Successes and challenges experienced by a teacher and her students engaging in scientific argumentation in a sheltered English instruction classroom

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The Next Generation Science Standards (NGSS) (NGSS Lead States, 2013), which were informed by recent research (NRC, 2012), have reconceptualized what it means to engage in science teaching and learning. Moving away from the traditional emphasis on students' knowing discrete facts by certain grade levels and participating in inquiry activities that were often only vaguely defined, the NGSS describe a three-dimensional view of science education that integrates science and engineering practices, crosscutting concepts, and disciplinary core ideas. This perspective recognizes the importance of science education encompassing both practice and content (Duschl, 2008; Kuhn, 1993), believing this combination to more appropriately reflect how scientific knowledge is accumulated, constructed and refined over time (Pruitt, 2014). However, this vision of science education will require a major shift in how science has been historically taught (Osborne, 2014; (Windschitl, Thompson, & Braaten, 2011) and understood, especially in terms of students comprehending how scientists have come to know what they know (Duschl & Grandy, 2013).

The expectations outlined in reform documents and standards increase the rigor of student learning, especially in the ways that they prompt students to actively participate in the learning process all the while developing a stronger understanding of the nature of science (Osborne, 2014). Moreover, these reform efforts are taking place during a critical time in the United States, particularly in terms of the rapid changes that are occurring in this nation's student demographics. For instance, the number of students who are identified by their schools as English language learners has increased nearly 80% in the past twenty years, despite an overall student enrollment increase of only 12% (Kindler, 2002). This trend is expected to continue, with projections that by the year 2020, 40% of the K-12 age population in this country will be children whose first language is not English (AACTE, 2002). This quick growth has resulted in English-learning students now constituting the fastest growing student population in the U.S. (National Center for Education Statistics, 2012). These changes in demographics are important to consider as states adopt and implement the NGSS in upcoming years, because engagement in the science practices outlined in these standards involves not only sensemaking skills, but language use as well (Lee, Quinn & Valdés, 2013). Ensuring implementation of the NGSS in ways that make them accessible to all students is particularly important in such a context. Teachers attempting to use these rigorous science reform standards will need to have strong understandings of not only the practices, but also of strategies for supporting all students in them, regardless of English proficiency levels.

However, despite expectations that all students engage in these practices, little prior research has focused on how such opportunities will be created for English-learning students, who have been historically underserved in science classrooms (Lee, Miller & Januszyk, 2014). Furthermore, the teachers of many English-learning students have received little to no preparation for providing the types of linguistic supports and instruction necessary for these students to succeed in school (Lucas & Grinberg, 2008). As such, to support these students' engagement in scientific practices, particularly in argumentation (which has been identified as being especially language-intensive by Lee, Quinn and Valdés, 2013), it is necessary to better understand the tensions and opportunities that arise in classrooms attending to both science learning and second language development. Consequently, embedded within Ms. Newbury's middle school sheltered English instruction science classroom, our work explores the challenges and successes experienced by this teacher and her English-learning students as they engage in scientific argumentation. This understanding is a necessary first step in developing instructional strategies and learning environments that promote high quality science instruction for all students.

THEORETICAL FRAMEWORK

To contextualize this study within the larger field of science education, we start by reviewing two areas of research. The first area draws upon studies of argumentation, discussing the role of this practice in science education. This section distinguishes between the structural and dialogic components of argumentation, both of which are necessary to consider when exploring teacher instruction and student engagement in this practice. Secondly, we review the research that exists on the science education of English-learning students, focusing on the United States context. This review concentrates on the critical role that discourse plays in science education, as well as how classroom discourse relates to the learning experiences of English-learning students. Furthermore, this section highlights factors that have been shown to influence these students' discourse experiences in the science classroom, factors that are important to take into account when studying English-learning students' argumentation experiences.

Argumentation in Science Education

In alignment with the perspective of numerous other researchers (e.g. Gee, 1990/2012; Lemke, 1990), we think of the classroom as a context in which the teacher and students engage in practices that are discipline-specific. In science, these practices relate to communally established and accepted norms that inform how science knowledge is built, refined and disseminated (Schwartz et. al, 2009; Duschl, Schweingruber & Shouse, 2007). Recent reform efforts in science education promote student engagement in such practices during their schooling as a means for not only learning scientific concepts and ideas (NGSS Lead States, 2013; NRC, 2012), but also for helping students better understand the nature of science (Lehrer & Schauble, 2006). However, adjusting classroom practices so that students play a more active part in the learning process, constantly constructing and negotiating their knowledge (Berland & Reiser, 2009), will require a great shift in traditional classroom roles (Jiménez-Aleixandre, Rodriguez, & Duschl, 2000). This shift impacts not only how teachers instruct and support their students, but also the ways that students drive the learning, both of which are impacted by established classroom practices (Berland, 2011). As such, it is important to consider both teacher and student roles when exploring their engagement in science practices, as well as the learning environments in which they are embedded.

Our work focuses on the practice of argumentation, one of the science practices emphasized in the NGSS (NGSS Lead States, 2013). Historically, this particular practice has been absent from science classrooms as education continues to primarily be seen as a process of information being transmitted from an expert (i.e. a teacher) to a novice (i.e. a student) (Osborne, 2010). Nonetheless, numerous arguments (e.g. Osborne, Erduran & Shirley, 2004) have been made for the importance of student engagement in argumentation as a means for improving the quality of science learning. Researchers in the field of science education have used various frameworks to conceptualize what argumentation is and what it means for a classroom community to be engaged in this practice (Sampson & Clark, 2008). Similar to others (e.g. McNeill & Pimentel, 2010; Jiménez-Aleixandre & Erduran, 2008), our study conceptualizes argumentation as encompassing both a structural and a dialogic component. In terms of structure, we consider the framework of an argument to include a claim, evidence, and reasoning (McNeill, Lizotte, Krajcik & Marx, 2006), where a claim is an answer to a question; evidence includes scientific data (i.e. accurate measurements and observations) that are both appropriate and sufficient in supporting the claim; and reasoning is an explanation of how the evidence supports the claim, which often includes scientific principles.

Furthermore, because scientific knowledge is socially constructed through the process of argumentation (Driver, Newton & Osborne, 2000), this practice plays an important epistemic role in scientific discourse (Bricker & Bell, 2008). As such, the dialogic component encompasses the actions people take when participating in argumentation. Specifically, this type of activity includes the dialogic elements of constructing and critiquing claims and their justifications (Ford, 2012). In a science classroom, this should include the teacher creating opportunities for students to articulate, either through writing or talk, their conceptual understandings of a topic. By making their thinking visible to their peers, other students can then challenge, question or build upon these understandings. Through such actions, the class develops a clearer conceptual understanding of the science. As noted by Newton, Driver and Osborne (1999), "In such a manner, knowledge is co-constructed by the group as the group interaction enables the emergence of an understanding whose whole is more than the sum of the individual contributions" (p. 554). Combining these structural and dialogic components, our work explored the successes and challenges that Ms. Newbury and her students encountered engaging in the discursive process of argumentation as they constructed and refined the structure of an argument.

Science Discourse and English-Learning Students

Because science discourse takes time to develop and support, teachers need to help students make connections between language expectations in various classroom contexts (Lemke, 1990). Engaging in classroom discourse, be it through writing or speaking, is important for students not only so that they can communicate their ideas to their teacher and peers, but, more importantly, so that they can build and refine their own knowledge (Michaels, O'Conner & Resnick, 2008). The examination of discourse thus provides an opportunity to explore not only how different classroom members engage in the construction of knowledge, but also who is (and who is not) participating in this process. However, even though scientific discourse plays a central role in the mediation of learning, the means by which to engage in this type of discourse are not innate (Kelly, 2007). Students of all backgrounds encounter difficulty when learning to effectively communicate and learn through scientific discourse (Wellington & Osborne, 2001). These difficulties tend to be further heightened for English-learning students (Goldenberg, 2008), as they are learning to navigate language practices of both science and English.

Engagement in the science practices described in NGSS, which require participation in classroom science discourse (Kelly, 2007), inherently involves intensive language use on the part of the students (Lee, Quinn & Valdes, 2013). For instance, students might be charged with the task of reading and analyzing a written argument, or engaging in a debate in which multiple perspectives are being orally disputed. Research on science discourse has addressed how this facet of learning relates to the experiences of all students, including those who have been traditionally marginalized. Specific to English-learning students, this work has highlighted the need for teachers to not only attend to the linguistic challenges these students might face in the science classroom, but more importantly to consider, appreciate, and tap into the linguistic resources that they bring into the classroom (Lee & Fradd, 1996; Ballenger, 1997). This includes permitting and encouraging students to use their native languages during instruction in order to engage in the classroom discourse (Rosebery, Warren & Conant, 1992). Brown & Ryoo (2008) have argued that teachers should make the norms of discursive science practices explicit to students as a means for facilitating students learning while maintaining cultural identity. Focused on the practice of argumentation, Honeycutt-Swanson, Bianchini and Lee (2014) found that high school-aged English-learning students also benefited from working in small groups, and from their teacher implementing deliberate language scaffolds into the lesson. In this present study, we take these different factors into consideration when exploring the successes and challenges that Ms. Newbury and her students face while engaging in argumentation.

Purpose of this Study

Exploring the tensions and opportunities that arise in teaching and engaging in argumentative discourse is especially critical with regards to the experiences of English-learning students, since they are expected to engage in this type of discourse using a language they are still in the process of developing. Despite the demands made in the NGSS for all students to engage in rigorous science learning, little research has explicitly examined argumentation as it relates to the experiences of English-learning students. Building upon prior work, our study was guided by the following research questions:

1. What are the experiences of a teacher and her students in a middle school sheltered English instruction science classroom as they engage in lessons designed to elicit scientific argumentation?
2. What factors influence the teacher and students' argumentation experiences?

METHODS

In the following sections we will describe the qualitative research methods that were utilized to develop a single case study of Ms. Newbury's classroom (Yin, 1994). Case study methodology provided an appropriate means for the exploratory nature of this work. Furthermore, this approach allowed us to develop a deeper understanding of the nuanced complexities of this middle school sheltered English instruction (SEI) science classroom. Although a single case study does not enable generalizations to be formed about all middle school SEI science classrooms, the descriptions of Ms. Newbury and her students' argumentation experiences shed light on challenges and successes teachers might encounter when engaging English-learning students in this science practice. Thus, this approach provides insights into a largely unexplored area of research with regard to understanding how to instruct and support English-learning students in the language-intensive practices promoted in the NGSS. Moreover, a case study will enable us to richly illustrate the circumstances of the learning environment that fostered or limited the teacher and students' argumentation experiences.

Curricular Context:

This study took place during the pilot of a middle school life science curriculum that was developed by the Learning Design Group at the Lawrence Hall of Science, a curriculum that purposefully interwove science and literacy instruction in order to support student engagement in science concepts across language modalities (Pearson, Moje & Greenleaf, 2010). Moreover, lessons in this curriculum were written to elicit student engagement in scientific argumentation. Ms. Newbury taught two life science units, *Microbiome* and *Metabolism* (Regents of the University of California, 2013). The first unit, *Microbiome*, which was comprised of 10 sessions, focused on bacteria and other microorganisms that live on and in the human body. During this unit, students explored the idea that changes in a person's microbiome result in alterations to that person's health, for better and for worse. Students also learned about fecal transplants, a medical treatment that involves using one person's healthy microbiome to cure another person who is suffering from a life-threatening infection called *C. difficile.* During the second unit, *Metabolism* (made up of 22 sessions), students explored how the human body systems work together at a cellular level in order to produce energy by getting matter to and from cells. During this unit students often used a metabolism simulation, which was run through a tablet computer, to investigate body systems that were and were not working properly (e.g. the body system of a person training to become an athlete, or the body system of a person with diabetes).

Taking into consideration language modality, activity structure and area of argumentation elicited and focused on (i.e. argument structure, or the dialogic process of argumentation), six target lessons were purposefully selected across both units. Regarding language modality, lessons were selected for prompting students to engage in argument using both receptive (i.e. reading and listening) and expressive (i.e. speaking and writing) language skills. In terms of activity structure, these lessons were chosen for engaging students in argumentation through various types of activities, such as completing an evidence card sort or writing a persuasive argument. Across all six lessons, there was an emphasis on both the structural and the dialogic goals of argumentation. Table 1 provides additional information on the target lessons.

Table 1: Description of target lessons

Unit/Lesson	Lesson Description
Microbiome Lesson 1.6	Students gather evidence through both an agar plate investigation and an evidence card-sort activity in support of the claim: Antibiotics cure infection by killing all types of bacteria in the body, including the harmful bacteria that cause the infection. During the card-sort, students differentiate between relevant evidence and irrelevant information in support of the claim, and articulate their reasoning explaining how the evidence connects to the claim.
Microbiome Lesson 1.9	Students individually write arguments to answer the question: How did a fecal transplant cure the patient who was infected with *C. difficile*? In preparation for the writing task, students compare and contrast two written arguments and engage in a discussion about the characteristics that make one argument more convincing than the other (i.e. organization of the evidence, and a description of how the evidence connects to the claim).
Microbiome Lesson 1.10	Students create persuasive video arguments that answer the question: Why did a fecal transplant cure the patient who was infected with the "killer" bacteria? Incorporating three different investigations conducted in a prior lesson, students collaborate to plan and execute their video arguments.
Metabolism Lesson 1.12	Students draw on evidence that they have collected over many sessions (through both readings and metabolism simulations) to write scientific arguments in which they support a claim about a fictitious patient, Elisa's, condition (e.g. Elisa does not have asthma OR Elisa does have asthma).
Metabolism	Students use a metabolism simulation to gather evidence to answer the question: When the body has to do extra cellular growth and repair, can it maintain the same activity

Lesson 2.8	level? Once students have gathered data they engage in a discussion about the lesson's guiding question, using evidence in support of the claims they are making.
Metabolism Lesson 2.10	Students engage in a science seminar in which they debate answers to the question: When a person trains to become an athlete, how does her body change to become better at releasing energy? Students are prompted to utilize data that they have collected from prior lessons (through both readings and metabolism simulations) when engaged in the debate.

Participants and Instructional Context

This study took place in a public school that served nearly 800 students in kindergarten through 8th grade. Located in a large urban district in the Northeast United States, the student population of the school was approximately 73% Hispanic, 15% White, 9% African American/Black, 2% Asian and 1% Other. Furthermore, 79% of the students were eligible for free and reduced lunch, and 50% were identified by the school district as English language learners. Influenced by requests from a large Spanish-speaking immigrant population that lived in close proximity to the school, there were long-term plans in place to slowly transform the school into a Science, Technology, Engineering, and Mathematics (STEM) English-Spanish dual-language school. This drive and initiative reflects the school's underlying commitment to students' retaining or regaining oral and written literacy in their native language, as well as their deep dedication towards students' science learning.

Because we were interested in learning how to better support English-learning students in the language-rich scientific practice of argumentation, the school district's science director identified Ms. Newbury as exhibiting expertise in this area. Ms. Newbury was a female, White teacher in her mid 30s who had been teaching SEI science for nearly 10 years. The SEI model is an instructional approach in which both content and language development objectives are simultaneously attended to in the classroom (Echevarria, Vogt & Short, 2008). Although Ms. Newbury was a native-English speaker, she often communicated with students and their parents in basic conversational Spanish, having studied the language during her own schooling. Ms. Newbury held a master's degree in education and was certified to teach middle school science. Although she did not possess English as a Second Language (ESL) certification, she had completed a series of professional development workshops that were intended to provide knowledge for effectively educating English-learning students. Additionally, Ms. Newbury had taken a Sheltered Instruction Observation Protocol (SIOP) training course that gave her further background on how to plan and deliver lessons that support English-learning students in acquiring academic knowledge as they develop English language proficiency.

The students in Ms. Newbury's SEI classroom were a mixture of 6th and 7th graders whose English proficiency levels had been identified as either Level 1 (Entering) or Level 2 (Beginning), as classified by the World-Class Instructional Design and Assessment (WIDA) English Language Development Standards (WIDA Consortium, 2004). These standards range from Level 1 (i.e. Entering) to Level 6 (Reaching). While some of the students were new to Ms. Newbury's instruction, namely the 6th graders, others had been in her class the previous academic year. This heterogeneous grouping, in terms of both grade levels and English language proficiency, was due to Ms. Newbury being the only middle school SEI science teacher at the school. As such, English-learning students in grades 6-8 were placed in content classes according to language proficiency levels. The students in Ms. Newbury's classroom were all native Spanish speakers from various countries in Central or South America, most having immigrated to the

United States within the last few years. Ms. Newbury's enactment of the pilot curriculum lasted approximately 4½ months. During these months both the size of the class, as well as the students in the class, varied. Table 2 illustrates the students in Ms. Newbury's classroom during the six different target lessons.

Table 2: Students in Ms. Newbury's SEI science classroom across lessons

	Target Lesson					
Student	*Microbiome* Lesson 1.6	*Microbiome* Lesson 1.9	*Microbiome* Lesson 1.10	*Metabolism* Lesson 1.12	*Metabolism* Lesson 2.8	*Metabolism* Lesson 2.10
Guadalupe	X	X	X			
Beatriz	X	X	X	X	X	
Penelope*	X	X	X	X	X	X
Soledad*	X	X	X	X	X	X
Marina*	X	X	X	X	X	X
Teresa*	X	X	X	X	X	X
Marco*	X	X	X	X	X	X
Juanita	X	X	X	X	X	
Adriano			X	X	X	X
Jaime				X	X	X
Rosario				X	X	
Sebastian				X	X	X
Daniela				X	X	X
Valentina						X
Camila						X

*Students selected for interviews

The fluctuation that is seen in the table above is a result of the nature of SEI programming; as students' English proficiencies improve, they are transitioned to classrooms that better address their linguistic needs. Specifically at this school, when a student reached a Level 3 (Developing) English proficiency they were transitioned out of SEI programming and into mainstream content classes. The first two students that are listed in Table 2, whose names are un-shaded (Guadalupe and Beatriz), were moved from Ms. Newbury's class because their English proficiency levels advanced and exceeded a Level 2. The five students that follow, whose names are shaded in a similar light grey hue (Penelope, Soledad, Marina, Teresa, and Marco), were the only students present for all of the target lessons. Juanita was in attendance for five of the target lessons but missed the final one due to illness. The remaining seven students were transitioned into Ms. Newbury's classroom at various points throughout course of the study. Before entering Ms. Newbury's class these students had been receiving instruction in a classroom specially tailored to meet the needs of recent immigrants.

Data Collection

Multiple data sources were collected for this study including classroom videotapes, student artifacts, and teacher and student interviews. The first two class periods of all six lessons were videotaped, and student artifacts related to each lesson were collected. The first two class periods per lesson were selected because they captured Ms. Newbury's introduction to the lesson and argumentation tasks, and also included footage of student engagement in these particular argumentation activities. This resulted in approximately 7½ hours of videotape that were analyzed. The student artifacts included copies of students' Investigation Notebooks (for the *Microbiome* Unit) and Consultant Notebooks (for the *Metabolism* Unit) for the target lessons.

Additionally, Ms. Newbury was interviewed seven times throughout the study, once before the start of the study and once after each target lesson, with each interview lasting approximately 30-45 minutes. The purpose of these interviews was to learn more about her ideas around supporting English-learning students in argumentation, and to discuss her enactment of each lesson and the instructional decisions she made throughout the lessons. Finally, five students were selected for a post-study interview, with each interview lasting about 10-15 minutes. Student selection for these interviews was based on having been present for all of the target lessons (see Table 2 for details). These interviews focused on students' understanding of argumentation as well as to how these understandings were shaped by their engagement in the target lessons. Given the linguistic needs of Ms. Newbury's students, as well as their comfort and proficiency in speaking in English, at the beginning of each interview students were asked what language(s) they wanted the interview conducted in (i.e. English, Spanish, or both). Two students asked for the interview to be conducted in English, two in Spanish, and one student alternated between both languages. This accommodation was possible as a result of the first author being a native Spanish speaker herself. Both the teacher and student interviews were conducted using a semi-structured interview protocol, and all interviews were audiotaped, transcribed, and translated (when applicable) for analysis.

Data Analysis

In analyzing the data, we were ultimately interested in exploring the argumentation experiences that occurred in Ms. Newbury's SEI science classroom, as well as the factors that may have influenced these experiences. Consequently, while analysis of the videotaped target lessons and student artifacts helped answer *what* the teacher and students' argumentation experiences were (i.e. research question #1), the analysis of the teacher and student interviews helped answer *why* these experiences may have occurred (i.e. research question #2). Table 3 shows the data sources that were used to inform each of the study's research questions.

Table 3: Data sources in relation to research questions

Research Questions	Data Sources			
	Videotaped Lessons	Student Artifacts	Teacher Interviews	Student Interviews
1. What are the experiences of a teacher and her students in a middle school sheltered English instruction science classroom as they engage in lessons designed to elicit scientific argumentation?	X	X		
2. What factors influence the teacher and students' argumentation experiences?			X	X

Our analysis began with the classroom videotapes for the six target lessons. In examining these videotaped lessons, we were interested in how the teacher and students engaged in argumentation. We explored these experiences in two different ways. First, we focused on the quality of the teacher and students' argumentation. We developed a coding scheme for such an analysis using the theoretical framework, as well as an iterative analysis of the data (Miles & Huberman, 1994). For each lesson, the teacher and students' argumentation across both the structural and dialogic aspects of this practice was coded in terms of presence and quality (i.e. present and of high quality, present and of low quality, not present). Two independent raters coded each video using this coding scheme, and obtained 82% reliability. Any disagreements about coding were resolved through discussion.

Furthermore, as informed by the literature regarding English-learning students' experiences with science discourse (e.g. Lee & Fradd, 1996), and argumentation specifically (e.g. Honeycutt Swanson et al., 2014), our goal was to examine how the teacher and students' engagement in this practice related to the second language supports that Ms. Newbury employed. As such, descriptive coding (Saldaña, 2013) of the video was used to identify and inventory the second language scaffolds (e.g. providing sentence starters for the various structural elements of an argument, and simplifying a complex claim to key words) that Ms. Newbury implemented to support her students' engagement in argumentation during the target lessons. Using this analytical technique, two independent raters re-watched each video and coded it with regards to this feature. Afterwards, these raters met to discuss and categorize their inventoried accounts of these codes. Specifically, second language supports were classified as supporting either receptive (reading and listening) or productive (speaking and writing) language skills, as they related to students' argumentation engagement. Moreover, when synthesizing these language supports we took note of which area(s) of argumentation they supported (i.e. argument structure, dialogic argumentation or both).

The data reduction that resulted from coding the videotaped lessons across both argumentation and second language supports led to the emergence of preliminary themes focused on the teacher and her students' argumentation experiences. The validity of the preliminary themes was tested by looking for confirming and disconfirming evidence from the multiple data sources (Erickson, 1986), namely the videotaped lessons and the student artifacts. Furthermore, because we were interested in the teacher and students' accounts of what influenced their argumentation experiences, we were open to emergent patterns in their interviews about the factors that impacted these experiences (Marshall & Rossman, 1999). In analyzing the interviews, the first author engaged in initial coding (Saldaña, 2013), iteratively reading through all of the transcripts, making note of sections of the interviews that related to the second research question. Following this first cycle of coding, the first author grouped these initial codes into patterns, which became evident through the reoccurring ideas expressed and the language used by the teacher and students in the interview transcripts (Miles & Huberman, 1994). Once identified, the first author shared the patterns with a research assistant who read all of the interview transcripts in order to see whether she agreed with the interpretations that were made. Overall, the research assistant found these patterns to be consistent with the interview transcripts. The few disagreements that arose related to whether there was sufficient evidence from the interview transcripts to support the patterns observed. Following these discussions, during which a few patterns were dropped if unsupported by sufficient evidence, we arrived at a clearer focus of the analytic work.

RESULTS

This section, presented in two parts, characterizes the argumentation experiences that occurred in Ms. Newbury's classroom. We will first describe the successes and challenges experienced by Ms. Newbury and her English-learning students as they engaged in the six target lessons that were designed to elicit scientific argumentation. These experiences will be discussed in terms of the three themes that emerged from the data analysis (see Table 4). The first two themes stemmed from Ms. Newbury's argumentation instruction, as seen primarily through the videotaped lessons. The third theme however emerged from students' argumentation engagement as evidenced in both the videotaped lessons and the student artifacts for those lessons.

Table 4: Themes around Ms. Newbury and her students' argumentation experiences

Theme 1	The second language scaffolds that Ms. Newbury provided most often focused on supporting students' understanding and use of the structural elements of an argument (i.e. claim, evidence, and reasoning)
Theme 2	When engaging students in the dialogic components of this scientific practice, Ms. Newbury provided few and often contradicting messages regarding student expectations.
Theme 3	Students' use of evidence for justifying a claim appeared to be a classroom norm, however their inclusion of reasoning occurred less frequently, and often only after being prompted for by Ms. Newbury.

Then, in the second part of this section we will discuss the factors that influenced these experiences. Specifically, we found that patterns from the interviews fell into two general categories describing factors that influenced Ms. Newbury and her students' argumentation experiences (see Table 5).

Table 5: Factors that influenced Ms. Newbury and her students' argumentation experiences

School Level Factors	A school-wide initiative to incorporate the claim-evidence-reasoning framework into writing across all subject areas resulted in the teacher and particular students having more familiarity with the structural aspects of argumentation.
Individual Level Factors	The limited understanding that both the teacher and students had of reasoning and the dialogic components of argumentation, influenced how these aspects were enacted in the classroom.

The school level factors stemmed from an initiative that had been implemented at the school the previous year around incorporating the claim-evidence-reasoning framework into academic writing tasks across subject areas (e.g. math, science, social studies, English language arts). The individual level factors emerged from the ways that the teacher and students' limited understanding of certain aspects of argumentation – namely reasoning and the dialogic components – impacted the ways that this practice was enacted in the classroom.

Part I: Ms. Newbury and her Students' Argumentation Experiences

Theme 1: The second language scaffolds that Ms. Newbury provided most often focused on supporting students' understanding and use of the structural elements of an argument (i.e. claim, evidence, and reasoning)

As a science teacher in a SEI classroom, Ms. Newbury employed many second language supports to make the argumentation more accessible to her English-learning students. Occurring more frequently during the *Microbiome* unit, these second language supports primarily focused on the structural elements of an argument as opposed to its dialogic goals. For instance, in *Metabolism* Lesson 1.6, the students engaged in a card sorting activity in which they differentiated between cards that represented relevant evidence and irrelevant information in support of a claim. In the case of this lesson the claim was – Antibiotics cure infection by killing all types of bacteria in the body, including the harmful bacteria that cause the infection. During this lesson, Ms. Newbury employed two different language supports that enabled students to successfully engage in the argumentative task. First, she took the time to discuss with students the meaning of the word *relevant*, a term whose understanding was vital in order to accomplish the activity. The transcript in Table 6 was taken during this classroom conversation.

Table 6: French Fries Analogy from Microbiome Lesson 1.6

- Ms. Newbury: In order to make the most persuasive argument possible, we're going to need to make sure we're only using information that is relevant. Okay? We've sort of talked about this word before, it's a really important word [Walks over to the white board and writes the word relevant on it] when you're talking about claim, evidence, and reasoning. Okay. What does it mean? Everybody take a second, talk to your partner, what does relevant mean?

[Students are given approximately 45 seconds to talk with a partner about the meaning of the word relevant. Once they come back together as a class, students continue to struggle with the meaning of the word, explaining it to mean "declarative."]

- Ms. Newbury: I can be declarative without being relative. For example, let me give you an example. You guys are trying to learn more about me, right, and you ask me where I'm from. Right? Marina, ask me where I'm from.
- Marina: Where are you from?
- Ms. Newbury: Oh, I really like to eat french fries.
- Guadalupe: That is not relevant.
- Ms. Newbury: But it is declarative. Right? I'm telling you something that I believe is true. I like to eat french fries, but it doesn't answer the question, right?

After this discussion, Ms. Newbury went on to explain why liking french fries was not relevant to the question that had been asked. She said, "I'm telling you something that I believe is true. I like to eat french fries. But, it doesn't answer the question…you asked me about me. I gave you information about me. But, it's not really connected to the question." (17:11) Ms. Newbury used the french fries analogy throughout the lesson to remind her students of both the meaning of the word, but also the importance of using relevant evidence to justify a claim. For instance, later on in the lesson, while the students engaged in the card sorting task, the teacher was heard using this analogy to help a pair of students who were having challenges with a particular card. Ms. Newbury said:

> *Does the information on the card directly relate to, or connect to, our claim. Alright? Does it answer the question or is it french fries? Okay? And remember, we need information not just about bacteria, but also about how bacteria are affected by antibiotics. Make sense? (53:35)*

The other second language support that Ms. Newbury employed during this activity was simplifying the lesson's guiding claim to three key words: *antibiotics*, *kill* and *bacteria*. The teacher identified the need for this support while circulating the classroom as students engaged in the card sort, realizing that some students were having difficulty comprehending the claim. The transcript in Table 7 is of Ms. Newbury reminding students of this simplification during the card-sorting task.

Table 7: Simplification of the Claim from Microbiome Lesson 1.6

- Ms. Newbury: What are we looking for? What is the, if you had to put this claim into three words, what would you say?
- Beatriz: Antibiotics kill bacteria.
- Ms. Newbury: *[Pointing at a card in a student's hand]* So, is this evidence for that? Is it relevant? Does it talk about antibiotics killing bacteria? *[Students nod their heads]* Okay, so it's relevant evidence.

Simplifying the language of the explanatory claim enabled her students to not only understand the claim, but also determine whether a card from the card sort provided supporting evidence for it. This is exemplified in the conversation captured in Table 8, which occurred between two students as they engaged in the card sort.

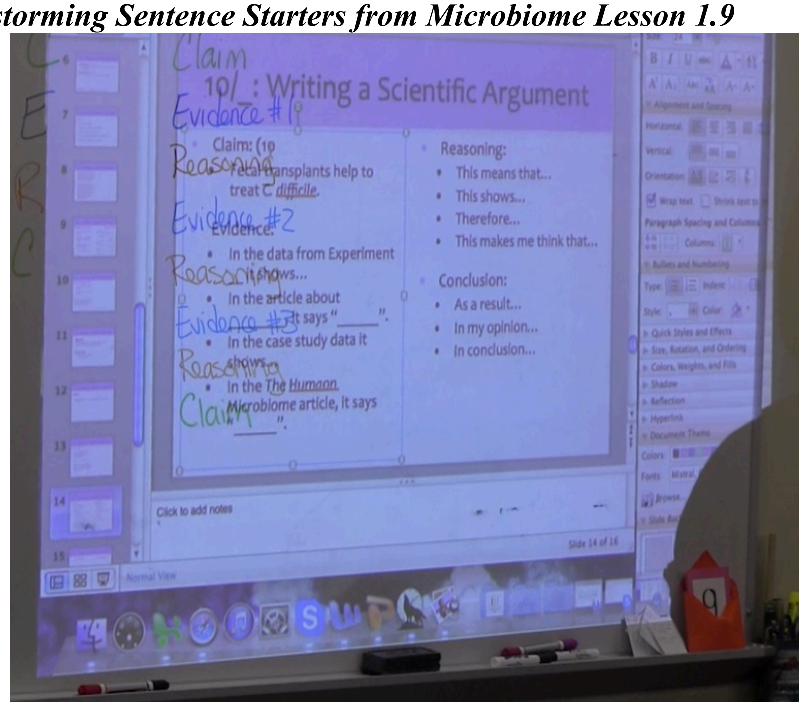
Table 8: Students Using the Simplified Claim to Engage in the Card Sort

- Juanita: ¿Irá esta aca? (*Does this one go here?*) [Student places card in irrelevant pile.]
- Marina: [Student reads aloud the card] "Unfortunately, not all bacteria are helpful. Harmful bacteria can invade the human microbiome through cuts, spoiled food, and even the air we breathe. An invasion of harmful bacteria is called an infection, and infections can make people very sick."
- Juanita: [Student chimes in and finishes reading aloud the card with the other student] – "make people very sick." I think this here [Student points to irrelevant pile] because doesn't support the claim.
- Marina: Why?
- Juanita: [Student rereads card] Because dice (*it says*) [student reads off card] "unfortunately not all bacteria are helful, helpful. Harmful bacteria can invade the human microbiome through cuts, spoil food, microbiome through cut." I think, yo no puedo hacer bien la cosa esta. (*I can't do this thing well*)
- Marina: Okay, I think here is [Student points to cards in irrelevant pile] here are information because they are like not connecting in the claim because they don't have any antibiotics and kills and bacteria [student points to cards in irrelevant pile], like [card] B right? And here [student points to cards in the relevant evidence pile] they have, we have to see and read if they are [student points to claim card] antibiotics killing bacteria. And here this say [student points to card in relevant evidence pile] antibiotics kill bacteria, that's why it's here.

During the activity, Juanita had a difficult time sorting one of the cards and expressed her frustration to her partner, which in turn prompted Marina to use her developing English to support Juanita. During this explanation, not only did Marina correctly sort the card as supporting evidence for the claim – using the language of the simplified claim that Ms. Newbury guided students in identifying – but she also provided some reasoning to why the evidence supported the claim.

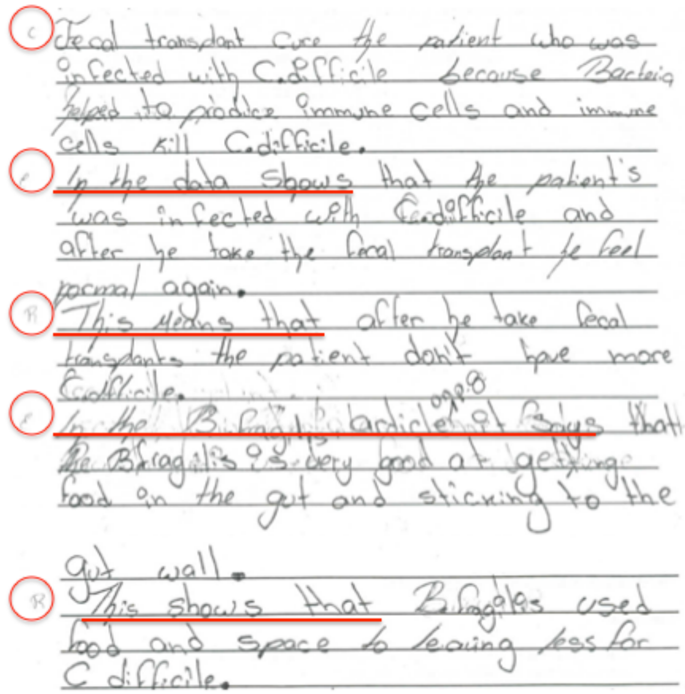
The language scaffolds that Ms. Newbury implemented to support her students' use and understanding of the structural elements of argumentation occurred across productive language modalities (i.e. writing and speaking). For instance, in *Microbiome* Lesson 1.9 students wrote arguments answering the question – How did a fecal transplant cure the patient who was infected with C. difficile? To support students' writing, Ms. Newbury spent nearly twenty minutes holding a discussion with her students about the various phrases one could use when discussing the structural components of an argument (i.e. claim, evidence, and reasoning). During this lesson, the teacher projected her computer screen onto the front board and took notes as students brainstormed different sentence starters that they could use when writing their arguments. Figure 1 includes a screen shot of the projected screen where Ms. Newbury recorded students' ideas.

Figure 1: Brainstorming Sentence Starters from Microbiome Lesson 1.9



As seen in Figure 1, Ms. Newbury made sure to distinguish whether the sentence starters aligned with the claim, evidence or reasoning. This image also illustrates the teacher making transparent for her students the manner by which a written argument is organized, using different colored markers to indicate the different structural components (e.g. claim, evidence #1, reasoning, evidence #2, reasoning, etc.). It was evident from students' work that this support helped them organize and write their arguments. For instance, Figure 2 shows part of Beatriz's written argument. As seen in the image, Beatriz incorporated sentence starters into her writing (i.e the underlined phrases) and even marked her own argument in terms of structural features (i.e the C, E, R, E, R markings in the margin).

Figure 2: Student Writing from Microbiome Lesson 1.9 Showing Use of Sentence Starters



It was not uncommon to see students' use this language support in their writing. In fact, sentences starters that the class brainstormed and markings of the structural features of an argument were seen in the written arguments of seven of the eight students that were in Ms. Newbury's class during *Metabolism* Lesson 1.9.

Theme 2: For engaging students in the dialogic components of this scientific practice, Ms. Newbury provided few and often contradicting messages regarding student expectations

Compared to the instructional moves used to emphasize and highlight the structural components of an argument, Ms. Newbury engaged in fewer moves focused on the dialogic process of argumentation. Despite the curricula being written to elicit all aspects of argumentation, throughout the six lessons there were few instances during which Ms. Newbury attended to the idea that engaging in argumentation necessitates students critiquing and questioning one another's arguments, as well as listening to and building off of each other's ideas. Moreover, when this dialogic component was identified in the videotaped lessons, it was coded as being of low quality. Specifically, this aspect of argumentation was only seen in two of the six target lessons, and primarily in *Metabolism* Lesson 2.10, which entailed students engaging in a science seminar debating answers to the question- When a person trains to become an athlete, how does her body change to become better at releasing energy? Before beginning the science seminar, Ms. Newbury used a number of instructional moves to try and encourage this type of student-driven interaction. Table 9 illustrates part of the discussion when she introduced the student expectations for the seminar.

Table 9: Ms. Newbury Introducing the Science Seminar from Metabolism Lesson 2.10

- Ms. Newbury: So during the seminar you'll be talking to each other, not to me. Remember to be respectful and to really listen to what everyone has to say. If you're not speaking, what should you do? Everybody.
- Students: Listen.
- Ms. Newbury: Listen. Is it okay to go [makes whispering sound] to your neighbor while somebody else is talking?
- Students: No.
- Ms. Newbury: It's really not. Okay, so today the way it's going to work is I'm going to start the conversation, we're going to come to this U of chair [points to the back of the room]—everybody see the chairs? —Everybody's gonna grab a seat, you do not need to sit with the people you worked on the studies with, it's probably better if you don't, okay, so you can share your ideas better. As much as possible, you guys are gonna run the discussion. That means if there's a long period of silence, somebody needs to think of something to say, or a question to ask. Right? Yes?
- Students: Yes.
- Ms. Newbury: If we need to sit for thirty minutes of silence that will really be boring. Yeah? I'll help out once in a while but mostly this is up to you. Okay? It's really okay. This is your time to control the conversation and to share your expertise about this topic. You have a lot of ideas, this is your time to come together as a team to build the best explanations about how athletic training changes the body. Yes? Alright.

In the sample transcript in Table 9, Ms. Newbury emphasized that the students would be in charge of the discussion during the science seminar (i.e "As much as possible, you guys are gonna run the discussion. That means if there's a long period of silence, somebody needs to think of something to say, or a question to ask"). She made it clear that they should not be talking to her nor looking at her for guidance during the discussion.

Furthermore, Ms. Newbury encouraged students to question and critique one another's contributions. For example, after a student, Marina, shared evidence for her argument, and a few seconds passed with no student responding, Ms. Newbury prompted and modeled how students could question one another. She said:

> *Does anyone have a question for Marina? So I'll give you an example of a question I am looking for. So Marina, I heard you say that when you exercise three hours your heart pumps, I think it was 19 liters? [Marina responds "yes"] Okay, and when you exercise twelve hours your heart pumps 21 or 22 liters. Why does that matter, how much blood the heart pumps?* (26:22)

However, at other times in this lesson Ms. Newbury used contradictory instructional moves related to this aspect of argumentation. During other instances of silence following a student's contribution, the teacher switched the emphasis of the seminar and prompted students to simply share out their ideas. Table 10 illustrates such an instance.

Table 10: Contradicting Messages during the Science Seminar in Metabolism Lesson 2.10

- Teresa: I think when a person trains to become an athlete her body change to become better at releasing energy by heart pumping more blood. In the data it shows that in subject one, a non-athlete is .04 and in subject one, an athlete it shows that is umm .07. That decrease by 3 more mito-micro-mito [inaudible]. Okay, if the heart pump faster, the blood move faster it can make more energy because the blood help pump glucose and oxygen to get to the cells. That makes more energy because when glucose and oxygen get to the cells goes to the mitochondria and that release more energy.

[10 seconds of silence pass by during which two students turn around to look at the teacher]

- Ms. Newbury: Don't look at me. Look at Teresa. What did you think about what Teresa said?

[Nearly 15 seconds of silence pass by]

- Ms. Newbury: Are you kidding me? Brave Teresa spoke for 3 minutes and nobody's going to respond to her? I agree with that, I wonder about, can you explain? You guys can do better than that. You know what, we're just going to go around the circle. Daniela, you're next. You can respond to Teresa or you can say your own.

Here, Ms. Newbury changed the emphasis of the science seminar (i.e. "You know what, we're just going to go around the circle. Daniela, you're next."). By directing students to go around the circle and take turns presenting their arguments, instead of encouraging them to ask each other questions or build off one another's ideas, the teacher offers instruction that opposes the underlining objectives she had earlier stated of the seminar. Furthermore, at other points of silence during the seminar, Ms. Newbury used other contradictory moves, such as prompting students to simply repeat back what they heard their peers share, using the phrase "I heard you say that ___". The conflicting teacher moves that occurred during the lesson were not in line with the dialogic goals of argumentation, and subsequently influenced how students engaged in the seminar, rarely driving the conversation nor interacting with one another in productive ways (e.g. questioning and building off of one another's ideas). Moreover, for the entirety of the science seminar, which lasted approximately twenty-five minutes, there were few instances of students interacting with their peers' ideas. For the most part, the discussion was driven by the teacher, and most interactions happened to and through Ms. Newbury.

Theme 3: Students' use of evidence for justifying a claim appeared to be a classroom norm, however their inclusion of reasoning occurred less frequently, and often only after being prompted for by Ms. Newbury

Across all six lessons, some students used evidence to support their claims, and in five of the lessons also provided reasoning. For instance, during *Microbiome* Lesson 1.10 students worked in groups of three or four to design and make a video that argued why fecal transplants should be legal. While students filmed their messages, one student was heard saying, "In the case study it shows in week 7 that the microbiome is sick and in week 9 they treat with fecal transplant. And then after the fecal transplant all the bad bacteria is gone" (V3 3:18). This student used data from the case study patient to justify that the fecal transplant treatment had been successful in killing the deadly C. difficile bacteria. Other students' videos were not as easy to hear because groups were spread out around the room and in the hallway. Nonetheless students in a few groups were seen holding up and referencing their student notebooks, specifically pie charts of the case study patient's microbiome during the treatment process, while filming their arguments. By referencing these charts during their oral arguments, these students also utilized evidence in support of the claim they were making.

Students also used the structure of evidence and reasoning when constructing arguments in larger group settings. For instance, in *Metabolism* Lesson 2.10, students engaged in a science seminar during which they debated how energy is released in the body, and the effects that exercise has on this energy release. Table 11 includes a transcript from this science seminar.

Table 11: Science Seminar Discussion from Metabolism Lesson 2.10

- Marina: [Reading from her notebook] I think that when a student tries to become an athlete her body change to become better -- [interrupted by the teacher]
- Ms. Newbury: Look at Marco. Talk to Marco, he can't hear you. You have beautiful ideas, I'm 100% confident in you, sit up straight, talk to Marco, okay? You can do this.
- Marina: When a person tries to become an athlete her body changes to become better at releasing energy by pumping blood. Umm my umm the data shows that umm—
- Ms. Newbury: You can look at the data Marina if you don't remember.
- Marina: That before the [inaudible] was just three hours a week and when amount of blood heart pumps was umm like three li-liters.
- Ms. Newbury: Liters is right.
- Marina: Liters per week. So in the first in the evidence shows like 19 then after day thirty was exercise 12 hours. So then the pump shows that the amount of blood heart pumps per one minute was the average was twenty-two.
- Ms. Newbury: Does anybody have a question for Marina? So I'll give you an example of a question I'm looking for. So Marina, I heard you say that when you exercise three hours your heart pumps, I think it was 19 liters?
- Marina: Yes.
- Ms. Newbury: Okay, and when you exercise twelve hours your heart pumps twenty-one or twenty-two? [Student replies "twenty-two"] Twenty-two liters. Why does that matter, how much blood the heart pumps?
- Marina: Cuz, that matter because umm—
- Ms. Newbury: There were many other people that read about this study, right? Teresa, wanna jump in and help her out?
- Teresa: [Talking towards the teacher] That help because umm—
- Ms. Newbury: Talk to Marina, okay?
- Teresa: That help because when the blood pump faster it help the glucose and oxygen get to the cells and then when they are in the cells they get into mitochond— [Teacher helps student pronounce mitochondria] and that help to produce energy.
- Marina: Okay.

During this section of the seminar discussion, Marina provided evidence for her claim (e.g. the amount of blood the heart pumps per minute increased from 3 to 22 liters with exercise). However, prior to the teacher prompting, she had not included an explanation of how that evidence related back to her claim—the reasoning. After being prompted and helped by her peer (namely, Teresa), the reasoning for that particular argument was articulated. Throughout the science seminar, this example transcript more accurately exemplifies the students' use of the structure of argumentation; they frequently used evidence to support their claims, and only after being prompted by the teacher did they explain why they felt their evidence justified their claim. As such, while the use of evidence was a norm of classroom discussions, the inclusion of reasoning was less frequent.

Another example that illustrates this theme occurred during *Metabolism* Lesson 1.6, the lesson in which students sorted cards as either relevant evidence or irrelevant information in support of the lesson's guiding claim. Prior to the card sorting task Ms. Newbury articulated the importance of explaining reasoning by stating the following:

> *In science making an argument is not just about stating something you think is true. It's also about describing how you know it's true. Alright? We've talked about this many, many, many times. Yes? What's more important the answer, or how you know it's true? (13:27)*

Throughout the lesson Ms. Newbury pushed students to explain their reasoning, describing this aspect to be more important than the card sort decision itself. While students engaged in the card-sorting task, the teacher circulated the room prompting students to explain why they placed the cards in the piles that they did. For instance, after a pair of students finished their card sort quickly, having simply gone through all of the cards and placed them in piles, Ms. Newbury walked up to them and said:

> *So now that you have a general idea of where you want to put things, remember that the most important thing that I wanna know is why you think what you think. Right? So go back and talk about each one. Make sure everybody can explain to me why. (57:58)*

As a result of her doing so, students began to clearly explain how they knew cards to be relevant supporting evidence. Moreover, after consistently reinforcing that students should be articulating their reasoning, students were seen prompting each other to do so. The student exchange in Table 10 shows Marina pushing her partner, Juanita, to explain why she wanted to sort a card in a particular way. However, had Ms. Newbury not prompted students to explain their reasoning, and frequently emphasized the importance of doing so in science, it is unlikely that her students would have be seen doing so in this lesson.

Part II: Factors that Influenced the Argumentation in Ms. Newbury's Classroom

In the second part of the Results Section we discuss the factors that influenced the experiences previously described (see Table 5 for a summary of these factors). From our analysis we found that these factors grouped into two categories, specifically at the school and individual level. Because of the interrelated nature of these findings, we will use examples that illustrate how these factors influenced a specific theme (see Table 4 for a summary of these themes), but also examples that show how these factors influenced multiple themes. By presenting our work in this manner we intend to provide a richer understanding of the circumstances under which Ms. Newbury's class engaged in argumentation.

School Level Factors

It became apparent during Ms. Newbury's pre-interview that the middle school teachers at the Amani Academy had already been thinking about how to engage and support their students in argumentation (more generally) across the content areas. During this interview Ms. Newbury informed us that prior to the year of this study, the school had begun developing a cross-disciplinary initiative to attend to the practice of argumentation. Specifically, she said:

> *Last year umm my team, the other teachers who teach the same students than I do, social studies, ESL and to some extent math, but mostly just science, social studies and ESL, those teachers, we got together and umm developed sort of a common framework for teaching claim, evidence and reasoning. (8:51)*

We found that this school-wide initiative influenced the teacher and student experiences in a few different ways. In terms of the teacher, this initiative resulted in Ms. Newbury having more familiarity with the structural aspect of argumentation, and less with the dialogic component (which we will speak to momentarily – and more thoroughly – in terms of how this limited understanding influenced Theme 1).

Furthermore, as this practice was mostly integrated into classrooms through writing, Ms. Newbury was more comfortable instructing and supporting her students around argumentation through this language modality. During the pre-interview she discussed a rubric had been created (in collaboration with her colleagues) for evaluating students' written arguments. Given the English-learning student population that her team of teachers worked with, they made sure to develop this rubric taking English proficiency development into account. As Ms. Newbury explained:

> *We developed a rubric for SEI kids, the ELLs, on, that's got five different categories with a five point scale in each category so that we can really track small, umm, we can really focus on one thing at a time. That was our goal while we were doing that. (10:54)*

The categories in the rubric that Ms. Newbury discussed included the structural features of an argument – claim, evidence and reasoning – as well as a category called "conclusion" (which was articulated as a restatement of the claim) and another labeled "vocabulary" (which focused on English proficiency markers, such as the degree to which students were using content-specific language correctly).

The school-wide focus on the structural aspects of argumentation likely impacted the areas in which Ms. Newbury instructed and supported her students. One area where we saw this occur was in the second language supports that the teacher utilized throughout the target lessons. The vast majority of these scaffolds, which occurred predominantly during the *Metabolism* unit, most often revolved around supporting students' understanding and use of the structural elements of an argument (i.e. Theme 2). For instance, during *Metabolism* Lesson 1.6, Ms. Newbury simplified the lesson's guiding claim to "antibiotics kill bacteria" in order to help her students better comprehend and engage in the evidence card sorting task. In *Metabolism* Lesson 1.9, the teacher analyzed a model written argument to not only illustrate her expectations for students' writing, but also to highlight features of a written argument that make it more persuasive (in this case organizing evidence in a coherent manner, and explaining how the evidence relates to the claim). Then, in the same lesson she guided students in brainstorming sentence starters for the various structural components of an argument (see Figure 1). It was critical that Ms. Newbury included these linguistic supports in lessons, especially since her students benefited from them and were subsequently able to engage in the activities more meaningfully. However, the lack of second language supports focused on the dialogic components of argumentation resulted in her students participating less frequently in that aspect of this practice.

The Amani Academy's claim-evidence-reasoning cross-disciplinary initiative also impacted the students in Ms. Newbury's classroom, specifically with the degree to which students' were familiar with the practice. At this particular school, Ms. Newbury was the only middle school SEI science teacher, which meant that unless students transitioned out of SEI programming or moved to another school altogether, she was their science teacher for three consecutive years (6^{th}, 7^{th}, and 8^{th} grade). Since our case study classroom had a mixture of 6^{th} and 7^{th} graders, Ms. Newbury's 7^{th} graders had received instruction about an argument's structure from her the previous year, while this practice was newer to the 6th graders. During the post-lesson interview following *Microbiome* Lesson 1.9, Ms. Newbury spoke to this discrepancy:

> *I have two different groups who are at two different places. My seventh graders were taught a lot of it last year. My sixth graders haven't seen it before except if they've seen it, maybe once or twice in September and October of this year, they haven't had a lot of practice with it. Whereas my seventh graders got it in all of their classes last year too. So they're sort of much further ahead…They're further ahead because they've had it for a year.(7:46)*

In this description, Ms. Newbury voiced how some students' prior learning about the structure of an argument might influence their experiences with this practice in her classroom.

Student interviews supported this idea. When students were asked to explain what they knew about the practice of argumentation, which the Amani Academy referred to as CER (i.e. claim, evidence, reasoning), their responses ranged widely. For example, 6th grader Soledad replied, "Siempre hay que escribir one claim, three evidence and three reasoning. Umm y no sé que más" (You always have to write one claim, three evidence and three reasoning. Umm and I don't know what else) (0:42). Similarly, 6th grader Penelope said, "Argumentación es como umm I don't know how to explain…argumentación es un claim?" (2:32) (Argumentation is like umm I don't know how to explain… argumentation is like a claim?) On the other hand, the 7th graders' responses showed a slightly more advanced understanding. For instance, 7th grader Teresa said, "So first the claim is what you think. And the evidence is what you see, what you touch and what you smell. And reasoning is umm, it's like why the claim make you think." (0:25). Likewise, when 7th grader Marco was asked the same question he replied, "CER claim, evidence, reasoning. Claim is like what you think, and evidence is like to support the claim, and reasoning is like umm like umm I forget about reasoning." (0:23) These student quotes illustrate differences in students' understanding of argumentation; while 6th graders Soledad and Penelope – both of whom were new to Ms. Newbury's classroom – only mentioned the terms related to the structural aspects of an argument (i.e. claim, evidence and reasoning), 7th graders Teresa and Marco – both of whom had been in Ms. Newbury's class since the previous year – were able to not only articulate but also describe each of the structural components of an argument (except for reasoning, which all students had more trouble with). It is important to note that students' descriptions of argumentation focused on the structural aspects of this practice, and not on the dialogic elements, an issue that likely impacted the individual level factors that we will now turn to discussing.

Individual Level Factors

The argumentation experiences that took place in Ms. Newbury's classroom were also influenced by individual level factors. These factors were, to some degree, impacted by the Amani Academy's claim-evidence-reasoning initiative, in that both the teacher and students were less familiar with the dialogic aspect of this practice. In the post-lesson interview for *Metabolism* Lesson 2.10, during which students engaged in a science seminar debating responses to the question "When a person trains to become an athlete, how does her body change to become better at releasing energy?" Ms. Newbury discussed the novelty of this argumentation focus, and what that meant in terms of her instruction. She said:

> *This was the first time I've ever done anything like this. So I was not real sure that I knew what to do. I'm still not sure I did it as well as I could have but you know there's a first time for me too. (5:19)*

During this same interview, the teacher also discussed how this discursive aspect of argumentation was different from how she customarily taught and engaged her students in this practice (i.e. through writing):

> *We do written argumentation, obviously for testing reasons right? Kids have to have practice in written argumentation. Umm so that testing bias and the curriculum bias is always towards the written thing, so the verbal is always just preparation, organizing your thoughts. It's not necessarily the final product by itself, if that makes sense. (19:05)*

As we previously discussed, the dominant focus of engaging students in argumentation through writing impacted the area in which the teacher implemented language supports (i.e. Theme 2).

Later on in the post lesson interview, Ms. Newbury added that she was "not sure I did a really good job scaffolding for verbal argumentation, I mean oral argumentation" (20:26) explaining that this may have been due to the fact that "the part that was new was doing it orally and on the fly, as opposed to a prepared written statement." (25:36) Although Ms. Newbury articulated that it was important for her students to engage in the dialogic aspects of argumentation, she admitted not knowing how to support them in doing so, especially with regards to their language development:

> *I think I would need to do it five or six times to really figure out how best to prepare my kids, what the best sentence starters are, you know, those kinds of things. I would like investigate more how this works, I think it's a great idea but I couldn't begin to tell you now what the successful strategies are going to be for my kids. (20:50)*

This likely impacted why Ms. Newbury provided few and often conflicting messages to her students about their roles during the science seminar (i.e. Theme 1).

Ms. Newbury's lack of familiarity with both instructing and supporting her students' engagement in argumentation through the spoken modality impacted students' understanding of this science practice, and the resulting classroom discourse. For instance, as seen in the previous section on influential school-level factors, when students were asked to describe what they knew of argumentation, most of them discussed the practice in terms of its structural components (i.e. claim, evidence, reasoning). Furthermore, student interviews revealed that they also had developed conflicting understandings of the dialogic aspect of this argumentation. During the student interviews, students were shown two video snippets of the science seminar to help them recall the lesson. When Marina was asked why she believed students had remained quiet during the seminar, she articulated feeling confused and also uneasy about providing a contribution that would be criticized by the teacher. She said, "I was a bit nervous 'cause I don't have idea what to do" (20:51). She also explained students' silence saying, "Cause they don't want that, I think that they don't want to say that Ms. Newbury says, 'Oh that's not that's not right, that's wrong.' So that's why everybody was quiet." (23:40) However, another student, Soledad, believed students did well during the science seminar. When asked what some of the things were that she and her peers did well she explained, "Yo creo que cuando, no sé, que sí respondían y sí leían lo que tenían" (*I think that when, I don't know, that they responded and they read what they had*) (12:25). This student believed that simply reading off an argument counted as engaging in this dialogic science practice. Subsequently, student interviews demonstrated varied understandings of argumentation, particularly in relation to its dialogic components.

DISCUSSION

Recent reform efforts (NGSS Lead States, 2013) assert that science education ought to encompass both practice and content learning in order to address "conceptual, epistemological, and social learning goals" (Duschl, 2008, p. 269). Although rigorous and more accurately mirroring how science occurs in the real world (Osborne, 2014), this vision of science learning inherently involves intensive language demands that will be particularly difficult for English-learning students (Lee, Quinn, & Valdés, 2013). In order to ensure that all students are able to access the high quality instruction advocated by these reforms, it will be necessary to comprehend both the opportunities and challenges they occasion (Lee, Miller & Januszyk, 2014). This work represents an effort towards such ends, specifically as they relate to English-learning students. Exploring the argumentation practices of Ms. Newbury's middle school SEI science class allowed us to develop a richer understanding of how Ms. Newbury and her students engaged in argumentation, as well as various factors that influenced their classroom experiences. Our findings suggest the importance of: 1) moving argumentation instruction beyond its structural framework, and towards a more holistic conceptualization of this practice, and 2) identifying and developing linguistic supports to facilitate English-learning students' participation in science practices.

Moving Beyond the Structural Framework

A prevalent instructional approach for teaching students about argumentation has been through its structure, such as thinking of an argument as being comprised of a claim supported by evidence and reasoning (McNeill et al., 2006). Using a framework that highlights certain features of an argument (e.g. claim, evidence, reasoning) can prompt students to consider, include and evaluate critical features of an argument, such as the need for a claim to be supported by sufficient and appropriate scientific data (McNeill, 2009). However, these components only reflect one aspect of this practice, as students need to know more than structure in order to appropriately engage in argumentation (Ford, 2012). As we and other researchers (e.g. Jiménez-Aleixandre & Erduran, 2008) have articulated, engaging in this practice also encompasses the dialogic aspects of critiquing and debating the strength of a particular claim with others (Ford, 2008). If teachers primarily center argument instruction on knowledge of structure, students miss the opportunity to engage in social knowledge construction and critique, both of which lay at the heart of this practice (Ford & Forman, 2006).

In exploring the argumentation experiences in Ms. Newbury's classroom, we found that the students and teacher engaged more frequently with the structural aspects of this practice than in the dialogic features. For instance, students often constructed arguments that were supported by evidence from investigations, readings and simulations, but less often questioned and critiqued one another's ideas. In our study, we found the school-wide initiative to include argumentative writing across disciplines to be an influential factor. While it was beneficial that students were receiving this type of instruction in all of their content classes, it also resulted in the discursive aspects of this practice being largely omitted from the classroom. Furthermore, when they were included in instruction, as lessons had been purposively written to engage students in the dialogic components of argument as well, both the teacher and students were less familiar with this aspect and the subsequent enactment was of lower quality. Therefore, it is critical that research and practice push towards a more holistic conceptualization of argumentation so that students have opportunities to foster a stronger understanding of how science knowledge comes to be constructed and refined over time by engaging in the process themselves. In terms of instruction, this might include teachers developing classroom goals that purposefully focus on students engaging in dialogic interactions (Berland, 2011). Without such a deliberate shift, it is possible that this science practice could lose its epistemic drive, and instead become reduced to students completing a formulaic template for writing arguments.

Identifying and Developing Discursive Linguistic Supports

To ensure that all students, specifically English-learners, have access to the rigorous learning promoted by current science reforms, it is of utmost importance that as a field we identify and develop linguistic supports that enable these students to engage in classroom discourse. As we have discussed, this is especially important given that engagement in science practices, including argumentation, necessitates intensive use of the English language across modalities (i.e. speaking, reading, writing). Some initial work has been done with regards to this need. For instance, in Appendix D of the NGSS (NGSS Lead States, 2013) the Diversity and Equity Team wrote a case study highlighting how teachers might design instruction to meet the needs of English-learning students while engaging in these reform standards. This case study is followed by a brief summary of findings from research literature on effective classroom strategies for supporting this student group. These findings include intentionally designing lessons to include literacy and language supports, as well as home culture connections (Lee & Buxton, 2013; Roseberry & Warren, 2008). However, while helpful, we need a more nuanced understanding of how to support this diverse student group in each of the practices described in the NGSS. While some language supports might cut across multiple practices, others might be particular to one or two practices. Identifying these distinctions will be critical for designing effective instruction and learning environments.

Throughout the duration of our study we observed Ms. Newbury employing numerous linguistic scaffolds to engage her English-learning students in argumentation, such as simplifying the explanatory claim during the evidence card-sorting task, and doing a think aloud to model expected language use during an argumentation activity. Because of these instructional supports her students were able to not only understand, but also meaningfully engage in this science practice. Further, these instructional practices supported her students' science learning and second language development, as both areas are simultaneously attended to in practice (Lee, Quinn, & Valdés, 2013). Although we were able to identify some effective strategies that Ms. Newbury used in her SEI class, more research is needed in this area particularly around identifying supports that might target specific language modalities (e.g. engaging in oral debate about an argument, reading and evaluating a written argument).

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