial to not only communicate research findings, but to assess which findings will be most relevant in a particular setting (Higgins & Katsipataki, 2016). Thus, as an international scholar, I am aware of the complexities of international research dissemination. As a result, the possibility of bringing US-based research to other contexts has the potential to significantly contribute to the continuous professional development of various educational stakeholders, who will become key experts in teaching and learning processes in

their own educational institutions. Finally, my identity as a scholar is deeply rooted in both my research and pedagogical experiences, as I conceive research on teacher professional learning as being deeply connected to public service and community advocacy. Consequently, I strive to enact those practices, which are supported by research and which I firmly believe in. I envision my future work as a scholar as connected to the communities I am a part of, and thus, bridging the existing gaps between academia, schools and society remains central to my research agenda.

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