English Teaching: Practice and Critique September, 2009, Volume 8, Number 2
http://education.waikato.ac.nz/research/files/etpc/files/2009v8n2art1.pdf pp. 6-24

Legitimacy and language in a science classroom

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ABSTRACT: In this study, we explore language – specifically the use of Spanish, in a sixth-grade science classroom, where the district recognises English as the official language of instruction. The question guiding our analysis is: How is Spanish positioned in Ms. Cook's science class? Transcribed interaction from twelve weeks of videotaping is coded and analysed to highlight when and how Spanish is used during everyday classroom activities. Most of the formal, public talk during Ms. Cook's science class was in English. Ms. Cook consistently spoke English in discussions, modeling English "science talk". However, during small group work, a significant portion of science class, language flowed between English and Spanish. As students tried to interpret and make sense of science concepts, students chose the language that was most useful to them. In this article, we will share transcript excerpts that illustrate interaction where Spanish and English are both positioned as legitimate tools for students to use when exploring science concepts. The excerpts also show how Spanish was respected as Ms. Cook legitimised Spanish, without translating it or marking it as unacceptable. In this classroom, Spanish works as a significant resource, helping students achieve success in science class.

KEYWORDS: Classroom discourse, science inquiry, sociocultural development, qualitative inquiry, bilingual education, middle school education.

INTRODUCTION

Imagine implementing a new, middle-school, environmental science curriculum, which is based on inquiry, empirical data collection about one's local environment, and data visualisation. The concepts are as unfamiliar to you as the methods are for teaching them, but you are excited to lead your students in authentic inquiry in which *they* explore scientific concepts through their own experiments. The classroom will become the workshop, the experimental findings will be your textbook, and the students themselves will be the co-creators of scientific information.

However, your classroom presents particular challenges. You teach in a Southern Californian school where the vast majority of your students are not native speakers of English. Even though you are bilingual, your background is very different from that of your students. In addition, the immersion model delegated by Proposition 227 mandates that you should not present your lesson in a language other than English. This means that all directions, small group discussions and assessments are supposed to be conducted strictly in English, a language that for your students at this point in their development of academic English, limits their ability to demonstrate what they know. Since the unit relies on discussion and debate, expectations for participation differ dramatically from what the students are accustomed to. In short, you are faced with designing a whole new learning environment. The success of that environment is restricted by the "elimination" of perhaps the most critical tool your students need for making connections to the material: Spanish. Despite the mandate, you realise that there is room for Spanish in the classroom and you organise your classroom based on the needs of your students. This is the scenario that Ms. Cook faced and is the context for our analysis.

Teachers are constantly faced with contradictions between their beliefs and policies about teaching and learning. What happens when there is a clash for a teacher between the importance of building a community that values heritage language and the importance of implementing state or school language policies? How do students use Spanish to make meaning of new concepts? In this article, we explore language and learning in a science classroom through a sociocultural lens. More specifically, we systematically examine the way Spanish is used as a legitimate tool by a teacher and her students. This teacher, Ms. Cook, through her language in everyday classroom interaction, expresses legitimacy for the use of Spanish in an "English Only" science class. As we explore how "talking science" (Lemke, 1990) influences the climate of the classroom, we examine the effect of this inquiry-based model on English Language Learners and the development of their understanding of science concepts.

SCIENTIFIC INQUIRY AND TALKING SCIENCE

The study of science is a means of inquiry and discovery into the way the world around us works. Traditionally, science was taught in a reductionist model, wherein the teacher acted as an authority of knowledge passing information on to students. In this environment, students acted as passive receivers of information. They were not responsible for participating in the process of questioning or experimenting, much less discussing the content of a science curriculum with one another. Since the late 1980s standards movement, there has been a national push to move away from traditional science teaching towards a model of teaching science through inquiry (National Research Council, 1996, 1998, 2000). In such an approach, there is more emphasis on engagement with scientifically oriented questions, where the learner gives priority to evidence when formulating scientific explanations.

Classroom-based inquiry shares features of the work conducted by scientists. Most importantly, "inquiry science requires student discussion with others-working cooperatively and sharing ideas. In addition to these being important skills to learn, dialogue and socially gathered and shared information is a powerful means toward building individual conceptual understanding" (Kluger-Bell, 1999, p. 48). The

rationale for inquiry as a way to teach science is multifaceted. Perhaps the most compelling argument is that from the National Science Teachers Association: "Understanding science content is significantly enhanced when ideas are anchored to inquiry experiences" (National Science Teachers Association, 2004, p. 1).

As the goals for teaching science have moved toward a model based on authentic student inquiry, the expectations for the roles of students in the classroom have shifted as well. No longer passive recipients of empirical information, students are now expected to join in the process of making meaning of the physical world through "doing" science themselves. This process relies not only on students' abilities to practise science, but also on their abilities to observe, discuss, hypothesise, clarify, analyse, and evaluate scientific concepts. This process of "doing" is inseparable from "talking science." In other words, students "do" science through the medium of language, wherein they use language as a tool for making meaning of the physical world (Lemke, 1990).

Through "talking science", students reason through a problem to make sense of a particular situation. They do not simply parrot back *words* (as in the reductionist model), but rather construct meaning by adapting words to meet the needs of a problem or situation and by making connections to their own understandings and experiences. Sharing this information enables students to "talk their way through a task," practising and making sense of something new by relating it to something they have observed. Thus, teaching science as inquiry is ultimately a social process: students learn through communication with the teacher and with one another. This focus on communication implies the existence of a community – a shared space comprised of individuals with shared values and shared goals. And as Lemke states: "We communicate best with people who are already members of our own community: those who have learned to use language in the same ways that we do" (Lemke, 1990, p. ix).

The challenge of learning science lies in the subject's unique semantic structure. These spcialised ways of using language include "a specific grammar (passive voice), certain rhetorical structures or figures of speech, and certain models for activity (for example, the question and answer structure)" (Lemke, 1990, p. 21). These patterns present a challenge for all speakers, including native English speakers, who must adapt to a new framework for explaining and communicating concepts. Until a student can work out these patterns, which are rarely *explicitly* taught, little of science makes any sense at all. Fluency in science requires practice, much like acquiring fluency in a foreign language; students must learn a new schematic for articulating and reasoning. As a result, those with different social or language backgrounds (such as bilingual students) are subsequently put at an even greater disadvantage, as they are being forced to adopt two completely new and different frameworks for communication of concepts at once.

There are particular challenges in teaching science. Lemke (1990) identifies two challenges that are specific to the needs of bilingual students in the classroom. First, current methods of teaching give an advantage to students with middle-class language skills. Second, race, social class and gender can influence interpretations of students' abilities based on how they communicate in class. In the classroom, dialogue becomes the means through which students present and share thematic concepts. If

the content and expectations of the teacher are not understood, and if heritage languages that help students communicate effectively are banned from the classroom, students will fail to communicate and learn new concepts effectively. Essentially, these gaps in understanding prevent students from being able to fully capitalise on all the ways language is connected to understanding and being proficient in science. In addition, if student learning is assessed in a medium of language that restricts the possibilities for discussing or making connections in a more familiar language, it is difficult for teachers to know whether they are assessing students' English language or their understanding of science content.

BROADER CONTEXT: PROPOSITION 227

In the previous section we discussed how students' perception of the nature of science and the process of learning science concepts are both tied to engaging students in scientific discourse. Before we analyse how Spanish was positioned in relation to this endeavour, we need to introduce the larger context of how Spanish was positioned by policy and various institutions at the time of our study. Proposition 227 was passed by the state of California in 1998, replacing the model of bilingual education with a full-immersion model for students learning English after a year of intensive English instruction.

Supporters of Proposition 227 cite increased test scores as evidence that immersion is working in California. Opponents, on the other hand, state that these test scores are misleading, and that the year-long English instruction is inadequate for preparing students for full immersion. Thomas and Collier (1997), in their longitudinal studies of English Language Learners, estimate four to ten years for English Language Learners to become proficient in English. Yet, ten years later, some educators do not see improvements in student learning since the law was first passed (Sifuentes, 2008). There have, however, been several movements to alter the immersion program. In addition, while a handful of states, such as Arizona and Massachusetts, have since followed California's lead in passing English immersion programs, many states have not passed such strict laws for immersion. In fact, some states have overturned efforts to eliminate bilingual education completely, such as Colorado in 2006 and Oregon in 2008 (Sifuentes, 2008).

The American Institutes for Research and WestEd (2006) submitted a five-year evaluation to the California Board of Education that analysed the long-term effectiveness of Proposition 227. This report assessed district and school practices, including the implementation of English language (EL) instruction, EL tracking and segregation, the quality and appropriateness of instructional approaches, and teacher preparation programs. Those that supported Proposition 227 (which comprised about half of the respondents in the study), cited that the renewed focus on English helped EL students fare better on state testing exams (p. II-4). In addition, these supporters claimed that Proposition 227 helped focus attention on ELs, moving them into the mainstream so that they acquired English skills more rapidly (p. II-4). Those with the opposing view believed that removing bilingual education limited the schools' ability to "use primary language instruction to clarify academic content" (p. II-4). The focus on learning English language has also been criticized as lowering expectations and the rigour of other courses in the curriculum.

In addition, there have been various tensions with the way Proposition 227 has been implemented in schools across California. The study cites a short timeline and insufficient guidance as undermining the intent of the law. In addition, there has been continued confusion over what Proposition 227 actually requires and allows, and with the possibility for parental waivers, there is inconsistency with the way the law has been implemented across the state. In the conclusion of their report, the Institute states: "Very little evidence can be found in the empirical analyses conducted during this study that its basic premise was correct (that is, that immersion methods of instruction are uniformly superior to bilingual methods in enhancing educational outcomes for ELs)" (p. VII-2). The report includes various recommendations for monitoring and adapting Proposition 227, but ultimately concedes that evidence proving the effectiveness of full-scale immersion is inconclusive.

On the other side of the bilingual debate, educators argue about how heritage languages are critical linguistic resources. Lucy Tse (2001) cites the importance of providing "interesting and meaningful exposure to the language" (p. 68). Moreover, language is an important part of group membership. Tse (2001) argues we "want to promote group membership by cultivating positive opinions about the language and its speakers" (p. 65).

In a summary of current research and practice, Tse (2001) identifies key components of good language programs. Some of these components are not possible in Ms. Cook's classroom, such as providing students with substantial oral and written exposure to the heritage language. However, Ms. Cook does promote or encourage the other key components identified by Tse:

1. Students learn in a comfortable and nonthreatening learning environment with opportunities and support to use English (but are not required to do so until ready).
2. Students are exposed to types of language and language situations that they consider to be useful and important.
3. Discreet language points or correctness of student speech or writing are taught minimally, as needed.
4. Non-standard forms of language are accepted and the varieties of language are valued.

THE NEED FOR SPANISH: CONNECTING SPONTANEOUS, PERSONALLY MEANINGFUL EXPERIENCE TO ABSTRACT SCIENTIFIC CONCEPTS

We have provided arguments from current literature about the importance of learning how to talk science in order to learn science, as well as the importance of one's first language as a resource in the process of constructing meaning. Clearly, these views support the idea that learning is an inherently social process. Because of this stance, Vygotsky's (1978) theory of learning has proved particularly useful for us to understand the general ways interaction are contributing to learning in this study, as well as the particular ways that Spanish interactions are contributing to conceptual development.

In his theory, Vygotsky emphasised three, interconnected factors in human development: history, tool-mediated action and social interaction. ,The first distinguishing aspect of Vygotsky's theory is his recognition that people grow into their culture and that the history of a given culture plays a role in shaping the course of an individual's development. A second idea Vygotsky postulates is that human thought is mediated by material and conceptual tools. These tools, first among them being language, are cultural tools that individuals appropriate. The implication here is that tools are the product of a culture's history. They are developed to facilitate the work that people do and to communicate the ideas that the culture defines as important; as individuals appropriate a culture's tool kit, they simultaneously grow into that culture. Third, Vygotsky's theory proposes the Genetic Law of Cultural Development, which argues that the process of appropriating the conceptual toolkit of one's culture is through social interaction. According to Vygotsky, mastery of new ideas and ways of thinking is first accomplished in social interaction, often with the aid of others, and is then only later internalised by the individual.

Of particular importance to our study of English Language Learner students doing and learning science is Vygotsky's notion of scientific and spontaneous concepts. Vygotsky held that when one first learned a new word or concept, this point was merely the beginning of the trajectory of the concept's meaning. With experience and guidance, the sense and meaning of the concept grew, and more importantly for education, children grew into the pre-defined cultural meaning of the word. Vygotsky's position differs from other developmental psychologists such as Piaget (1983), and many of today's constructivist researchers. These researchers emphasise a child's construction of personal meaning through a process of abstraction from one's physical and mental activity.

Like Piaget, Vygotsky recognised that children abstract meaning from their personal and idiosyncratic concrete experiences. He called these meanings spontaneous concepts. However, Vygotsky also recognised that there were pre-existing, cultural definitions of these concepts. According to Vygotsky, other people, primarily adults, used language in culturally appropriate ways, and either assume their children did as well, or make efforts to demonstrate the existing meaning as they understood it. He called a certain class of these cultural meanings, scientific concepts. Thus, Vygotsky argued for conceptual development as a bi-directional process between constructing personal meaning and being guided to pre-existing cultural meanings.

Spontaneous concepts are rich in personal meaning for a child, while scientific concepts are rich in organisational structure. Scientific concepts relate one idea to the next in a systematic way not likely to be developed spontaneously. Vygotsky used the example of brotherhood to illustrate his argument. A child may have a brother and therefore a rich, but idiosyncratic understanding of what brothers are and how they act. Yet, if asked whether he has a brother, the same child will often say "no". This is because children lack the formal definition of a brother as a male offspring having both parents in common with another offspring. It is the formal definition that allows the child to think about the reciprocal relationship of two brothers in a systematic way. That is, the child's spontaneous concept of brother is not yet organised by the correlating scientific concept of brotherhood. Conceptual development, according to Vygotsky's model, is the bi-directional process of linking one's personal concrete

experiences to the culturally defined, organisational structure of a scientific concept.

This is important to our analysis of language in the classroom. For English Language Learners, spontaneous concepts are likely to be tied to their first language (in the case of most of the students in our study, Spanish) because the concepts were originally formed and abstracted from experience steeped in the language with which the students are most experienced. While in the classroom, especially classrooms organised politically by an English-only mandate, scientific concepts will be introduced in English.

There is a danger, however, that we might be seen as endorsing a simple dichotomy between students using English for abstract, formal science talk and Spanish for informal concrete experiences. This is not the case. Our focus (and goal) is on developing conceptual understanding. Language, both English and Spanish, are tools in that process. At times they may play different roles in this process. However, we do not suggest that any language should be rigidly or exclusively held to any one role. While identifying multiple roles that language use plays in developing understandings of science concepts, flexibility is key. Science concepts and Academic English are on a trajectory that is intertwined and co-evolving. The role that Spanish and English play in the process is likely to change as the students' understandings change.

The degree to which spontaneous concepts can be wedded to scientific concepts depends on the quality of the social interactions and the organisation of the classroom as a discourse community. Social actions are embedded in classroom practices, meaning that social relations and interactions among people underlie the learning process. Therefore, "in order to understand the individual, one must first understand the social relations in which the individual exists" (Wertsch, 1985, p. 58). The inclusion or exclusion of Spanish changes the quality of social interaction for English Learners, as does how the Spanish that is used is positioned in the classroom discourse.

One key dimension of quality instructional interactions is the various ways in which adults scaffold student learning. In particular, dyadic communication between an individual student and the teacher and between student peers themselves can be fostered through group activities. Ultimately, these two separate interactions combine to create a community of learners in which students have multiple resources for processing new information. Group scaffolds in school provide yet another resource for students in the development of their learning. For busy teachers, students may have fewer options for individual conferencing. Feedback from peers can compensate for times in which the teacher cannot provide undivided attention for a student. In addition, many children benefit from more varied presentations of a topic, which allows them to learn from a diversity of approaches and experiences in the classroom (Cazden, 2001). All of this points to the importance of not excluding linguistic resources, such as one's first language, which can be used by students to have more successful interactions and, therefore, learn more.

METHODS: CASE STUDY OF A CLASSROOM

Ms. Cook teaches at a relatively new, K-8 school located in an industrialised

neighbourhood of the greater Los Angeles area. Over 600 students attend the school. Over 95% of the students are Latino/a with a high percentage of English-language learners (61%). Ms. Cook is a Caucasian, bilingual (English and Spanish) veteran teacher of over twenty years, with the last four at this school. There are twenty-seven sixth-grade students in Ms. Cook's self-contained classroom, where she teaches all content areas. The classroom is part of a wing of portable buildings placed on the school grounds. Students sit together in groups, typically four per table. Colourful posters, encompassing a wide range of subjects, cover the walls. On counters along the wall, there are tanks with animals, including a snake. Despite the rich environment that Ms. Cook has helped to cultivate through her decorating, you can't help but notice the lack of full-size windows in the classroom. The only natural light in the classroom comes from a small window in the metal door.

We started our relationship with Ms. Cook as researchers in a study investigating the implementation of new technologies and their impact on student learning. This focus on technology was prompted by a donation of more that 80 computers to the school by a major computer corporation. The teachers were implementing the Global Learning and Observations to Benefit the Environment (GLOBE) project. This project promotes learning environmental science by having students collect scientific data to share with scientists and other students worldwide. We met as a research team weekly with the two teachers to discuss study progress. The teachers chose to focus on the GLOBE atmosphere and soil scientific protocols because of the limited access to water and the lack of ground cover. The school had little green space with the entire playground covered in asphalt. (See Enyedy & Goldberg, 2004; Enyedy, Goldberg & Muir-Welsh, 2006, for reports on the original research study.)

We visited Ms. Cook's classroom, as well as two other teachers, when they taught science 45-90 min per day, two to five times per week, for three months. We videotaped science instruction every visit. Most days, two researchers videotaped in each teacher's classroom to get different perspectives. For research purposes, raw video footage was collected with minimal camera edition. Videotape was shot with moving the camera as little as possible during whole class discussions to view interactions among students and between Ms. Cook and students. During small-group work, one group was typically followed with each camera. The researchers had minimal interaction with the students. The intention was that the operator's presence would be less intrusive and the camera's presence less distracting for the participants. The main advantage of this type of footage is that it provides "a continuous and relatively comprehensive record of social interaction" (Erickson, 2006, p. 177) with greater authenticity.

The nuanced, moment-by-moment classroom interaction is so complex that it is often difficult to study (Erickson, 2006). To study the fine-grained information of social interaction, we recorded, transcribed, and then analysed moment-by-moment interaction (Erickson, 2006). Videotapes were viewed (multiple times), content logged, and three lessons were initially transcribed for close analysis. In these lessons, students explore humidity, soil and air temperature, and soil nutrition. We highlighted instances of Spanish use by Ms. Cook and her students and noted the lesson and context (whole group instruction/discussion or small group investigation). We began by individually and as a research team richly describing the classroom interactions that involved Spanish. Questions emerged during initial analyses about when, how,

and why Spanish was used (and not used). We then re-examined the video and transcript excerpts, coded the data, and created a table indicating uses of Spanish by Ms. Cook and students and the reasons for the uses of Spanish. This table was used as an organisational tool for our analyses and writing. The uses of languages were also analysed in the context of learning science, particularly in how Spanish is used as a legitimate tool for understanding science inquiry. Other lessons that we felt captured some of these patterns were studied for further analysis. These multiple layers of analysis help us better understand the use of Spanish in this science classroom.

We begin with an examination of how Ms. Cook promotes students' home or heritage language, Spanish, during classroom interaction, using Tse's (2001) four components of an effective heritage language that were discussed previously: 1) a non-threatening classroom environment; 2) exposure to authentic language contexts; 3) minimal correction of student speech; and 4) honoring non-standard forms of language. Then, we build on these ideas to analyse ways that Ms. Cook's legitimacy of Spanish more specifically influences students' understandings of science concepts.

FINDINGS: MULTIPLE LANGUAGES AS LEGITIMATE LEARNING TOOLS

The language that dominates during official talk in this classroom is English; however, English is not the only language used in classroom activities. Spanish emerges as an important resource in social interaction. This critical language tool becomes especially powerful as the teacher and students are interacting with the new science curriculum.

Ms. Cook cultivates a non-threatening environment, helping provide a supportive context for science inquiry and opportunities for multiple languages to be used. Students have exposure to authentic language contexts; Ms. Cook uses Spanish within practical science activities. Furthermore, Ms. Cook encourages students to talk about science in multiple languages, not only by occasionally incorporating Spanish into her own talk, but through minimal markings or corrections of students' Spanish. By honouring non-standard forms of language and multiple languages, students have the opportunity to link Spanish spontaneous concepts to English scientific concepts. In the following sections, we explore this environment and these patterns in detail.

A non-threatening environment

One way Ms. Cook creates a safe learning environment is to help students understand her expectations for them. This is even more critical given that this science unit was a departure from school as usual. Often Ms. Cook used Spanish to clarify her expectations: "I'm not asking you to really average it out. Just kind of *mas* or *menos* [more or less] it." For the mathematical term that they are already familiar with, she uses English: "average", but she uses Spanish to let students know that she wants an approximate answer. Across our data Ms. Cook frequently used Spanish to provide clear directions and encourage a particular type of student response.

Taking the lead from the teacher, student talk includes Spanish, English, or both, often flowing between languages. In various social contexts, students used Spanish

more frequently than the teacher during class. The teacher's linguistic openness helps to create a non-threatening environment for the students. For example, the other three teachers in the original study tended to only use Spanish with single words or phrases. Students, however, often used Spanish in full sentences, for a wide range of purposes. This positions a clear divide in the language of the teacher compared to the student.

On the other hand, when Ms. Cook is speaking English, students freely responded in Spanish (or English) with no marking of their choice by the teacher. For example, Ms. Cook introduces a lesson about humidity by saying, "Okay, the water evaporates. So, what you think we're going to do?" A student responds, "Echarle mas [put it more]." Ms. Cook continues in English. This pattern of the teacher initiating talk in English, a student responding in Spanish, and the teacher continuing in English happens frequently in both whole class and small group interaction. This pattern of English-Spanish-English helps establish language rules that involve multiple languages and avoids marking Spanish in a way that could de-legitimise the use of any languages. The absence of marking Spanish is the first way Ms. Cook weds Spanish to English and helps to establish a focus on conceptual understand rather than recall of vocabulary.

Code-switching also occurs during small group work. During small group work focused on testing soil nutrition, a student asks, "Miss Cook? The distilled water *es esta, verdad* [is this one, right]." Ms. Cook responds in English.

Later during this lesson on soil nutrition, while students were working at their tables, Ms. Cook instructs students to record their observations in their individual science notebooks. At one table, a student said, *"No más mire cuando lo tenia, pero...* [I only saw when she had it, but...]" The other student responded in both English and Spanish: "No, this way. Take it away. Make it 1. 1. See I'm on this, 1…2, 3, [??], 7.6…6…7.6. [unintelligible Spanish] You're supposed to twist it."

Perhaps the most interesting way that a safe environment was maintained was through peer interaction without the teacher present. During this same lesson on determining soil nutrition, the students continue to code-switch:

Student 1: *Si les ponemos agua* [if we put them water]
Student 2: *Agua* [water]
Student 1: No, burn it.
Student 2: We're gonna put water.

During peer interaction, often students helped each other stay on task, choosing Spanish as the language of choice for this organisational maintenance. There were several variations of this theme in our data: monitoring attention , "*Ya, ya, haber fijate* [Hey, hey, pay attention];" directing attention, "*Mira pa tras* [look behind];" understanding how to use equipment, "*Tomalo de arriba, el* [?] *no.* [Hold it from the top, the [?] no];" and understanding directions and/or scientific protocols as in the excerpt below:

Student 1: *Y ya despues que hagamos esto* [and after we do this]
Student 2: *Y ya despues*...[and after]
Student 1: Yeah, then you start, read what it says.

Student 2: *Y las, lo va sumar las que estan atras tambien.* [and, and the one in the back are gonna be added to.]

To create a safe an open linguistic environment, Ms. Cook models using both Spanish and English. Further, she does not mark students use of Spanish in anyway. Finally, one of the primary places we see the teacher use Spanish is to help establish a shared understanding of her expectations for student participation. The students respond in kind, using both languages. Additionally, the students use Spanish in a way that compliments the teacher's use of Spanish – they use it to monitor and self-correct their own activity to better align with the teacher's expectations. Although in these cases Spanish is not used directly to discuss science concepts, these directives are critical in shaping student activity, completing the task and hence indirectly contribute to understanding the science concepts.

Exposure to authentic language contexts

We translate Tse's (2001) second component – exposure to authentic language contexts – as examining the ways language is used during the practical activity of science. When explaining how to use a sling psychrometer to measure humidity, Ms. Cook uses Spanish to help students understand the tools of science. First, Ms. Cook says about sharing the sling psychrometers, "you won't mind sharing too, though, 'cause your arm's gonna get really tired. And we have to go on for three whole minutes. *Bastante* [A lot]. Fast. With this thing." Then, Ms. Cook uses Spanish in an explanation of reading the tools, "It has an arrow on here. And there's a groove. You know, what is a groove, like *donde esta cortado* [where it's cut]. And if you line up the arrow in the groove, you can close it." Later in the discussion, Ms. Cook continues: "you're talking about squeezing it first and then a *coladora* [a strainer]." Ms. Cook used Spanish in these cases to help her students see and understand the key features of the scientific tools and protocols.

The students, in turn, used Spanish as a resource to aid in their own problem solving during the investigations. For example, as students work together, they encourage each other to try different approaches. While trying to measure different levels of nutrients in soil, students struggle with how to use the scientific tools to measure levels of phosphorus and potassium. One girl says, "*Asi como este color se va hacer, algo asi o si no este otro* [it's gonna take this color, something like, or this other one]". As students in the group differ on what steps should be next, they use Spanish during their problem-solving:

Student 1: *Okay, este se va hacer para esto* [This is gonna be for this].
Student 2: *Todavia no, un ratito más* [no yet, a little more]

Spanish is used by all, students and the teacher, during practical science activities, including instructions for using scientific equipment and problem-solving.

Minimal marking of student speech

GLOBE materials, including all student protocols, are written exclusively in English. Yet, as demonstrated in numerous examples in previous sections, students frequently used Spanish. How did students know that it was "okay" to use Spanish? Ms. Cook

never stated explicitly that Spanish could be used as a resource for understanding science concepts and for completing assignments…but she also didn't say that they could not use Spanish. By not marking and not formally acknowledging students' choices of language, Ms. Cook provided an environment where multiple languages were accepted.

In an introduction to a protocol investigating the temperature of soil and water and different levels, Ms. Cook asks students to imagine the feeling of sand and water during a trip to a beach. She tells them, "you go in the water and you have fun all day. And then you stay. And then at high tide you make a fire and you taste marshmallows and hot dogs." At this point in the whole class discussion, multiple students respond in Spanish with related ideas, such as "*esta caliente*". Ms. Cook does not mark or correct the Spanish in any way. Instead, her response considers the content of student talk. Students are discussing the temperature and she encourages more discussion of this by asking students to " Talk to your friends about a time that you have been to the beach. And about how how the ground felt. And how the water, how the water felt."

Honouring non-standard forms of language: Linking Spanish spontaneous concepts to English scientific concepts

To examine the ways in which Ms. Cook honoured and at times used non-standard forms of language, we focus our analysis on the times she talks with students directly about the science concepts. In these cases she uses Spanish in a very specific way – to ground scientific abstractions in everyday and personally meaningful experience. Not surprisingly, there is a marked increase in Spanish when Ms. Cook talks about everyday concepts.

For example, Ms. Cook introduces a sling psychrometer to students in a lesson about humidity. Through her gestures and uses of both Spanish and English, Ms. Cook sets up the contrast between wet and dry. Though she utters just one Spanish word, "seco" (repeatedly), it provides emphasis on what is familiar – using familiar language – about the scientific concept.

Ms. Cook:	Let's say it again. This is hard. I'm giving you hard stuff here. If the air is very, very, very, very dry, dry, dry, *seco* [dry]...
Student:	Oh, yeah. Dry, *seco* [dry].
Ms. Cook:	If the air is very dry, dry, *seco* [dry], that means more evaporation takes place.

Elsewhere, in the same lesson on humidity, Ms. Cook also uses one word in Spanish to emphasise the familiar concept of wetness and link it to humidity. In interpreting the results of their experiment on a dry day she says, " [wet]? No, it's not?" In both of these interactions (and others throughout the study), Ms. Cook uses a Spanish word that highlights the familiar parts of a scientific idea that is expressed only in English.

Another important way Ms. Cook grounds scientific abstractions in personal experience is through narrative. For example, during a lesson on soil moisture, students begin by exploring moisture in sponges. Then during their discussion, Ms. Cook relates it to their everyday life:

Ms. Cook:	Okay, does everybody agree that that soil out there even though

Amanda and I have watered it, in a really, really long time but it kind of rained. Even though I. I came in this morning all excited to see if there was any rain in our rain gauge because it did rain Friday afternoon. Friday night, a little bit.

Student: On Saturday in the morning *cuando venimos estaba* sprinkling [On Saturday in the morning when we were coming, it was sprinkling.]

Ms. Cook: So that's the only water that's in that soil. So, Maya says let's take that soil and weigh it.

Ms. Cook relates the hands-on sponge activity directly to a personal experience. It becomes a shared experience as a student expands on the narrative that focuses on moisture, the science concept they are exploring. Although the student switches to Spanish, Ms. Cook continues in English; the code-switching is seamless and this provides another example where Ms. Cook does not mark shifts in language or more specifically, Spanish.

Additionally, in these narratives we saw not only an increase in the use of Spanish but also an increase in the length of the Spanish utterance. For example, during a lesson about soil nutrition, students in small groups collaborate to use kits to determine the levels of various nutrients sound within soil samples. While working to measure levels of nutrients, based on the changing colors of samples, students use Spanish:

Student 1: *Porque no la pones* [?] two [Why don't you put it in [?] Light, medium, high, light medium, high.

Student 2: *Porque no se veni* light, medium or high. [Why it doesn't look like light, medium, nor high.

Student 1: *Asi como este color se va hacer, algo asi o si no este otro* [it's gonna take this color, something like, or this other one]

Scientific inquiry involves exploring scientific concepts in ways that are relevant to students. Connections between concepts, lessons, and everyday activities are critical for inquiry. Although the curriculum provides helpful protocol for organising inquiry, true inquiry is not likely to happen for students without active social interaction. In this classroom, Spanish provided opportunities for all students to talk, regardless of proficiency in English. Although the official curriculum and lesson mandated English in reading directions and completing the written assignments, the teacher and students used Spanish in many ways as an important resource. The teacher used single words or short phrases in Spanish in everyday classroom interaction. As a result student talk frequently involved Spanish in discussing the assignment and scientific ideas.

But how does this relate to student learning?

To examine the degree to which Ms. Cook's organisation of the language environment and science activities helped students understand science content, we look at three types of evidence of student uptake of ideas and terms. First, we analyse the transcripts of lessons with a focus on the conclusions of class periods. At the end of a class, it is common to review what was learned that day. These exchanges become an excellent way to identify the immediate effects of the exchanges we presented in previous sections. Second, for a more complete picture of the aggregate growth in learning, we examine pre- and post-test gains, based on assessments taken at the beginning and end of the original twelve-week study. Third, we narrow our

analysis of test scores to focus on those items in the post-test that directly assess humidity, a topic analysed in transcript excerpts above.

At the end of the humidity lesson, students who participate in the class review demonstrate an understanding of the systematic relationships between arid and humid, and between the amount of water in the air and the geographic features that contribute to humidity. These types of inter-relationships are the hallmark of Vygotsky's notion of scientific concepts. In the exchange below, Ms. Cook begins by asking about the key idea of humidity, checking to see if students understand locations where humidity is expected to be higher and asking students to contrast the term humid with its opposite, "arid." Although the exchange only involves a portion of the students, it provides evidence that students understand the key scientific concepts. For those students who do not participate, the interaction is still an opportunity to learn through active listening (see Enyedy, 2003, for additional examples).

Ms. Cook: What do you think makes a difference in the humidity in the air? The relative humidity, what are some of the things that make a difference?
Student 1: Water.
Ms. Cook: Water, okay so if you are close to water do you think you're going to have higher humidity or lower humidity?
Student 2: Higher.
Ms. Cook: If you're in the middle of the desert and there's no water around are you going to have higher humidity or lower?
Student 3: Lower.
Ms. Cook: Lower. What's that called does anybody remember?
Student 3: Temperature.
Ms. Cook: The, the, like it's humid or if it's really super dry?
Student 4: Arid.
Ms. Cook: Arid, okay arid okay.

As the review continues, Ms. Cook suggests that students use the Internet to compare the humidity at their school to another school in Los Angles at the same longitude, but closer to the ocean. A student questions how different it will be, providing an opportunity for Ms. Cook to review the mechanism for humidity – the process of evaporation.

Ms Cook: Let's try a school that's close to a big body of water. That's still in our latitude and longitude. So Hector, what kind, what area, Long Beach. She says Long Beach. What big body of water is Long Beach by?
Student 5: An ocean.
[Students generate several possible schools for their comparison of humidity.]
Ms. Cook: Okay, so you have some ideas. If it has in our latitude and longitude it has the word beach in it, click on it. Now, and I want you to look at their relative humidity. Ours was 70 today. Is this a typical day? Well, it kind of is a typical day in April, isn't it?
Student 6: Is that for everyone in Los Angeles?
Ms. Cook: Excuse me.
Student 6: For everyone in Los Angeles or there's has to be any difference?
Ms. Cook: Do you think there will be a difference if you're right next door to the beach? 'Cause what's going on with that water?
Student 6: Evaporates.
Ms. Cook: And where is it going?

Student 6: To the air.
Ms. Cook: Into the air, yeah. It's dried up.
Student 7: It is?
Ms. Cook: Yeah, it's dried up today. Go look at it. Yeah, we're [?] a couple of nights ago it was totally dry. Okay so if you can do that, go over to the globe site. See that blue rectangle on the left, visualisation.

These transcript excerpts help us examine immediate understandings of humidity. In an analysis of changes in scores from pre- to post-tests, we also see a positive change in understanding. There are two separate sections on the assessments, one that focuses on the concepts and procedures of monitoring climate change and a second section measuring understanding of inquiry skills and interpretation of data. Because the assessment was administered over two days, only twenty students in the class completed both pre-tests and both post-tests. In Ms Cook's class, the mean score on the combined assessment rose significantly from 5.5 to 12 out of a total of 30 possible points ($t=2.4$, $p< .05$). For a more detailed statistical analysis of the assessments, see Enyedy and Goldberg (2004).

While the pre-post gains show significant improvement, they assess multiple science concepts and skills that go beyond the focus of this paper. As we look more closely at just the questions on the assessment that relate directly to a single concept, we begin to see a clearer picture of student understanding of the concepts explored in the qualitative analyses above. For example, there are three questions on the pre-and post-tests that focus on humidity. The first question assesses ability to calculate relative humidity. On the pre-test, 43% of students answered this humidity item correctly. On the post-test, it was 92%. The second question asks what would happen to the humidity as one environmental condition (temperature) changes. This item most directly targets a student's conceptual understanding as one has to understand the relationships between measurements, temperature and evaporation. 2% of students answered this item correctly on the pre-test compared to 42% on the post-test. The third question is an opened ended question, "What does relative humidity tell us about the weather?" Only 8% of students answered the third item correctly on the pre-test and it rose, just slightly, to a disappointing 15% on the post-test.

Summary

Throughout this study, talk flows between Spanish and English, serving multiple purposes. Ms. Cook primarily speaks English during class; however, she helps position Spanish as a legitimate resource for meaning-making by co-creating a comfortable, supportive language environment. She does not stop and translate students' Spanish into English or rephrase Spanish contributions into English. Instead, the focus is on understanding science concepts.

In summary, the use of Spanish in classroom discourse is particularly important in Ms. Cook's class because of the collaborative expectations for learning and the focus on group activities. As a classroom modeled on inquiry-based learning, students learn larger concepts through hands-on experimentation and data collection. For example, in learning about humidity and condensation, students break into small groups and use a sling psychrometer to measure the humidity of their surroundings. Students are expected to share the instrument in a group of eight. To do so, they must work together to use the instrument carefully and effectively, record and exchange the

resulting data, and finally communicate their groups' findings to the rest of the class.

In this environment, Spanish plays a major role in enabling students to build a learning community. Through side-talk, students interact with one another informally and lessen the anxiety of learning new concepts. They joke with one another and talk about other activities that they have in common while they engage in the hands-on activity. In addition, students often use Spanish to regulate one another's behaviour once a member of the group becomes too distracted or gets too far off-task.

Spanish is used, not only to build a community, but also to help students present, debate, analyse, and explain new concepts to each other. Especially when using scientific equipment for the first time, students would translate the directions into Spanish as they told one another what to do next. In these instances, students moved seamlessly between English and Spanish, modifying the English directions so that they were in a format that could be easily understood by the other active members of the group. In addition, students used Spanish as a tool to explain concepts to one another. For instance, students often use Spanish to replace words such as "moss" or "water" in order to clarify these terms for others.

Students also felt comfortable using Spanish with their teacher in the classroom. While the teacher interspersed some Spanish words to emphasise a concept (For example, "Dry, dry, dry, *seco*), she addressed her students mainly in English. Students, on the other hand, were often so immersed in Spanish during their conversations with one another that they would address their teacher in Spanish as well. The teacher typically responded in English, without correcting or mentioning this to students and allowed students to return to Spanish when speaking in their small groups. Thus, she effectively validated the use of Spanish in the classroom as a tool for communicating and learning.

In his study of the importance of language in learning, Lemke identifies "side-talk" as an essential resource for student learning. Through these informal conversations, students are often able to mediate and translate for one another when the teacher's language is unfamiliar (Lemke, 1990). Even when side-talk is not related to the topic at hand, it can be a way for students to build a community of support and familiarity. In Ms. Cook's class, we can see that students' engagement in side-talk is primarily done in Spanish. As a result, the Spanish language becomes a much-needed tool for community-building and the collaborative exploration of new concepts.

The GLOBE curriculum and many other current environmental science programs include essential hands on components. As students grapple with new concepts and new scientific tools, their social interaction is critical. Students work together as a team and in this classroom, they needed Spanish to do all of this. Their language brought cohesiveness, even when Spanish didn't dominate classroom talk.

DISCUSSION

Legitimacy from a teacher to a student may come in many forms, such as a good grade on an assignment or report card or a positive evaluative comment ("good job"). In this article, we carefully examine the way one teacher, through her language in

everyday classroom interaction, expresses legitimacy for the use of Spanish in "English Only" science classes. Despite the use of English as the primary classroom language, Spanish was clearly positioned as a legitimate, helpful resource for better understanding Spanish.

We also analysed how the legitimacy of language is closely connected to the legitimacy of scientific inquiry. In this classroom, the process of science instruction changes from a model based on reductionism to that of one based on authentic scientific inquiry. This new model inherently upholds reasoning through language skills, as students are forced to encounter, practise, and discuss what they find in the classroom in order to make meaning of thematic scientific content.

There are numerous contradictions we face in teaching and learning, including contradictions in beliefs about language, power/authority, and scientific inquiry. Ms. Cook was teaching a science program that involved the following of laboratory protocols in an English-speaking environment. Yet, Ms. Cook believed in collaboration, inquiry and the importance of multiple languages. We believe that these contradictions led to a learning environment that involved the legitimacy of multiple tools for learning including Spanish, English, inquiry and protocols. Ms. Cook's openness to multiple legitimate tools and languages helped cultivate a community of learners in this science classroom.

This study also highlights the importance of looking beyond official curricula and lesson plans into everyday classroom interactions. In an age of science reform, teachers need more than prescriptive standards and suggestions for lesson activities. Teachers also need a "repertoire of lesson structures and teaching styles, and the understanding of when one or another will be most appropriate for an increasingly complex set of educational objectives" (Cazden, 2001, p. 56).

In summary, within this study we draw on the everyday classroom interaction and reflections of a teacher in an urban school implementing a new science program. More specifically, we explore the uses of Spanish and English in this classroom and analyse it within the broader sociocultural context. Although at times our analysis focuses on an individual teacher, our emphasis is on the impact of this teacher's behaviour on the learner. Teaching processes affect "how students become involved in classroom interaction, the effectiveness of questioning-answering strategies on student understanding, and the relationship between students' participation of classroom goals and teacher-instructional discourse" (Rex, Steadman, & Graciano, 2006, p. 732).

The language in this classroom emerged as a critical tool for learning science. Ms. Cook summarised some of the key ideas we analysed as she spoke about the importance of social interaction. This quotation is Ms. Cook's response to a question about how she addresses students' struggles with English in understanding "what's going on in the classroom":

> The social part. I think that's the really – the biggest part is -–well, number one it's hands-on, they have to be doing. And, they have to be talking about what they're doing. And talking with other people that might have different levels of English always helps. And, not just English but different levels of knowledge and background

and all that kind of stuff. So that's – having the group is what really helps. (Interview #1 May 30)

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Manuscript received: May 15, 2009
Revision received: September 1, 2009
Accepted: September 10, 2009