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Examining Hispanic students' science learning in an argument-based inquiry classroom

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EXAMINING HISPANIC STUDENTS' SCIENCE LEARNING IN AN ARGUMENT-BASED INQUIRY CLASSROOM

by

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CERTIFICATE OF APPROVAL

PH.D. THESIS

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I dedicate this dissertation to my
family for their unconditional love and endless support.
I love you deeply.

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ABSTRACT

The Hispanic population in the United States experiences many challenges in education that have placed them behind their Euro-American counterparts in terms of achievement. These challenges are associated with socioeconomic status and family structure, educational expectations, and low-quality schooling in the elementary grades. The purpose of this study was to examine how Hispanic students construct science learning in an argument-based inquiry classroom. This research constituted a qualitative case study grounded in a sociocultural constructivist framework. Data was collected using a variety of qualitative techniques, including nonparticipant observations, analysis of semi-structured interviews, audio recordings, and transcription. The focal participants of this study were three Hispanic students, two in fifth grade and one in fourth grade. Findings indicated that the two aspects of an argument-based inquiry approach (laboratory activities and cooperative negotiation) impacted students' learning in science under diverse factors. These factors included importance of dialogue, importance of classroom setting (grouping and time allotment), and importance of various learning tools. Students also encountered particular challenges while they were involved in this learning context. These challenges involved developing connections between claims and evidence, classroom routines and decisions, administrative decisions of the school, issues associated with group conforming or pairing up students, and language issues. This study provides implications for science education policies, teaching practices, and research in science learning improvement for minority students.

PUBLIC ABSTRACT

The Hispanic population in the United States experiences many challenges in education that have placed them behind their Euro-American counterparts in terms of achievement. These challenges are associated with socioeconomic status and family structure, educational expectations, and low-quality schooling in the elementary grades. The purpose of this case study was to examine how Hispanic students constructed science learning in their science inquiry. Data was collected using a variety of qualitative techniques, including nonparticipant observations, analysis of semi-structured interviews, audio recordings, transcription, and observations. The focal participants of this study were three Hispanic students, two in fifth grade and one in fourth grade. Findings indicated that the two aspects of science inquiry approach (laboratory activities and negotiation) impacted students' learning in science under diverse factors. These factors included importance of dialogue, importance of classroom setting (grouping and time allotment), and importance of various learning tools. Students also encountered particular challenges while they were involved in this learning context. These challenges involved developing connections between claims and evidence, classroom routines and decisions, administrative decisions of the school, issues associated with group conforming or pairing up students, and language issues. This study provides implications for science education policies, teaching practices, and research in science learning improvement for minority students.

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CHAPTER ONE

INTRODUCTION

Hispanic Students in America

By the end of the first decade of the 21st century, Hispanics constituted more than half (50.5%) of the general population growth in the United States (U.S.) (Passel, Cohn, & Lopez, 2011) as reported in the 2010 census. This has been a significant demographic increase for the largest minority group in the nation, which now accounts for 16.3% of the entire population.[1] The academic performance of Hispanic students in the U.S. public school system is of increasing concern to the federal government, state educational agencies, and educational organizations as the population of Hispanic students in the public schools keeps growing (Gándara, Rumberger, Maxwell-Jolly, and Callahan ,2003)

Since the mid-1990s, the enrollment of Hispanic students in public schools has changed the landscape of public education in the U.S. due to the growth of the Hispanic population. During the school years of 1990 to 2006, the overall number of students enrolled in U.S. public schools went from 12.7% to 20.5% (Fry & Gonzales, 2008). There are now around 10 million Hispanic students in the nation's public schools, and they constitute about one-in-five public school students in the U.S.

[1] These results are based on birth certificate, death certificate, immigration data, and other records used by the government (Passel et al., 2011). By place of origin, the largest Hispanic populations are constituted by Mexicans, 29.3 million; Puerto Ricans, 4.1 million; Cubans, 1.5 million; Salvadorans, 1.5 million; Dominicans, 1.2 million; Central Americans, 3.6 million; and South Americans, 2.5 million (U.S. Census Bureau, 2010).

The Hispanic population in the U.S. experiences many challenges regarding education that have placed them behind their Euro-American counterparts in terms of achievement (Garcia-Bedolla, 2012). Challenges are associated with socioeconomic status (SES) and family structure, educational expectations, parent education level, and low-quality elementary education (Lee & Burkam, 2002; Isaacs & Magnuson, 2011; Gandara & Contreras, 2009). According to Galindo and Reardon (2006), one of the most consistent patterns for Hispanic students is that students from families with low socioeconomic status are more likely to be more disadvantaged in educational environments. For example, students who are socioeconomically disadvantaged are less likely to have access to educational resources such as books and computers in their homes. Second, students are more likely to attend schools with teachers who have lower levels of qualifications, and lack teaching experience in bilingual education or teaching English as Second Language (ESL) (Galindo & Reardon, 2006).

Such disadvantages have led to an increase in the dropout rate of students in high school. For example, the national status dropout rates in 2012 reported Hispanic students with 12.7% as opposed to other racial groups, such as whites with 4.3%, and blacks with 7.5% percent (National Center for Education Statistics [NCES], 2012). Moreover, multiple sociological, economic, and language barriers faced by Hispanic students are evident through the college experience. For example, Fry (2003) and Llagas and Snyder (2003) stressed limited English proficiency (LEP) as a major obstacle to academic success. Hispanics are among the least educated ethnic group in the U.S.; in 2013, only 15.7% of Hispanics age 25 and over had earned a bachelor’s degree or higher education degree. In contrast, 40.4% of whites and 20.5% of blacks age 25 and over had earned a bachelor's degree or higher (National Center for Education Statistics [NCES], 2011, 2012).

Literature indicates that Hispanic students do not achieve at the same level as non-Hispanic students on a number of educational measures (Lee, 2002; National Assessment of Education Progress [NAEP], 2015). For example, the National Assessment of Educational Progress (a congressionally mandated project administered by the National Center for Education Statistics (NCES), within the Institute of Education Sciences (IES) of the U.S. Department of Education) reported a gap between Hispanic and Caucasian scores in mathematics and science. Achievement gaps in the NAEP science assessment have remained unchanged since 1996. As shown in Table 1, this pattern is consistent across grades 4, 8, and 12, where Hispanic students underperformed Caucasian students by 30 points throughout these years (NAEP, 2009, 2011).

Table 1

National Average Scale Scores for Science, Grades 4, 8, and 12 by Race/Ethnicity Used to Report Trends, School-Reported.

Grade	White	Black	Hispanic	Asian/Pacific Islander	Year
4	163	127	131	160	2009
8	163	128	136	159	2011
12	159	125	134	164	2009

A central goal for the science education (Rutherford & Ahlgren, 1990) reform effort is to support the development of scientific literacy for “all students.” This education reform is a commitment to providing quality science education for all students, which requires an understanding of the special needs and culture of each child regardless of disability, gender, race, language, sexual orientation, class, ethnicity, or religion. It also requires a solid belief that science benefits academic achievement by embracing and welcoming all students as they bring unique perspectives and approaches to the science classroom (Rutherford & Ahlgren, 1990).

In order to achieve the goal of scientific literacy for “all students” it is necessary to recognize that students need access to the knowledge content to be taught and value what they bring to classrooms (Moje, 2007). For students to gain that access they need equitable opportunities to learn literacy practice through what Moje calls “socially just pedagogy” (Moje, 2007, p. 2). Socially just pedagogy offers opportunities for the transformation of students and a social context where students learn to question and perhaps offer changes to establish knowledge. One example of this type of opportunity is offering students socially just subject matter instruction. This can be done through disciplinary pedagogies such as teaching cognitive literacy processes using strategies such as KWL (what students Know/what students Want to know/what students Learned) and teaching epistemological processes using strategies such as the Science Writing Heuristic approach (SWH).

The Science Writing Heuristic (SWH) as a Vehicle to Provide All Students Access to Disciplinary Knowledge

To improve science achievement in all students, it is critical to provide teachers professional development programs that emphasize teaching science as inquiry. The *National Science Education Standards* (National Research Council, 1996) define scientific inquiry as “the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” (p. 23). Several researchers have reported the use of inquiry as a significant learning strategy to generate opportunities for all students (Wilson, Taylor, Kowalski, & Carlson, 2010), especially for creating an effective science-learning context for students from diverse backgrounds (Lee, Buxton, Lewis, & LeRoy, 2006). The Science Writing Heuristic (SWH) (Keys, Hand, & Collins, 1999; Martin & Hand, 2009) is an inquiry-based approach that underscores an intrinsic connection between language and science with the basic tenet that “there is no science without language” (Lemke, 1990; Norris & Phillip, 2003). This approach helps students to identify patterns in their data, use their data and prior knowledge to construct new knowledge, and draw significant relationships among data, claims, and evidence.

Within the last decade, researchers of this approach have explored the idea of science learning as inquiry, argumentation, and language (Hand, 2008) in a non-threatening learning environment (Yoon, Bennett, Aguirre-Mendez, & Hand, 2010). In addition, some work has been done on students from different backgrounds to demonstrate that this approach provides a social justice-appropriate pedagogy that allows students to gain access and power in order to openly participate in a dialogic classroom (Shoerning, Hand, Shelley, & Therrien, 2015). As Shoerning et al. (2015) explain, the SWH approach provides access to the power that is attached to the access of agency, which is in contrast to most traditional classrooms. They also explain that if power, agency, and language are blended, there are opportunities for students to gain access to science discipline-specific language. Students in an argument-based inquiry classroom, including the SWH, have access to different uses of language such as dialogue, representations, and writing. Klein (2006) argues that the SWH approach scaffolds students to represent concepts that are poorly bounded and fuzzy to more canonical forms including questions, claims, and evidence. All of these opportunities in the context of the SWH contribute to its positive impact on underserved demographic students' science learning (Hand, 2008; Chen, Hand, & McDowell, 2013).

Although research on SWH has reported its effectiveness to improve science achievement across a wide range of K-16 classroom settings using large scale quantitative research designs, little focus has been given to the micro level that emphasizes deep understandings of the experiences of individual students, especially minority students who have unique learning needs. In particular, with the growth of the Hispanic population in the U.S., it has become urgent to understand and address their educational achievement gap and explore their challenge in science classroom settings. By providing opportunities for all students to engage in science learning through scientific investigation, student-student dialogue, and negotiations, this approach would be helpful for students from disadvantageous backgrounds. However, it requires a great amount of language use. Given that language is a main obstacle for some of the Hispanic students' learning, it is not certain how the SWH, which necessitates a great amount of language use in various ways, would impact Hispanic student learning in science.

With this in mind, this study examined the lived experiences of three Hispanic elementary school students in SWH classrooms. The three students have disadvantageous backgrounds similar to the general Hispanic student population discussed before. All of them are from families with low socioeconomic status, as indicated by their eligibility for the free or reduced lunch program. In addition, 72.84% of the students in the school where the three students attend receive free or reduced lunch, which indicates more than two-thirds of the students in the school are in poverty. None of the parents of the three students are college graduates; the highest education level among them is high school. Thus, their capability to commit to their children's education is limited. Furthermore, one of the students participated in ELL due to her limited English proficiency.

This study explores how these disadvantaged students learn science in an argument-based inquiry classroom utilizing the SWH approach, especially through the negotiation process and laboratory activities. In this study, analysis of student learning focused on three key aspects: conceptual understanding, science practices, and understanding of argumentative components. These three areas are drawn from *Taking Science to School* by the National Research Council (2007). The report suggests that students who are proficient in science 1) know, use, and interpret scientific explanations of the natural world; 2) generate and evaluate scientific evidence and explanations; 3) understand the nature and development of scientific knowledge; and 4) participate productively in scientific practices and discourse. In addition, these strands promote reasoning skills crucial for students to be proficient in science and become educated citizens and participants in society. In this research, the four strands are compressed into three strands, since the second strand is connected to the third one in terms of using inquiry as a scientific practice and a way of constructing knowledge. Although the three aspects are examined separately in this study, one should acknowledge that science learning is an integration of concepts, practices, and discourse and they are not independent of each other; rather, they are interconnected and supportive to engage students in scientific tasks (National Research Council [NRC], 2007b).

Although SWH has been shown to improve students' understanding, no research has particularly focused on science learning of individual Hispanic students in elementary schools. Moreover, research in the SWH approach needs exploration beyond the numbers, such as how context and social meaning affect the participants' involvement. This indicates a need to study how this approach requiring rich language use by its nature can or cannot benefit Hispanic students' science learning. The development of instructional strategies that promote successful science understanding in this particular group can be enhanced by research comprising a qualitative study of the components of SWH, such as laboratory activities and negotiations.

Research Questions of the Study

1. In what ways do two aspects of the argument-based inquiry classroom (i.e., laboratory activities and negotiation process) impact three Hispanic students'

science learning in terms of a) conceptual understanding, b) science practices, and c) understanding of argumentative components?

2. What challenges do these Hispanic students encounter in the argument-based inquiry classroom?

Rationale of the Study

Researchers in science education have supported the idea that teaching science as inquiry is an instructional approach that promotes learning opportunities for students from diverse backgrounds (Lee et al., 2006). Lee and other collaborators found a positive impact for all students after the intervention of science inquiry skills. Results were particularly significant for students from non-mainstream and less privileged backgrounds.[2] Despite these positive results, the authors also found that students still needed support to be engaged in the inquiry process through providing them with a supportive learning environment incorporating the cultural and linguistic diversity that this population brings to the classroom.

Previous research into the implementation of SWH has shown improvement in learning science in students with learning disabilities and low social economic status (SES) based on their quantitative results from science scores on the Iowa Test of Basic Skills (ITBS) (Akkus, 2008). The maximum benefit for low-achieving students' learning occurs when students are engaged in inquiry activities combined with language practice,

[2] According to Lee et al. (2006), non-mainstream and less privileged backgrounds in science include: low achievement, females, low SES, Spanish-speaking students, and ESOL students (English to speakers of other languages).

such as debate and discussion of claims and evidence (Akkus, Gunel, & Hand, 2007). Students who are engaged in the SWH approach gain ownership of their learning and feel a greater sense of engagement with their science activities such as their laboratory experiences (Hand, Wallace, & Yang, 2004). In addition, several studies on SWH show how this approach is effective for improving students' conceptual understanding and engagement in cognitive activities based on quantitative designs (Rudd, Greenbowe, Hand, & Legg, 2001). It must be noted that most of these studies used ITBS (Cavagnetto, Hand, & Norton-Meier, 2011) with an analysis of pre and post-test performance as an indicator of student achievement (Akkus et al., 2007).

No research on the SWH approach to argument-based inquiry, however, has used a qualitative perspective. To address this gap, this research focused on the two main aspects of the SWH approach to argument-based inquiry, the negotiation process and laboratory activities, in the form of a case study. Moreover, although the SWH shows benefits for students' learning as measured by their test results, little research has focused on the science achievement of Hispanic students in elementary schools (Cavagnetto et al., 2010; Ahmadibasir, 2011; Chen, 2011). The majority of these studies have been conducted in middle school grade levels, or in college settings.

In addition, exploring how students' knowledge is produced through learning science using an argument-based inquiry approach can provide initial ideas of how to promote science achievement. For example, the Iowa Assessment Science Test, which evaluates students' understanding of life science, earth science, and skills of scientific inquiry, reveals that only 68.6% of Iowa's Hispanic students in eighth grade are proficient in science, compared to 85.5% of white students in the state (Iowa Department of Education, 2014).

Since it has been suggested that argument-based inquiry may address some of the inequities observed in educational achievement, it is imperative to understand how learning science as inquiry and understanding the argument structure of question-claim-evidence occurs for Hispanic students when constructing their scientific knowledge, in order to understand how they learn in rich language approaches and what factors are important for impacting their science learning. Additionally, it is important to recognize the possible intrinsic or extrinsic challenges that may impact their success in science. This issue has been discussed widely in the field, for which the National Research Council (2012) has recommended instruction with the goal of "providing students with multiple ways of demonstrating competence in science." Hence, this study may contribute to the literature in the areas of science general education and multicultural education in that it specifically addresses diversity and equity in classrooms.

Significance of the Study

As the Hispanic population is the fastest growing in American public schools, this study is an effort to contribute to Hispanic' educational attainment for the future of the nation. The economic future of the U.S. depends on graduating more Hispanics from college (Crisp, Nora, & Taggart, 2009). Given that the Hispanic population of students in Iowa public schools in grades K-12 increased from 3.6% in 2000, to 9.3% in 2012-2013, to 9.7% in 2013-2014 (Iowa Department of Education, 2014), it is also critical to prepare those students to become scientifically literate and responsible citizens. Exploring and understanding how Hispanic students learn science while they are involved in a student-centered instruction then becomes a top priority in education. The results of this study can promote new ways of teaching and learning to provide students with meaningful learning, knowledge restructuring, and conceptual change.

The contributions of this study would be of interest to policy makers, researchers, and teachers in general education and science education. Given the fact that Hispanic students are the fastest growing group in public schools, it is crucial for districts, schools, and teachers to understand the experiences of Hispanic students in American classrooms and to address their needs to improve their academic attainment. The contributions of this study might contribute to various sectors as follows:

Students

This study will provide insights for using effective strategies to support science learning for students, and encouraging their participation and engagement in science learning activities. Students' success in the classroom is a priority for American education. Therefore public education should guarantee that all students have equitable opportunities to receive quality teaching. This will help maximize their potential in academics that might help revitalize the state of economy of the nation.

Teachers

This research will provide science teachers insights into how to support all students to learn science, especially using argument-based inquiry approaches in elementary classrooms. It will also help them understand what demands, dilemmas, and challenges underserved demographic groups need to deal with in the school and classroom.

Policy Makers

This study can inform policy makers associated with teacher preparation programs to help them adequately prepare teachers to be equipped with knowledge and skills for working with culturally and linguistically diverse learners, especially in science classrooms. In addition, through examining the challenges these Hispanic students encounter while learning science and other subjects at schools, this study will provide useful information for policy makers to reevaluate common procedures to support English Language Learners (ELL) including pulling out students from regular classes such as science.

Researchers

The outcomes of this study will lay a foundation for researchers to explore various factors that affect minority students' underachievement in school beyond the language factor. In addition, this study helps to understand how argument-based inquiry impacts Hispanic students in their science improvement. Several researchers have reported the maximum benefit of the SWH approach to female, special needs, low socioeconomic status, and gifted students (Akkus 2008; Chen, Hand & McDowell, 2013). These studies use a quantitative research design to show those benefits in student performance, but how those benefits occur and are meaningfully created need to be understood. This study helps to identify what factors are attached with students' improvement and learning experiences.

Overview of the Study

In this chapter, I provided the background, focusing on Hispanic students' issues in American education and explored learning science as inquiry as a possible strategy to support their educational challenges. The research questions and the rationale of this study also were specified.

Chapter Two provides a review of the literature relevant for this study. First, I discuss the theoretical framework that helped to establish the parameters for this study. Then I discuss existing literature related to Hispanic students in elementary classrooms and their academic achievement. Second, I explore what research has been conducted to support Hispanic student issues specifically in science. Then I talk about the Science Writing Heuristic (SWH), as a context for all students to learn science. Finally, I discuss the incorporation of language activities in classrooms as a means to develop better student understanding in science contexts.

Chapter Three provides the rationale for the use of case study qualitative research to answer the two questions. In addition, it provides a detailed description of the main data sources, data analysis, and explains strategies to assure trustworthiness.

Chapter Four discusses the findings in terms of the two research questions. For the first research question three main results are indicated: 1) Importance of dialogue in the classroom: Through meaningful dialogue, students showed an initial understanding of science concepts, science practice, and argumentative components. 2) Importance of classroom setting (grouping and time allotment): The time invested for students in their investigation helped them to engage in a meaningful conversation and collaborative learning. 3) Importance of various learning tools: Using effective learning tools in both aspects of argument-based inquiry impacts students to gain initial learning in science. The learning tools found to be effective were using a KWL chart, multimodal representations, writing, and consulting experts. For the second research question the results indicate these students faced five challenges while engaged in an argument-based inquiry approach: 1) confusion between data and evidence; 2) classroom routines and decisions; 3) administrative decisions of the school; 4) group conformation and pairing up students; and 5) language issues.

Chapter Five discusses the findings related with argument-based inquiry as an approach that promotes Hispanic student learning in three areas where they need to be proficient in the science classroom. The second section of the discussion will cover the challenges that students experience during their participation in this approach. Finally, implications are discussed and further studies and applications are suggested, and reflect on the limitations of this study.

CHAPTER TWO

LITERATURE REVIEW

Theoretical Framework

Sociocultural Constructivism

As this study focuses on how Hispanic students engage in an argument-based inquiry, I found sociocultural constructivism to be essential to help make sense of my interpretations (Bryman, 2001). Sociocultural constructivism describes that learning is possible because individuals interact and get involved with people, events, and objects, such as family, school, community, classrooms, groups, or collaborative environments (Vygotsky, 1978). Within a collaborative environment, the learner is included in a new community of practical way of thinking. As new members come into a community, the community itself experiences changes in defining and enacting appropriate roles, responsibilities, and relationships (Pratt, 2002). Therefore, the sociocultural perspective also emphasizes that learning is a process of enculturation where the teacher's responsibility is to examine whether the learner's work is meaningful for the community of practice. One way the teacher can perform such an examination is through scaffolding, in which teachers can use activities from simple to more complex levels according to the work of the community.

Another teacher's responsibility is to explore the actual and potential levels of students' development which Vygotsky (1978) calls finding their "zone of proximal development." This concept refers to the difference between what learners can do independently and what they can potentially do with guidance from the teacher.

In a sociocultural constructivism perspective, learning is viewed in a social context where individuals bring their unique educational, cultural, gender, class, race, and age experiences to the learning process (Lemke, 2001). In addition, the sociocultural perspectives describe the social and cultural interactions as being mediated by culturally constructed tools such as language, materials, and symbols. The linguistic parts have emerged in a need to know how people learn to speak and write the language of science and make sense in a cooperative way of its extensive elements of subculture specific activities, such as observing, experimenting, and communicating (Lemke, 2001).

Sociocultural constructivism theories helped me address this study in several ways. First, it allowed me to consider the context in which the participants were involved. In this case the context of argument-based inquiry offered activities where students were engaged in a constant peer interaction, collaborative learning environment, and social events. Among such events, I found small and whole group discussions and negotiation of meaning. My observations and field notes through the science units that were investigated helped me understand how these interactions can generate Hispanic students' scientific concepts, scaffolding, students' inquiry, and understanding of argumentative components. Second, sociocultural constructivism emphasizes language as a meaningful part of the culture and unique characteristic for individuals to form their thinking. Michael Halliday explains that language development is a process that occurs simultaneously when individuals engage in "learning language" and "learning through language" (Halliday, 1993). Therefore, I wanted to explore through observations of students' dialogue, interviews, and writing samples how that process occurs in an argument-base inquiry approach where students have the opportunity to practice many forms of language, including writing, talking, and using multimodal representation.

Hispanic Students in Elementary School Science

Elementary school constitutes students' initial involvement into official education. During this period students engage in diverse activities that help them shape their cognitive and social skills. Unfortunately, for Hispanic students the story is different and characterized by underachievement and challenges in their academic life. The National Assessment of Educational Progress (NAEP) shows that in 2009, the average scale score for science for Hispanic students in fourth grade at the national level was 131 compared to 163 of white students and 160 of Pacific Islanders. The available literature reveals that there are some socio-historical factors associated with the underachievement of Hispanic students. For example, Lee & Burkam (2002) explain that race/ethnicity and SES (Socio Economic Status) are closely intertwined at the beginning of kindergarten. Achievement differences among children from different racial groups and different social classes at the beginning of kindergarten are quite large. They remark that socioeconomic status has the most powerful impact. Although depending on whether we are looking at reading or math, other significant factors come into play as well.

Similarly, Lareau (2003) claims that social class impacts children's life experiences when he affirms that "key elements of family life cohere to form a cultural logic of child rearing" (routines of daily life, dispositions of daily life, or the "habitus of daily life”) and that the differences among families seem to cluster together in meaningful patterns. Schools with high concentrations of poor students, for example, tend to be poorly maintained, structurally unsound, fiscally underfunded, and staffed with large numbers of uncertified teachers (García & Guerra, 2004).

However, among those factors three of them might play a significant effect on the underachievement of Hispanic students in science (Waxman, Padrón, & García, 2007). One of those factors is the lack of qualified teachers to teach these groups of students (Menken & Holmes, 2000). The goal of teachers’ preparation is to foster students’ academic achievement and to focus the attention on areas such as English as a second language. In urban areas where most of the student population is composed by ELLs, over 80% of the 54 largest urban school districts reported that they had non-credentialed teachers on their staff (Urban Teacher Collaborative, 2000). Therefore, teachers have difficulties with Hispanic students when they are not sufficiently qualified to address their needs.

The second factor that the literature points out is inappropriate teaching practices. According to Waxman et al. (2007), the common model used in classrooms with a high population of Hispanic students is the direct instructional approach where teachers control the whole process and there is not much student involvement in their own learning (Haberman, 1991). Waxman, Padrón, and Arnold (2001) called this instructional strategy as “pedagogy of poverty,” because teachers promote students’ low level of cognition where they are passive about learning. To illustrate this issue, Padrón and Waxman (1993) found that science teachers’ instruction consisted of 93% of teachers’ voice where students did not have independent work in science class and there was not a promotion of students' work in small groups. Another characteristic found in these classrooms is that teachers spend a lot of time explaining concepts to the students rather than asking questions, prompting or encouraging student to respond.

These practices are not aligned with the demands of the national reforms that emphasize promoting students in being active participants in their learning processes and applying scientific inquiry to reasoning or problem-solving situations (Zimmerman, 2007). In fact, teachers experience many challenges regarding the understanding of the content and discipline of science such as academic preparation in science, essential science content areas, their ideas about science as inquiry, and the nature of science (Davis, 2006).

The third factor that affects Hispanic students is at-risk school environments. The term refers to the school that is at-risk rather that the individual student. An at-risk environment occurs when a school hires inexperienced and underprepared teachers, when there are low expectations of students, lack of teachers' responsive pedagogy, absenteeism, lateness of Hispanic students, and inadequate preparation of students for the future (Padrón, Waxman, & Rivera, 2002).

Reviewing these factors that appear to being associated with students' low achievement in science, there are possible solutions in order to support Hispanic students' success in science. There should be some changes in the teaching and learning science conditions. There is a need to provide good learning environments to promote students in being active in their own learning, and foster students' critical thinking skills. As Dewey (1938) stated, "diversity is a resource, not a problem." Therefore, Hispanic students must be supported in a learning environment where they have opportunities to ask questions, collect data, gather evidence, build a claim, and access several resources of information by being involved in the practice of argumentation to negotiate meaning with their peers (Norton-Meier, Hand, Hockenberry, & Wise, 2008).

Approaches to Support Hispanic Students' Achievement in Science

There are several studies that have explored the issues about student diversity background focusing on some of the factors aforementioned. Researchers have been exploring aspects related to language and culture in science education, parent engagement, and assessment. These types of investigations face conventional notions of science content, learning, teaching, and assessment.

For example, Lee et al. (2009) studied the teachers' knowledge and practices in teaching science at the same time as supporting English language development with ELL (English Language Learner) students in urban elementary schools. Particularly, the study focused on urban elementary teachers' content knowledge and instructional practice in teaching science using inquiry to support ELL students. The results of this study imply that teachers had good content knowledge about science concepts according to the grade level. Their instructional strategies included inquiry-based lesson and conventional strategies on occasion. The participant teachers reported that they had positive support from their principals and collaboration from other colleagues. In addition, they explained that they used ESOL (English to speakers of other languages) strategies or ELL students' home language to promote English language development in the classroom. However, they did not discuss student diversity in their own teaching or with other teachers in the school as often. Teachers also perceived organizational obstacles to teach science. Those obstacles included internal factors, such as school-level constraints, school personnel, and students' poor academic skills; and external factors, such as statewide assessment, parents, family, and the community.

In exploring language and communication in science, Emdin (2011) focused his attention on urban science education, pointing out students' modes of communication. These modes of communication included the so-called "rap cypher," which is described as an urban youth/hip hop culture very popular among Black and Hispanic students. It includes Spanish words and expressions in combination with Standard English. When students are engaged in this activity, they have the opportunity to interact. Many topics can emerge from this interaction but the important point is that through this mode of communication they can debate about deep questions, dialogue, promote complex ideas, and argue about them. Even though the "rap cypher" offers many ways of promoting language and can be used to learn science, it is not taking into account the urban science classroom. The author implied that while the recognition of students' ways of communicating and participating are not an absolute approach to improving pedagogy, there are new avenues for improving communication and participation in the classroom and to support effective teaching and learning.

Other efforts have focused on studying cultural dimensions that affect Hispanic students' learning. Some studies report that these types of classrooms do not seem to meet the educational needs of Hispanic students. For instance, Hispanic students were taught with a Eurocentric science book, instead of using culturally familiar printed materials. Students were also taught primarily in English by a teacher who was not proficient in the child's native language. In addition, students were exposed to unfamiliar examples and analogies, and encouraged to work individually rather than in a cooperative learning group (Barba, 1993).

In addition, there are ideas about what happens when teachers work within different paradigms, that is, in a cross-cultural setting. Atwater & Riley (1993) describe some episodes with this situation. In this case of cross-cultural setting, the teacher recognizes that s/he is working in a different culture and is encouraged in his/her pre-service teaching training to accept, respect, and understand the cultural context of such a setting. In a different case, the authors also describe what happens when a teacher does not recognize that s/he is working in a different culture. The teacher then is operating with a "deficit paradigm." When teachers do not know the culture of a group of students, they can get some stereotypic characterization about students who are African-American or Hispanic, and with these ideas and beliefs, teachers, children, and schools fail to succeed.

Rakow and Bermudez (1993) point out that language constitutes a barrier for Hispanic students to effective communication, but it is not the only factor that can influence science learning. In addition, they explain that some additional aspects to consider are the culture, values, beliefs, learning styles, and home environment. Moreover, they encourage teachers to understand the needs and barriers that Hispanic students confront as they embark to succeed in an increasingly technologically-oriented society.

In another study, Gilbert and Yerrick (2001) designed a micro culture in a low-track earth science classroom. In the class, White, Hispanic, and African-American students join together to become a target in their resistance to a system silently hostile to them and their education. This micro culture, shaped in part by the students themselves, may allow them to survive the immediate shame of lower expectations, fewer resources, restricted ambitions, and racial biases. In contrast, according to Luykx et al. (2007), the role of culture and language sometimes is not considered to affect students learning, especially in science and math because there are assumptions that science and mathematics comprise a universal valid “culture-free” body of knowledge that stays essentially unchanged.

Meyer and Crawford (2011) show how to support diverse groups of students from underrepresented populations in learning and gaining an interest in science. One way in which they explore this issue is through students’ participation in scientific activities such as inquiry, science as a cultural way of knowing, and teaching the nature of science explicitly to students. They found that combining these instructional approaches may provide promise and possibility for reaching students in science education, particularly with underrepresented student groups. Making the nature of science explicit throughout instruction is thus relevant for students whose worldviews and subcultures differ from the cultural values of school-based science.

Other investigations have focused on improving teachers' ways of instruction based on teachers' professional development (Buxton et al., 2008). Since science has been included recently as part of the measures of annual yearly progress under the No Child Left Behind Act, it is a good opportunity to focus on teachers' professional development in order to promote quality instruction in today's classrooms. The professional development consisted of using curriculum materials for teachers and students to improve their content knowledge, belief, practice, and instruction in both English language development and science. The purpose of the workshops was to complement and improve teachers' content knowledge, instructions, and beliefs. The workshop emphasized how teachers can influence science learning by integrating students' cultural experience, and integrating cultural issues then can affect students' interactions in their home and community.

In addition, some efforts have been made to include and engage Hispanic students' parents in science class in order to assist students' learning in science. For example, Hagiwara, Calabrese, and Contento (2007) describe the participation of Hispanic parents in the science classroom as a way to engage in a learning process that transcended language, power, authority, and culture. The program in this study consisted of a 2-year upper elementary/middle school inquiry-based science program. Parents focused on learning and teaching life science and understanding concepts through collaboration by scaffolding along the cultural-linguistic framework, forming a foundation for learning about science and self. Even though this approach can be applied in schools, it still presents some limitations such as difficulties to gain access into the classrooms regularly.

In the same way, Ash (2004) worked on centering on dialogic inquiry in informal learning settings to include everyday understanding in languages other than English. In this research she explores how parents and children learn together as they participate in scientific conversations and reflective interviews. Ash analyzes the biology content learned in a Monterey Bay Aquarium in which members share verbally with each other the questions they ask, and how they negotiate understanding, including language and gestures. Ash describes how family dialogue progresses toward what are called scientific concepts, and how access to scientific dialogue in two languages "enhances, rather than detracts from science literacy." The family in the study uses many different resources to make sense of science concepts, including prior experiences, pictures of each other, live and preserved objects, the facilitator, and both Spanish and English.

Regarding the way minority students are assessed, Lawrenz et al. (2001) examine the science achievement outcomes for different subgroups of students using different assessment formats. Assessments should allow all students equitable opportunities to demonstrate their understanding of science concepts. The differences in achievement levels on the hands-on versus the multiple-choice/open-ended assessments found in this study suggest that the hands-on assessments may provide different information about achievement of some sub-groups. Therefore different types of assessments may affect interpretations of the achievement of students from different ethnic groups and from different typical course grade levels.

Science Writing Heuristic (SWH) Approach

With this evidence about the factors that affect Hispanic student achievement in science, some researchers have suggested that one alternative to provide support to all students is with a “constructivist” perspective and learning students’ prior knowledge and cognitive frameworks. Taking students’ individual frameworks into account will also allow teachers to understand students’ cultural environment and therefore teach more effectively (Aikenhead, 1993).

Moje (2007) also explains that teaching with a social justice perspective provides students equal opportunities to engage in forms of disciplinary knowledge where students can learn knowledge and critique. She also argues that what counts as socially-just instruction and pedagogy is providing students access to the following: expert subject-matter knowledge, disciplinary knowledge regarding everyday concerns and interests, disciplinary knowledge and ways of knowing, and producing knowledge via oral and writing text.

One way teachers can help students to do this is through inquiry-based science instruction. This perspective is based on the cognitive theories of learning that explain how learners construct their knowledge through an active process. It encourages teachers to be more sensitive about exploring students’ prior knowledge before they become involved in a particular topic. Using inquiry-based classes in science classrooms provides opportunities to students to learn science content, argumentation strategies, use science language, and become better critical thinkers.

By participating in inquiry-oriented activities, students can develop the ability to critically evaluate scientific data and models (NRC, 2000, 2001), overcome preexisting conceptions (NRC, 2001), and come to understand what it means to do science and participate in a scientific community (NRC, 2001). Students who participate in inquiry activities are often motivated to learn about science (Kubicek, 2005) and develop positive attitudes towards science (Brown, 2000). Additionally, some studies have provided evidence about how inquiry fosters content knowledge, scientific inquiry, questioning, and collaborative sense making (Van Zee et al., 2005).

Currently there is a need in the science education field to involve students in activities that promote scientific literacy. Students can achieve these goals by participating in science inquiry activities through argumentation strategies using the language of science (Yore & Treagust, 2006). With the development of ideas of inquiry to support teachers and students' learning, science inquiry has focused on language as an element to design an effective learning environment. According to NRC (2012), effective science teaching and learning must integrate communication and collaboration in classrooms. A major characteristic of the language of scientific inquiry is debate and argumentation focusing on competing theories, methodologies, and aims.

Science language can also be an approach for teachers to assess students' thinking by requiring students to engage in practicing and using discourse in a range of structured activities. As Duschl and Osborne (2002) explain, teaching science based on the process of inquiry without activities that engage students in argumentation, construction of explanations, and evaluation of evidence is a failure to represent the elements of the nature of science and improve students' developing understanding. They define argumentation as one aspect of science that constitutes a social and collaborative process essential to solve problems and advance knowledge that must address epistemic goals (how we know what we know) and epistemic belief (why we believe). Argumentation is dependent on the use of evidence to construct explanations. For student to construct explanations, there has to be some requirement, such as clarifying their thinking by generating examples, in order to be aware of the need for additional information and to examine and repair gaps in their knowledge. Berland and Reiser (2009) also claim that constructing scientific explanation and being engaged in argumentative discourse are essential in scientific inquiry and lead to sense-making, articulating, and persuading. Moreover, it has been reported elsewhere that students' involvement in argumentation develops communication skills, metacognitive awareness, critical thinking, and understanding of the culture and practice of science and scientific literacy.

There is significant research about scientific argument and approaches to apply in science classrooms. One of them is known as Science Writing Heuristic, an argument-based inquiry approach (Keys et al., 1999; Martin & Hand, 2009). The SWH approach considers an intrinsic connection between language and science that is grounded in the basic tenet: "There is not science without language" (Lemke, 1990; Norris & Phillip, 2003). This approach helps students to identify patterns in their data, use their data and prior knowledge to construct knowledge, and make significant relationships among data, claims, and evidence. A template for the SWH student is shown in Table 2.

Table 2

SWH Student Template from Hand, 2008.

The Science Writing Heuristic: A plan for students	
1. Beginning ideas	What are my questions?
a. Testable questions	
b. Non-testable questions	
2. Test	What did I do?
a. Remember the control and variables	
b. Share the sequence of your actions	
3. Observations	What did I see?
a. Organize your data in charts or graphs	
b. Make them easy to read	
4. Claims	What can I claim?
a. Use complete sentences	
b. Tell what you found out	
5. Evidence	How do I know? Why am I making this claim?
6. Reading	How do my ideas compare with others?
a. My classmates	
b. Scientist	
c. Reflection	How have my ideas changed?

In addition to the different aspects that involve students in the inquiry activities, this argument-based inquiry provides opportunities for students to engage in negotiation of meaning, whether individually or across small groups, and utilize and develop language practice, which includes writing, talking, and using models (Norton-Meier, 2008). The negotiation of meaning constitutes the language of science classroom where students develop the ability to articulate their ideas in an expression of power leading to agency (Shoerning et al. 2015). Therefore, teachers involving students in negotiations, collaborative work, and meaningful dialogue provide avenues for agency and power as an expression of students' authority in their classroom.

As a whole, the activities and metacognitive scaffold seek to provide authentic meaning-making opportunities for learners. The templates for student thinking encourage students to generate questions, claims, and evidence. Also, the template scrutinizes what science and others say about their investigation, and scaffolds students to reflect on what they learn from their inquiries. Students are expected to develop arguments using the language of science to talk, read, and write about the concept they are investigating (Hand, 2008).

This approach has been incorporated effectively into science curricula. Rudd et al. (2001) compared the performance of general chemistry laboratory students who used the standard laboratory report to the performance of students who used the Science Writing Heuristic (SWH) template on a laboratory experiment that involved physical equilibrium. Students in the SWH sections demonstrated a better understanding of equilibrium when written explanations and equations were analyzed, performed slightly better on the equilibrium practical exam task, and spent less time completing the SWH laboratory reports than students in the standard sections. SWH instructors spent less time scoring reports of their students. The SWH was shown to be a practical mechanism for progressively modifying the laboratory curriculum to reflect inquiry-based learning.

It also has been implemented in physics laboratories as reported by Erkol et al. (2010). In this study, a topic in physics in the mechanic unit was evaluated. The study was carried out with 42 freshman students who were admitted to the science education department in a university in eastern Turkey. Results indicated that the SWH approach and the reporting format considerably increased students' mechanic unit achievement, conceptual understanding of the unit, and attitudes toward laboratory. In general, using both a guided-inquiry format for the experiments and the Science Writing Heuristic format for the laboratory report, students were provided with opportunities to be involved in authentic science laboratory activities rather than doing traditional "cookbook" activities to reconfirm the same literature value or similar task.

In addition, research on SWH has shown that it is a powerful approach to assist students' learning science from diverse backgrounds. For example, Akkus (2008) describes the implementation of the SWH approach in elementary classrooms. The specific interest of this research was given to its implementation across different grade levels (K-6 grade) and its impact, along with students' characteristics that included socioeconomic status (SES) and individualized education programs (IEP), on students test scores. One of the major findings in this study was the improvement in learning of students with learning disabilities and low socioeconomic status. This held true even for those classrooms where the teacher had medium implementation, which still offered more student opportunities of negotiation among their peers.

The studies mentioned above focus their attention on some of the factors that influence Hispanic achievement in science, such as culture and language issues. This argument-based inquiry approach provides opportunities for teachers to encourage scientific understanding and argumentation in the science classroom where language is embedded in the science inquiry practice. Students who are involved in this argument-based inquiry also have opportunities to develop literacy skills, since this approach requires students to read, write, and speak which are essential to understand and communicate scientific ideas.

The Importance of Dialogue in Science Classroom

The National Science Standards and the NGSS require preparation for students in K-12 levels focusing on three main areas to assure high quality science educations. These areas are 1) Content of science; 2) Understanding of the practice of how science knowledge is acquired; and 3) Opportunities to develop and connect concepts across all domains of science. In providing students gaining those dimensions in their science education, teachers are preparing them to become scientifically literate citizens. Science is a way of knowing and a human endeavor that is attached to language. Therefore, teachers should prepare their classroom to talk about science in a real science context (Lemke, 1990).

One core idea that has been promoted and advocated to be included in the goal of teaching authentic science in classrooms is argumentation. Creating arguments is a process that takes place as an individual activity through thinking and writing, and it is a social activity that takes place as a negotiating act in a specific community (Driver, Newton, & Osborne, 2000). As it is seen, both individual and social activities require the use of language. To prepare students for this endeavor and supply the demand of including argumentation as a core of learning science, teachers should prepare students to collaborate with each other.

In setting the classroom for the demands of learning science as inquiry and preparing students for argumentations or negotiations, teachers have multiple responsibilities for establishing productive group work and dialogue (Webb, 2009). Dialogue is a common word used in several fields of education and in informal settings but as Game & Metcalfe (2009) explain, the meaning of dialogue sometimes is diluted if it seen as matter of exchange or negotiation of prior intellectual positions. He explained that the etymology of the word indicates that *dia* of dialogue indicates *through*. This means that dialogue moves through participants and vice versa. So he states that dialogue "allows participants to have thoughts they could not have had on their own." Game recognizes these thoughts as developments of the participants' own thinking. On this understanding of dialogue, education is a transformative rather than simply a cumulative process. Hence deep learning occurs through these strategies which can be implemented in science classrooms.

Therefore, one of the teacher's responsibilities is to recognize the conformation of the groups to avoid some of the members being dominating about ideas in the group, students' hostility toward one another, or groups that provide answers without justifications. A second responsibility is to describe and explain to students the behaviors that are expected during the actual group work. A third responsibility of the teacher is to show students the instructional ways of making discourse emerge from questioning practices and providing explanations to justify their inquiries or problem solving strategies (Howe & Abedin, 2013). These authors also found in their extensive review that dialogue is characterized by the pattern of initiation-response-feedback (IRF), with teachers taking primary responsibility for initiation, students providing responses, and teachers following with feedback. They emphasized that in the “dialogical interaction” feedback is crucial to the response-discussion relationship. Another finding from this review indicated that gender has been predominant in students’ characteristics, and ethnicity needs to be taken into account in terms of student participation in classroom dialogue. For example, boys are more likely than girls to respond to teacher initiations; however, girls were more likely than boys to raise their hands. With regard to ethnicity, the review revealed that minority ethnic students participate with low frequency because they feel uncomfortable when they participate.

The promotion of these responsibilities lead students to focus on the elaboration of conceptions. In research about the structure of students’ dialogic argumentation, Skoumios (2009) studied 20 students, 14 years of age, from the same urban school located in Greece. He investigated the effect of dialogic argumentation based on the concept of floating and sinking using sociocognitive conflict strategy. Sociocognitive conflict strategy is characterized by comparing and generating conflicting perspectives that foster the discovery of a more adequate, logical, coherent, and better understanding (De Lisi & Golbeck, 1999). The idea was to explore the structure of students’ argumentation and the contribution of teaching in that development. The result of this study revealed that students’ dialogic argumentation during teaching sequences was effective when several conditions were offered. For example, allowing students to work small groups because it creates a micro non-threatening environment to feel safe about their answers promoted conditions for discussions among students. Also the discussion led students to negotiate meaning of the floating and sinking concept. Third, the study suggested that learning environments that promote sociocognitive strategies is an effective strategy to scaffold student involvement in scientific discourse.

The process of using language as a form of dialogue to promote thinking is not a task exclusively of classrooms. It can be originated as a parent-child interaction in everyday life situations (Mercer & Littleton, 2007). They described that the causal adult-child interaction revealed that adults used several strategies to generate a common frame that included "establishing a referential perspective." In this study, the adult responded to the child's lack of understanding by referring to other shared knowledge. The second common frame is the adult used a reverse process. This consisted of making abbreviations when talking to the child or making cryptic references, assuming that the child already has that knowledge. Both of those common frames provided to the child a scaffolding to support their understanding and independence.

These experiences can be translated to the science classroom with student-student interaction or teacher-student interaction. These interactions and the generation of dialogue are based on the foundations of Vygotsky (1978) who proposed that in the use of language there is a close relationship between the use of language as a cultural tool that involves social interaction and the use of language as a psychological tool which helps us to organize our own individual thinking. Deep learning occurs through this kind of engagement that must continue to be supported in science classrooms as a way of learning concepts, science practices, and argumentation. Therefore the function of dialogue is to transform people's thinking to open new worlds and expand minds (Game & Metcalfe, 2009).

Effective Learning Tools Used in Science Classrooms

Science learning requires the use of language in classrooms to develop new knowledge (Hand, Norton-Meier, Staker, & Bintz Hand, 2009). In doing so many forms of language should be included when students are engaged in their science lessons. These forms of language serve as learning tools to help to shape their emerging knowledge. I already mention dialogue as a means to create cognitive restructuring for students involved in meaning-making of concepts. Other language tools have also been shown to be effective in learning science, applying the science practices, and focusing in the argumentation in classrooms such as using a KWL chart, representations, and writing.

KWL Chart

One of the learning tools that have been commonly used in elementary instruction is KWL. The KWL chart was developed by Donna Ogle in 1987 as a graphic organizer and reading tool to motivate students to get involved in the questioning process. It stands for what we Know, what we Want to know, and what we want to Learn. KWL is an exploratory tool in nature that promotes group thinking and it has been applied to other subjects such as reading and writing (Glazer, 1999), and in recent years with the encouragement of learning science as inquiry it has been incorporated in science classrooms with some variations (Hershberger, Zembal-Saul & Starr, 2006). For example, Hershberger et al. (2006) developed a variation of the KWL chart known as a

KLEW chart which stands for Know-Learning-Evidence-Wonder. The purpose of this variation was to emphasize the essential features of inquiry. The adaptation of the chart encouraged students to record direct observations, create questions based on the observation, continue doing investigations, and create evidence based on their learning. Using these approaches in science classrooms help students to create questions spontaneously as collaborative work and also creates opportunities for teachers to use additional tools to organize and explore students' ideas.

Developing and Using Models

The Framework for K-12 science education (NRC, 2012) emphasizes teaching strategies that align with science practices. This dimension describes the main practices that scientists use as they investigate the world. One of those practices is the development of models to represent systems or phenomena. Science is not developed and communicated only using verbal language. Lemke (1998) explained that "to do science, to talk science, and to read and write science it is necessary to juggle and combine in various canonical ways verbal discourse, mathematical expression, graphical visual representations, and motor operation in the world" (p. 88). Therefore, it is necessary to encourage students to employ representations to support their learning of science in classrooms given the central commitment of science to provide evidence-based explanations of phenomena.

Representations are also important in science because they provide students opportunities to better understand complex concepts. Research in representation has been conducted in order to investigate how students use representation to enhance their learning. For example, Danish & Phelps (2011) explored the representation practice of 42 students in kindergarten level and first grade. They discuss that early elementary students spend considerable time learning by drawing, sculpting, and enacting ideas, and sometimes how those processes occur in early elementary school can be overlooked. Therefore, the participants of this study were asked to create storyboards about how honey bees collect nectar before and after curriculum intervention. The findings pointed out that developing representations for these students grew into a more constructive way when teachers encouraged them to request feedback from each other since students were talking throughout these sequences of activities. Students were able to engage in conversation about representation by generating not only more talking but increasing the quality of the talk while they were using representations.

All students in classrooms at diverse ages are competent to design and develop representations to better make sense of ideas. What these students require is engaging in activities that motivate them in the form of deep and personal involvement (diSessa, 2004). This can include activities such as the use of multiple and multimodal representations of the science concept. Prain, Tytler, & Peterson (2009) define ‘multiple’ as the capacity of the science discourse to represent the same concept in different modes. Multimodal is the integration of different modes to represent scientific processes, explanations, and findings using different modalities such as language, depiction, and symbols. When students get involved in these activities they can explore alternatives to express their understanding and learn to communicate as scientists do. The multimodal environment in students' everyday life can become a motivating factor for teachers to take advantage of in the classroom (McDermott, 2010). For students to develop better scientific understanding they must participate in this practice actively. To achieve that goal, teachers should be prepared to understand first the value of representation in student science learning and then look for strategies to integrate them into their regular lessons.

Active Writing in Science Classrooms

Following the intrinsic idea that language is fundamental for science, there is a need for implementing, developing, and including different forms of language such as writing for students. "Communicating in written or spoken form is another fundamental practice of science; it requires scientists to describe observations precisely, clarify their thinking, and justify their arguments" (NRC, 2012). Writing is a tool that has impacted students' conceptual understanding. For example, Chen, Hand, and McDowell (2013) studied 835 fourth-grade students who wrote three letters for exchange to a specific audience, 11th graders, during the lesson of forces and motion. Students were immersed in an argumentative writing task which focused on the components of question, claims, and evidence. Their findings reveal significant performance in the students who participated and benefits for non-mainstream students. Therefore, initiatives of promoting students to be active writers can make a big difference for minority students such as Hispanic students who face educational underachievement in America (Gandara, 2010). In an effort to better meet all students' achievement expectations, schools have focused only on teaching the basic subjects at the expense of others, as in the case of science (Amaral, Garrison, & Klentschy, 2002), when it is in fact possible to integrate language arts into the science content area. Therefore, when students are immersed in the integration of reading, writing, and listening, this help them to recognize that one type of knowledge can be transferred to another (Morrow, Pressley, Smith, & Smith, 1997).

Writing should be used across the curriculum in math, science, and social science by involving tasks that include writing journals, freewriting, essays, creative writing, cartoons and explanations (Wallace, Hand, & Prain Wallace, 2007). Several conditions have been suggested in order to implement effective writing tasks to serve learning. Hand, Hohenshell, and Prain (2004) suggested that the writing task should emphasize conceptual understanding and have an authentic communicative purpose meaningful for students. In addition, students should have planning support in the form of small and whole group discussion involving peer and teacher feedback. Finally, students should engage in backward and forward searching. Forward searching is explained as the generation of text where students clarify ideas; backward searching includes activities related with revising goals and clarify meaning. These conditions should be one of teachers' goals in order to create environments where student could have rich opportunities to grow in their science understanding.

In the light of these findings, this researcher seeks to explore if this argument-based inquiry approach can benefit Hispanic students' learning science and how factors such as culture, language, poverty, and instruction are intertwined with the specific aspect of science writing heuristic (SWH). This research also explores how Hispanic students from the same elementary public school in an urban area whose home language is Spanish but generally speak English at the school can learn about the language through the process of using the language. As Norton-Meir and colleagues (2008) suggest, “If the understanding of science and the language is built within the context of science through embedded language practice, the student confidence in both the science and the language becomes much greater.” A few studies have evaluated those conditions, especially how the SWH approach encounters the challenges that underrepresented students bring to the science classroom.

Summary

In this chapter, I presented the theoretical framework about sociocultural constructivism and existing literature that describes the Hispanic students’ experiences in education and the factors that promote their underachievement in public schools. In addition, I present research that has addressed some of the factors that affect their education attainment. Then I describe the Science Heuristic Approach (SWH) as a possible strategy to support Hispanic students and the elements and learning tools that research, the national science standards, and the NGSS have shown to be significant for all students learning science.

CHAPTER THREE

METHODS

In this section, I explain the research methods that were used to examine Hispanic students' ways of learning in science in an argument-based inquiry context. Following this I explain the context of the study, participants, data sources, data collection and analysis.

Research Method

The SWH approach to argument-based inquiry offers opportunities to students to engage in activities that involve laboratory activities and negotiation of conceptual understanding while they are learning science (Table 3 shows the definitions for these terms). These activities may represent a positive impact in students' science learning and provide some insights of how their initial learning growth occurs and the challenges that they may encounter. This matter can be understood by examining the experiences of three Hispanic students learning science in the SWH context. The purpose of this study is to examine how Hispanic students learning can be supported by an argument-based inquiry approach. To this end, a case study approach (Merriam, 2009; Yin, 2009; Stake, 1995) was appropriate to explore in a descriptive nature the involvement and experiences of these students in their science classrooms and address the research questions driving this investigation, which are:

1. In what ways do two aspects of an argument-based inquiry classroom (i.e. laboratory activities and the negotiation process) impact three Hispanic

students' science learning in terms of a) conceptual understanding, b) science practices, and c) understanding of argumentative components?

2. What challenges do these Hispanic students encounter in this argument-based inquiry classroom?

Table 3

The Science Writing Heuristic Aspects Definition Adapted from Hand (2008)

The Science Writing Heuristic aspect	Definition
Laboratory activities	In the SWH classroom environment students are encouraged to answer questions to be explored through a scientific investigation. Students design and conduct investigations in which they collect data, analyze them, and develop claims and evidence. Students are also prompted to compare their laboratory findings with other sources or "experts" which include their peers, textbooks, the internet, or an actual person.
Negotiation	After students construct the question-claim and evidence in their team they present their findings either to small group or whole group. This process promotes public negotiations that allow students to critique the work put forward by peers. Further small group discussion occurs after whole group discussion in order for students to assess the feedback received and address any changes that they think are critical for the audience.

This research is based on a qualitative case study of three Hispanic students' learning science in an argument-based inquiry context in an elementary school. A case study is "a study of the particularity and complexity of a single case, [in order] to understand its activity within important circumstances" (Stake, 1995, p. xi). In other words, a case study is an empirical and holistic inquiry that explores a social unit, a single instance, or a phenomenon within a natural setting (Yin, 2009; Merriam, 2009).

According to Merriam (2009), a case study is characterized by being particularistic, heuristic, descriptive, and helpful in illuminating a phenomenon of a "bounded system." In addition, case studies are the method of choice when the researcher is going to explore "how" and "why" questions. These types of questions are more exploratory in nature and provide operational links to investigate a phenomenon traced over time rather than mere frequencies or incidence.

The case study is preferred in examining contemporary events in a real life context, but where the relevant behaviors cannot be manipulated by the researcher (Yin, 2009). Therefore, this approach is particularly appropriate for doing an in-depth study of a bounded system. For this study, the bounded system was the three students' immersion in the SWH approach from September 2011 until October 2012. The elements of this bounded system helped to understand how these three Hispanic students learned science while they were involved in an argument-based inquiry approach.

In this study, I examined the impact and challenges of an argument-based inquiry on students who had disadvantages in terms of English proficiency, parental education, socioeconomic status, and instructional environments in school. To fully understand this, it was necessary to carry out an in-depth study of the students individually, including their participation in groups in the classroom setting, as the unit of analysis (Merriam, 2009). This allowed me to describe in depth their experiences in the SWH classroom and how this approach used by their teachers impacted their learning in three science dimensions when they worked through laboratory activities, negotiation process as small and whole group discussion, and individually.

I conducted a multiple case study, as Yin (2009) defines as a research design in which each student is the subject of an individual case study, but the study as a whole involves two or more subjects. As Merriam (2009) explains, "the more cases included in a study, and the greater the variation across the cases, the more compelling an interpretation is likely to be." By using multiple case study, researchers have an additional strategy for improving the credibility and dependability of their findings (Lincoln & Guba, 1985). Therefore, taking in account the benefit of a multiple case study, several subjects were invited to participate in this study and from ten students contacted three agreed to become involved. This offered a viewpoint of how students learned in this particular context and what factors and challenges improved or prevented their learning at different stages in their participation. By exploring three students' experiences in the SWH classroom, this study provides an indication of the robustness and quality of the design (Herriot & Firestone, 1983). In addition, Herriot and Firestone (1983) indicate that this research design provides information to answer the same research question in several settings using similar data collection and data analysis for each case. Moreover, using three cases allowed for a cross-case analysis that led to create assertions and interpretation of the cases (Creswell, 2013).

Participants

The participants of this study were three Hispanic students in an elementary school in different classrooms where the science teachers had been involved in an argument-based inquiry for at least one year. For meeting the variations in qualitative studies a nonprobability selection was carried out through purposeful selection. This method allows the researcher to have the opportunity to determine, understand, and gain insight to select subjects, thereby learning most from the phenomenon under study (Merriam, 2009). There are several types of purposeful selection, such as typical, unique, maximum variation, convenience, and snowball or chain (Gerring, 2007; Creswell, 2007; Patton, 2002). The type of selection for this study was snowball or chain. This technique is defined as a set of strategies that involves and identifies a few key participants who easily meet the criteria established by the researcher for participation in the study. The criteria for this study consisted of several factors: a) participants or their parents were from a Latin American country; b) participants had to be enrolled in elementary level; c) the school's participants used the SWH as learning science approach; d) participants' teachers were involved in the professional development to implement the SWH approach in their classroom; and e) participants were disadvantaged in terms of socioeconomic status, low English skills, and low parent level of education (See Table 4 for descriptions of the participants).

Table 4

Participants' Descriptions.

Participant	Age	Grade	Parents' level of education	Gender	Language spoken at home	Free and reduced lunch program participation	Special program participation
Armando	10	5	Middle school	male	English and Spanish	Y	N
Alexandra	10	4-5	Elementary school	female	Spanish	Y	Reading, writing, math, ESL
Amelia	10	5	High school	female	English and Spanish	Y	N

One of the most consistent patterns that researchers Waxman and Padrón (2002) and Galindo and Reardon (2006) indicate regarding Hispanic students' education is that students from families with low socioeconomic status, non-proficiency in oral English, and low parental level of education experience more disadvantaged educational environments. Given those characteristics, this helped me in selecting students with similar backgrounds who were engaged in learning science in the SWH context. This argument-based inquiry offers opportunities for students to gain access to science learning through laboratory activities and negotiations of questions, claims, and evidence for claims (Hand, 2008). Those aspects are displayed in Figure 1 and shows the basic outline that teachers follow for a unit and its essential dimensions to promote students engagement in the lesson.

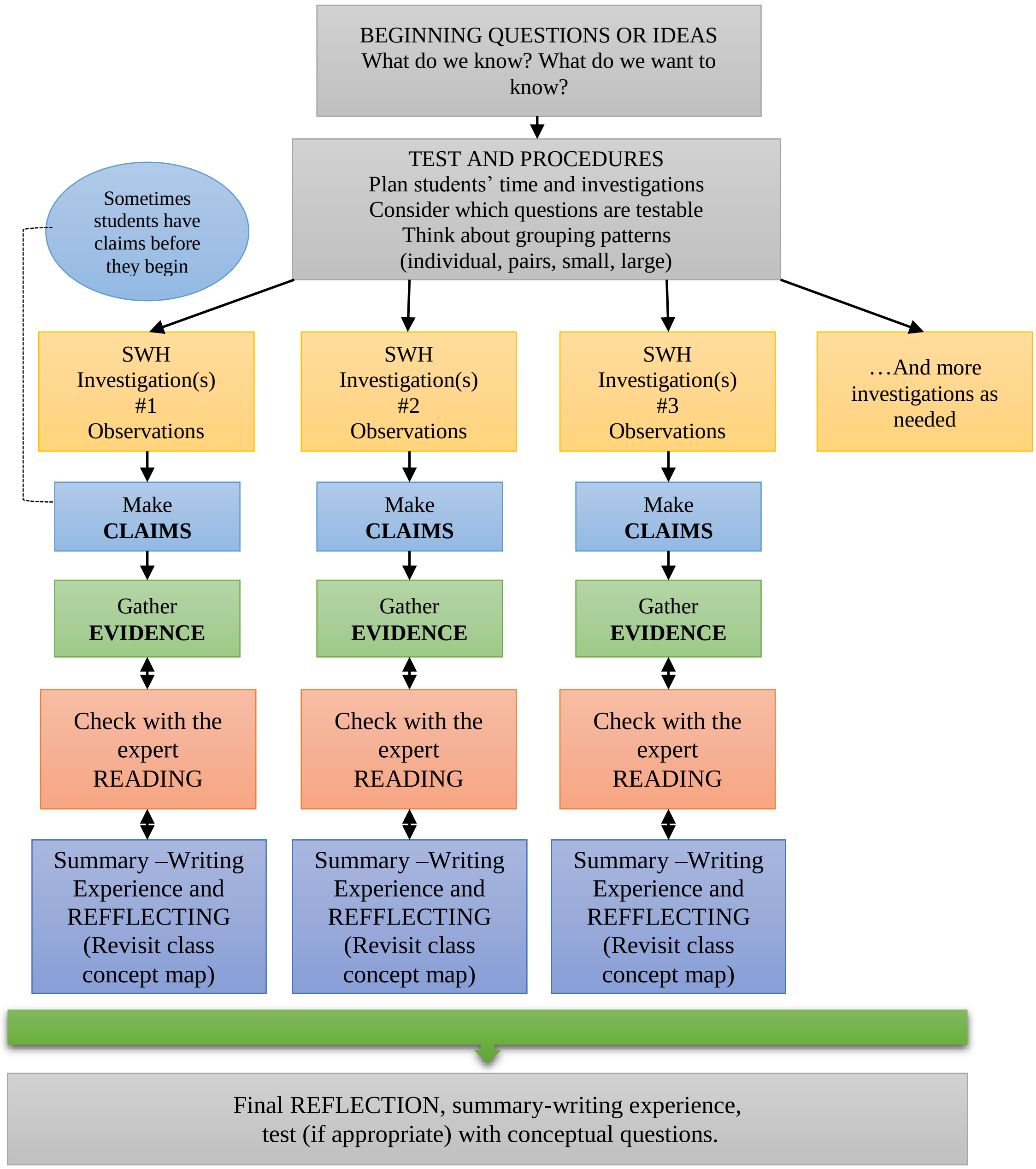

Figure 1. Essential dimensions for planning an SWH unit in the classroom. Adapted from Hand (2008).

Research Context

This research was conducted at Robinson Elementary School (pseudonym). This case study primarily explored three main classrooms in an urban area of eastern Iowa, which has a population of 390 students in the elementary school and two preschools.[3] In this school 72.84% of the students received free or reduced lunch. The population of the school was constituted by Caucasians, followed by African-Americans, and Hispanics. The percentage of Limited English Proficient Students (LEP) was 8.95% in the district. Figure 2 shows the diversity of Robinson School.

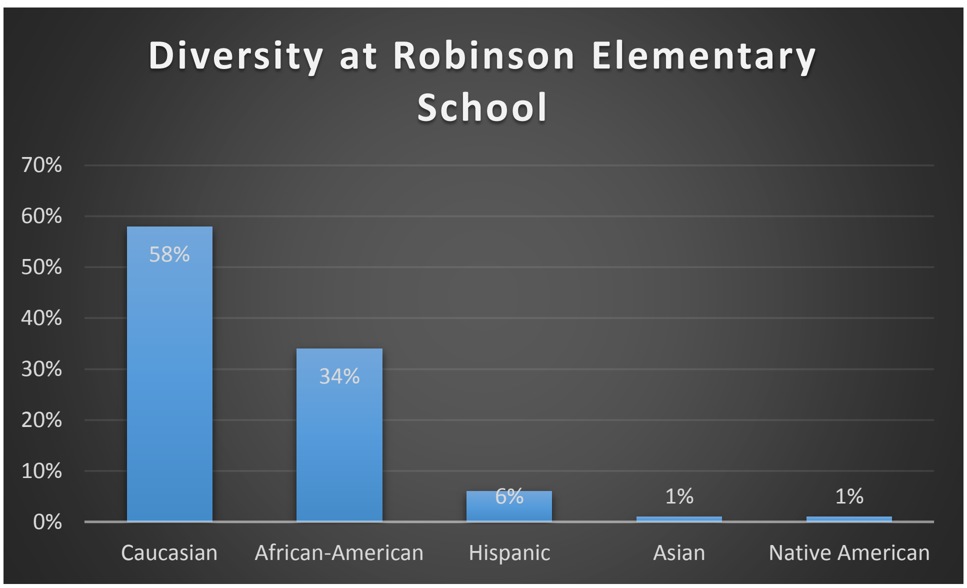

Figure 2. Diversity of the school.

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[3] Statistics for the State of Iowa, as reported in *The Annual Condition Report, Iowa Department of Education, 2014.* Caucasian 79.8%, African American 5.2%, Hispanic 9.3%, ELL 5.3%.

The teachers from this school participated in the project *Efficacy of the Science Writing Heuristic (SWH)* approach. They participated in the professional development that was performed during Summer 2010 and 2011. The teachers taught levels from third to fifth grade. Twelve days were spent in total for the two years of professional development. The teachers who were involved in this study were Mrs. Smith, who attended the professional development five times; Mr. Jones, who attended six times; and Mrs. Thomas, who did not participate in any. These teachers were involved in this study indirectly since the main subjects of this study were students who belonged to their class group. The level of implementation for these teachers varied according to a modified reformed teaching observation protocol (RTOP) score (Martin & Hand, 2009). For example, Mrs. Smith's level of implementation was classified as medium and Mr. Jones' was classified as low.

Based on the principal's message to the community, Robinson School is a child-centered school where the staff were committed, trained, and motivated to provide the best education to the students. Teachers were willing to participate in professional development such as the SWH project and implemented it in their classrooms. As a researcher of the SWH project I served as support for these teachers in the school. This led me to invite the school to participate in this additional project of examining Hispanic students in the SWH context that they were using to teach science.

Science time for the academic year was alternated with social science. For the science lessons teachers mostly followed the Iowa core curriculum as a guide to develop their lesson plans. The lesson plan for the whole year included two main units and two lessons per unit. Each lesson lasted from three to four weeks. For example, in Table 5 Mrs. Smith divided her main units and lesson for the whole year.

Table 5

Mrs. Smith's Fifth-Grade Science Units.

Main Unit	Lessons	Lessons
1. Life science	Animal's habitat Big idea: How does the animal's habitat affect the animal?	Human-changed environments Big idea: How do people affect the environment?
2. Physical science	Magnetism Big idea: How do magnets work?	Sound Big idea: How does sound differ in different substances?

In addition, Mrs. Smith's lessons followed some ideas from some science books such as Scott Foresman (a main science book publisher) to adapt the lesson to the SWH approach. In the lesson plan she included step-by-step how to explore the prior knowledge, inquiry question, assessment, and procedure for the laboratory activities of the lesson under study. A sample of the sound lesson plan is shown in Table 6.

Table 6

Mrs. Smith’s sound lesson plan adapted to SWH.

Activity 2: Mini-Labs
Must-Knows: • Energy exists as heat, electricity, sound, light, and magnetism.
Should-Knows:
Nice-to-Knows: • Heat can be produced by burning, rubbing, or mixing. • Things give off light, also give off heat.
Assessment Question: • Describe the different types of energy.
Inquiry Question: What forms can energy take?
Procedure:
Mini-Lab 1:
How do sounds differ when made in different substances? 1. Give students a tuning fork, tube, table, and stick, string, cups, container of water, stethoscope, and paper towels. 2. Create stations with: Station A–tuning fork/tube; Station B–table/stick; Station C–string/cups; Station D–container of water, stethoscope, and paper towels. 3. Students write observations from each station and then write one claim for the question. 4. Working in small groups, students write claims in journal and share with the class. 5. Students also write the evidence in journals. During the “negotiation” of claims/evidence, students may be asked to pause and reflect. 6. Students consult the experts using internet, non-fiction textbooks to find evidence that supports the class’s claims.

Data Collection

The data collection for this study started in Fall 2011 and concluded in Fall 2012. Data was collected using different qualitative methods, such as classroom observations, semi-structured interviews, surveys, students’ writing reflections, assignment examples, and researcher’s field notes. A total of nine interviews and 11 to 16 observations of each student were collected. In addition, at least two science units in fourth and fifth grade were observed. Table 7 shows a summary of the data collection.

Table 7

Data Set

Participant	Science unit	Number of observations	Number of interviews	Number of writing samples	Total time observed	Total time interview
Armando	Habitats Magnetism Sound	14	9	15	9.3 h	90 min
Amelia	Habitats Energy	11	4	26	7.33 h	40 min
Alexandra	Matter Habitats	16	9	13	8.6 h	90 min

Observation

Observation is one of the primary tools for data collection in qualitative research (Merriam, 2009). Participant observation played a main role in this study. A considerable amount of time was spent in the participants' classroom to watch their activities, and record through videotaping interaction, conversation, and their behavior in their engagement of science lessons. According to Merriam (1998), gathering data through observation as an outsider leads to noticing events that can be routine for the participants that may give information on the context. Second, observation is a source to triangulate the findings of the researcher when combined with other sources of data. Third, observation allows the recording of information as it is happening. Fourth, observations provide knowledge context of incidents that may help for conducting follow-up interviews. Finally, observation is the technique of election when situation or events can be observed first hand or when the participants are not willing to discuss the topic under study. For this study, observation helped to examine the participants' dialogues about science concepts, science practices, and argumentation. Some of the participants were shy and it was difficult to elaborate answers for them during the interview.

A good qualitative observer needs to develop a specialized eye for what, when, and where to observe. Therefore, Creswell (2013) suggests several steps to conduct observations such as: select a site to be observed; identify who or what to observe; determine the initial role as an observer; design an observation protocol; and record aspects associated with the physical setting, particular situation, and the researcher's own reactions.

For this study observations were carried out in the classroom setting of three Hispanic students. The number of observations varied among the participants but the range was between 11 and 16 observations. The length of the observation was 45 minutes, the same as the length of the student science class period. For each observation, transcripts were created to examine as much as possible the details of students' engagement in dialogue during laboratory activities and collaborative negotiation. As observer I was involved in what was occurring in the classroom. Therefore, depending on the engagement of the researcher, four types of observation procedures are common in qualitative studies. Creswell (2013) indicates those as complete participant, participant as observer, non-participant/observer as participant, and complete observer. In this study my participation was non-participant observer.

The role of non-participant observer

Although I was the SWH researcher responsible for serving as support for all teachers from third to fifth grade, my role was as a non-participant observer in the classroom where the Hispanic students were participating. I did not participate for the professional development of these teachers during the first year of their involvement in the project. During the second year, I collaborated with the professional development team during the summer. My involvement with the teachers at Robinson School was regarding the big project *Efficacy of the Science Writing Heuristic (SWH)* approach. In this study, I was not involved in the classroom while teachers were teaching their lessons nor intervened in their decisions for their lesson plans or regarding the classroom settings. My observations and activities in the classroom were known by the teachers and the students, and my participation in the groups observed was secondary. This method allowed me to gather a wide range of information as an outsider but the level of information is completely controlled by the teacher and students in their science lesson activities (Creswell, 2013; Merriam, 2009).

As a non-participant observer, it was significant for me to make the teachers and students feel comfortable with my presence in the classroom. As researcher, I was interested in the patterns that emerged from participants' actions. Hence, at the beginning of the project I used videotaping as method to collect observations. However, this action was interpreted by teachers as intrusive and distracting for students. For reducing the intrusiveness of having a video camera in the classroom, my strategy was to negotiate the number of observations to between four to six and collect the information as field notes and video recordings of the social actions.

Interviews

The interview is one of the most commonly used methods for gathering qualitative data. The type of interview will depend on the purpose of the research and the exploratory or confirmatory nature of the study, allowing interviews to be highly structured or completely open-ended (Drew et al., 2008). Merriam (2009) categorized interviews based on structure and philosophical and disciplinary orientation. There are three types of interview based on structure: the first is a highly structured interview, also known as a standardized interview, in which the topic addressed, the wording of the question, and the order of the question are pre-specified. Questions are designed to be forced choice (e.g., true-false, multiple-choice). This type of interview does not allow the researcher to access participants' understanding of the world.

The second is a semi-structured interview, in which topics addressed, wording, and order of questions are less structured and more flexible, and the question itself is open-ended but guided by a list. This format allows the researcher to respond to the situation at hand, promoting new ideas to emerge. The third type of interview is unstructured, mainly used in the early stages of a qualitative study. There is no predetermined set of questions and the interview is essentially exploratory. It is usually used in combination with observation. In most studies, an unstructured interview can be used to obtain standardized information. Some open-ended questions are asked using the unstructured mode for the researcher to get insights and new information on the topic.

Two types of structured interviews were used in this study. A survey, in the form of a highly structured interview, was used to explore students' family background first, followed by a semi-structured interview with open-ended questions, which allowed the participants to talk openly and at length. Open-ended questions elicited high quality information about students' interest in science; how they used language in the context of argument-based inquiry, especially during the negotiation stage and writing reflection; how the students' initial ideas of a particular unit changed through interaction with peers and teachers; and how they put all of the pieces together to construct their learning in science (See appendices A and B). This interview took at least 10-20 minutes. Interviews were recorded and transcribed for an in-depth analysis of students' thoughts. Before the interview, students were asked about their language of preference. These interviews took place before or after their science class. The interviews were scheduled such that they did not interfere with the students' classes.

Field Notes

Field notes are the written account of observations and constitute the raw data from which findings emerge (Merriam, 1998). The field notes are analogous to the interview transcript. The emphasis of the field note is to record and take notes during the observation. Field notes are intended to be highly descriptive with enough detail the readers can get a vicarious experience. In this study, I captured some field notes at the same time as the videotaping. However, it was convenient for this study analysis to collect field notes after the videos were watched again to find relevant events during students' science investigation. During field notes collection the researcher can use several guiding questions to narrow down what observations record. For example, Wolfinger (2002) explains that using questions such as "What do I notice? What do I choose to focus my attention upon? What do I subsequently recall?" can help to decide what to watch. Field notes are another source of data that includes descriptions, direct questions, and observer comments (Merriam, 2009).

Student Work Samples

Collecting objects in the field is another source of data in qualitative studies. Objects represent a form of primary evidence, such as computer printouts and students' writing samples, which can help to elucidate the content of the education happening in the classroom (Yin, 2011). In this study, students' work samples were collected as copies from participants, science notebooks, informal writing, and the structured SWH template. The collection of these documents was at the end of each unit and copies of them were made and returned to the students. This data source is useful for data triangulation and to help the researcher expose the meaning of relevant issues to the research problem (Merriam, 2009).

Data Analysis

A characteristic of case study research is the use of multiple data sources, a strategy which also enhances data credibility (Patton, 2002; Yin, 2009). Although making sense of the data collected can be challenging for researchers, attention to data management is important. Merriam (2009) explains that to start an intensive process of data analysis in a case study, all information about the case should be gathered together and organized in some manner for the data to be easily recovered.

Different sources of data were available for analysis: videos and transcripts, interviews and transcripts, and field notes and writing samples. For each source, the researcher looked for the two aspects of argument-based inquiry: laboratory activities and negotiations, and explored how they impacted students' science learning. The focus of the codification and analysis was on three dimensions of learning: conceptual understanding, science practices, and understanding of argumentative components.

All interviews were audio recorded and the observations were videotaped. Then, both interviews and observations collected through the videotaping were transcribed and imported to Atlas.ti, which is a program useful for organizing qualitative data through open coding and for building concepts from a textual data source to see their properties and dimensions. Data analysis involved several processes. The first coding process was to divide the data between the two aspects of laboratory activities and cooperative negotiations. Once the data that pertained to the process of laboratory activities and cooperative negotiation was defined, the second step was to examine the dimensions of learning sciences using several rubrics, as shown in Figure 3.

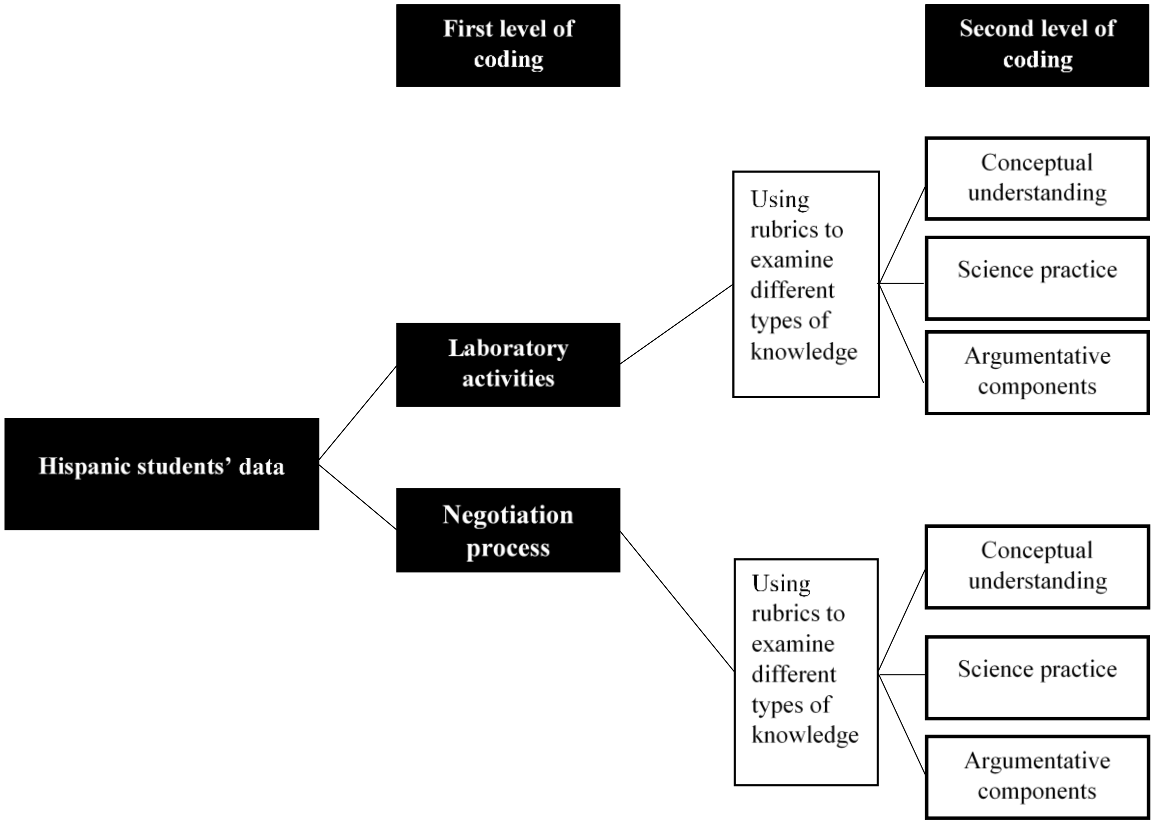


Figure 3. Schema of Hispanic students' data analysis.

The second level of analysis involved the use of several rubrics that describe the criteria for assessing students' key aspects of science learning and level of quality: 3 = significant; 2 = fair; 1 = limited; and 0 = no evidence. The label of quality level as "significant" means that students met the definition of the criteria and the guiding questions for that criteria. The level "fair" means that students met the criteria and the guiding questions partially. The level "limited" means that students met few or none of the criteria of the definition of the dimension and the guiding questions. "No evidence" means that the criteria was not found. For this second level, the analysis of the science dimension was performed for each student.

The first learning science dimension analyzed was conceptual understanding. For both aspects of laboratory activities and negotiation process the same rubric was used depending on the student's particular lesson. Amelia participated in two lessons: animal habitat and humans and environment. Armando participated in three lessons: magnets, sound, and humans and environment. Alexandra participated in two lessons: matter and animal habitat.

The science units that students explored were related to the core ideas of physical science (such as understanding and applying specific knowledge of sound and magnetism) and the core ideas of life science (such as understanding structures, characteristics, and adaptations of organisms that allow them to function and survive within their habitats). For the case of conceptual understanding on the different topics several categories were developed (see appendices C, D, E, F and G for more details on the rubrics for the different lessons). Table 8 shows the categories in the different topics analyzed for conceptual understanding in this study.

Table 8

Core Concept Lessons and Categories Observed in this Study.

Core Concept	Category
State of matter	a. Understanding the concept of matter b. Understanding the properties of matter
Life science: habitats	a. Understanding about ecosystem b. Understanding the concept of animal habitats c. Understanding niche concept
Humans and environment	a. Positive impacts to the environment b. Negative impacts to the environment
Conceptual understanding about magnets	a. Understanding the concept of magnetism as a property of matter b. Understanding characteristics of magnets c. Understanding about how magnets interact with each other d. Understanding of properties of magnets
Conceptual understanding about sound	a. Understanding the concept of energy as sound b. Understanding the concept of the nature of sound c. Understanding about how transmission sound occurs through a medium

The second learning science dimension analyzed was science practices. The rubric to examine this dimension was created based on the state standards, teacher learning goals, and the Next Generation of Science Standards (NGSS). The rubrics were evaluated by triangulation strategies using multiple source of data (Merriam, 2009). Based on what is explained in the K-12 framework of what students should know to be proficient in science, one of the three dimensions of focus is science practices. Science practices describe “behaviors that scientists engage in as they investigate and build models and theories about the natural world” (NRC Framework, 2012, p. 30*)*. As is suggested by the framework this dimension involves eight practices applied to science and engineering. The eight practices are shown in Table 9 and for this study the focus was only in a science context. As is explained in the Next Generation of Science Standards (NGSS), each practice is expected to be mastered by the students at the end of the semester, and the complexity of each practice increases across grades. The source of data to conduct the analysis and obtain the results for this section was students’ lesson observations, video transcripts, and writing samples (see details of this rubric in Appendix H).

Table 9

The Eight Practices of Science and Engineering (NRC, 2012).

Number	Science practices
1	Asking questions
2	Developing and using models
3	Planning and carrying out investigations
4	Analyzing and interpreting data
5	Using mathematics and computational thinking
6	Constructing explanations (for science) and designing solutions (for engineering)
7	Engaging in argument from evidence
8	Obtaining, evaluating, and communicating information

The analysis of science practices for the aspect of negotiation process is slightly different from the laboratory activities. Some of these analyses may overlap; therefore, I explored Hispanic students' practice of science by focusing on the category of constructing explanations (in science) and designing solutions (in engineering), engaging in argument from evidence, and obtaining, evaluating, and communicating information. These three categories were guided by the same rubric based on the Next Generation of Science Standards (NGSS). I am aware that these eight practices are not separated but are connected and overlap as is explained by the NGSS. However, for the purpose of answering the research question of this study I focused my attention on the practices that were very attached with the aspect of cooperative negotiation, which includes constructing explanations, engaging an argument for evidence, and obtaining, evaluating, and communicating information.

The third learning science dimension analyzed was understanding of argumentative components. Four categories were explored for the examination of understanding the argumentative components: the three core elements of argument, connections among elements of argument, level of scientific-explanatory argument, and level of rhetoric reference of reasoning (for more details of this rubric see Appendix I). The same analysis was performed for both aspects of laboratory activities and cooperative negotiations. Table 10 shows the summary rubric with the categories of this dimension.

Table 10

Understanding Argumentative Components Rubric.

Argumentative components categories	Definition
Three core elements of argument *(Questions/Claim/Evidence)*	Three core elements of arguments (questions, claim, and evidence) are explicitly and clearly described.
Connections among elements of argument	The author creates causal coherent connections among elements of arguments through his/her argument.
Level of scientific-explanatory argument	Student-authors' explanatory argument should make sense to readers to scientifically understand natural phenomena.
Level of rhetoric reference of reasoning	The author explicitly provides his/her reasoning to present how data in his/her investigation is used to support the claim.

After the analysis of each student's data in the three dimensions of science learning was completed, a third level of analysis was carried out. The third level of analysis was the constant comparative method of data analysis (Creswell, 2013). The analysis package and description of each student generated by the second level of analysis was used. The process of comparison started by separately examining and reading the result through each student's data set and creating margin notes that included labels indicating descriptive codes. Codes were organized based on their similarity and differences which generated emerging themes from the pattern of those codes. Hence, a code book was generated (see Table 11) because they provide a formalized operationalization of the codes (Fonteyn, 2008). Then the themes were identified and documented to address the research questions. The constant comparative method can use any set of data (Onwuegbuzie et al., 2009). Therefore, this was the method of election for the analysis of this study in which I was exploring how the learning growth in the three science dimensions occurred when students were engaged in two aspects of an argument-based inquiry approach. Figure 4 shows the third level of analysis of this study that involved the constant comparative method.

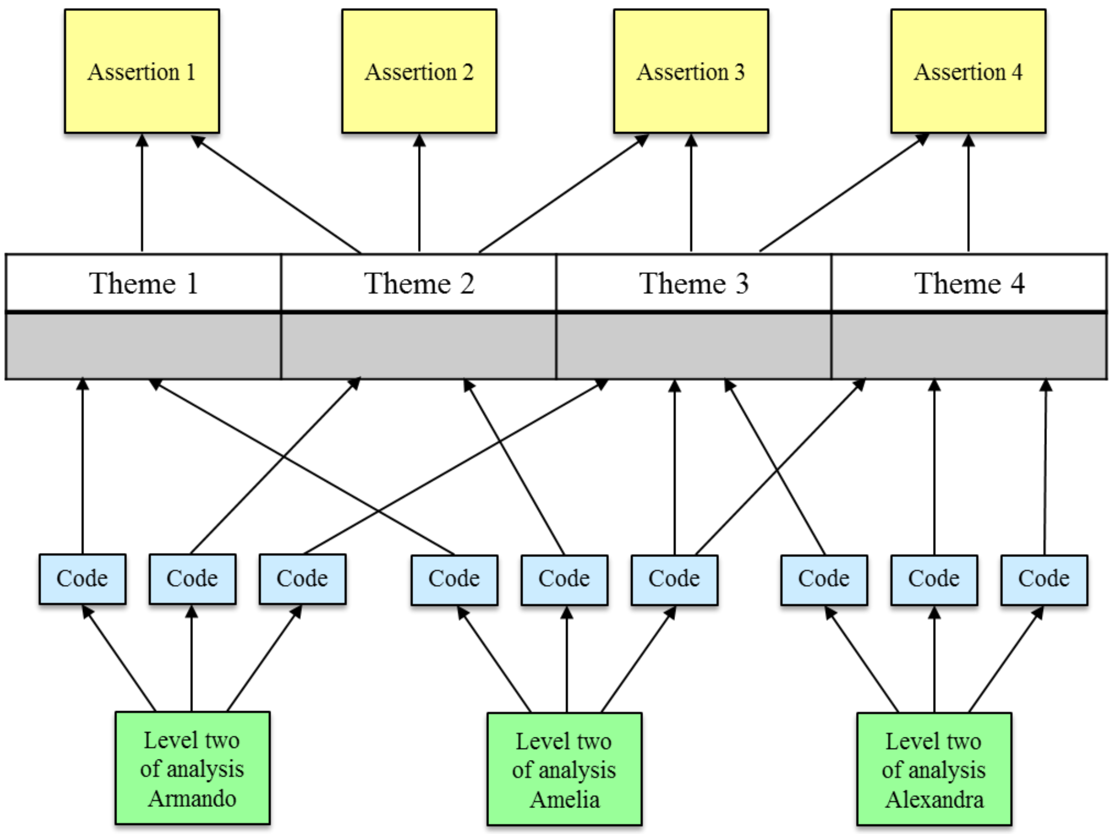


Figure 4. Combined conceptual analysis and constant comparative method process.

Table 11

Example of a Code Book to Address the Two Research Question of this Study.

Code	Participant	Aspect	Science dimension	Definition	Example
Time	Armando	Lab activities	Conceptual Understanding	Text coded to topic around the concept of time	Teacher: If your group gets done testing, you sit down, get your evidence paragraph written. Because remember these are mini labs and we've got several of them to do in the **next couple weeks**.
Dialogue student-student	Armando	Lab activities	Conceptual Understanding	Text code around dialogue captured during observation and transcripts	Armando: We used a lot of vibrations. Girl, blue shirt: Because every sound has a vibration. Armando: Wait, I still need to copy that. Girl, blue shirt: Vibration…
Learning tools (KWL)	Amelia	Lab activities	Science practices	Text code around students using tools in the science classroom	Teacher: **What do we know** about animals and their habitats? Student 2: They are like people. **Amelia:** If an animal's put in a zoo, then they don't have all the stuff that they have in their habitat.
Active dialogue	Amelia	Lab activities	Argumentative components	Text code around using active writing for an initial learning of the core of arguments	Callie: **The evidence** was, when we first opened it, it smelled like poop. We moved away the fur and small bones. After a while, we found a skull. It was hard to get the fur off. Amelia: Then we uncovered a jawbone. After that, we kept finding small bones. I've seen an owl pellet before, so I know that this was an owl pellet.
Challenge Issues Associated with Group Conformation or Pairing up Students	Alexandra	Negotiation	Science Practices	Text code around potential challenges learning science in the ABA approach	Alexandra: I think the animal was an owl that made it. Or a bird. How about a bird? Michael: Bird. A crocodile? Crocodile skin. It looks like it has tires on it, mini tires, like the tire pattern. Like seriously, it looks like a crocodile. Alexandra: How do you spell bird? How do you spell, I don't want to.

Trustworthiness

Numerous strategies can be used to enhance the trustworthiness of qualitative research. In qualitative research these can be credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). Credibility refers to the confidence in the true of the findings; transferability refers on how the findings have applicability in other contexts; dependability refers on how the findings are consistent and can be repeated; and confirmability refers to the findings being shaped by respondents and not by the researcher’s bias, motivation, or interest.

Lincoln and Guba (1985) suggest different techniques to achieve these evaluative criteria. For example, among the techniques for establishing credibility, this study used persistent observation, triangulation, and member checking. I triangulated my method of analysis by comparing the data generated from the set of interviews, transcripts, observations, field notes, and students’ sample work. Another credibility technique that I used was member check (Stake, 1995). I asked to my participants to review and confirm the accuracy or inaccuracy of interview transcriptions and observation. For establishing transferability, this study used thick description of the phenomena that happened in the classroom. Merriam (2009) explains that through this strategy the reader will be able to determine the degree to which the situations are equivalent within the research context and whether the findings can be transferred.

A description of design and its implementation was needed for establishing dependability in this study. Triangulation also worked for assuring reliability in qualitative study, which refers to the consistency of the results obtained from the data.

Finally, for establishing confirmability in this study triangulation and self-reflection was used, in which I had the opportunity to clarify my assumptions, worldview, and theoretical orientation at the outset of the study.

Research Bias and Assumptions

My academic background and its changes to different fields are very attached to my journey among three countries. I received my bachelor's degree in Chemistry and Pharmaceutics in La Universidad del Atlántico in Barranquilla, Colombia, my hometown. After working in a pharmaceutical company in my country I decided that I wanted to gain more experience in academia in a particular field and how to do research. So I decided to move to Puerto Rico and pursue my master's degree in chemistry. While I was there working as a teaching assistant for the general chemistry lab I learned that some students were taking the class just to fulfill a requirement, which was understandable, but the issue was the prior idea that students brought to the class: that chemistry was difficult to understand and a tough class. From that moment I realized that I needed more preparation in the educational area in order to engage my future students more and help to change a little bit that attitude toward science areas in general. That was the moment I decided to pursue my PhD in science education at The University of Iowa in Iowa City.

My first years in the science education program were a new experience for me, especially coming from a chemistry program where the structure of lecture, assignments, and research was different. While I became involved in the current literature I found that some researchers documented their findings in terms of comparison among races. I was strongly attracted to those numbers which showed that Hispanic students were behind in several subjects compared with other races. That was my initial motivation to pursue this project. I felt that I have a commitment with this community, as I am a Hispanic woman and I know how difficult it can be for some families to have good opportunities for their children's education. I believe that each child has great potential to succeed and it is in our hands as educators to provide them with those opportunities.

When starting my PhD in The University of Iowa I had the opportunity to work on several projects that involved argumentation and learning environment. Argumentation is a core practice of science and has recently been advocated as an essential goal of science education. So my assumption before I started this project was that for Hispanic students learning science in an argument-based inquiry would be beneficial. A second assumption was that they may encounter challenges regarding public communication and language in general. This assumption was based on what many researchers indicated as the achievement gap between Hispanic students and other races being mainly due to language.

Summary

In this chapter I presented the planned methodology to explore the ways Hispanic students learned science when engaged in an argument-based inquiry. This research used a case study made up of three students in the elementary level. The main data sources employed in this study consisted of semi-structured interviews, classroom observation, writing reflection, structured writing, and field notes. The analysis strategy involved the use of three levels of coding: stratifying the data between the two aspects of argument-based inquiry, using rubrics to explore student-emerging learning, and the constant comparative method. To enhance credibility several strategies were used such as triangulation of the data, member checking, and rich descriptions. The next chapter describes the results that emerged through these analytical approaches.

CHAPTER FOUR

RESULTS

This chapter describes the science school experience of three Hispanic students involved in the science writing heuristic (SWH), an argument-based inquiry approach. The purpose of this study was to examine how this argument-based inquiry approach supports or prevents Hispanic students learning science. My investigation into this phenomenon was guided by the following questions: 1) In what ways do two aspects of an argument-based inquiry classroom (i.e. laboratory activities and negotiation process) impact Hispanic students' science learning in terms of a) conceptual understanding, b) science practices, and c) understanding of argumentative components? 2) What challenges do Hispanic students encounter in this argument-based inquiry classroom?

Several sources of data were collected to answer the two research questions and to triangulate the findings. Tables 12, 13, and 14 summarize major findings for each research question and data sources from which evidence was drawn to support each finding. In those tables, data sources used in this study are abbreviated as follows: O= Observation, I=Interview, D=Document, and F= Field Note. In addition, due to space constraints, individual participating students' pseudonyms are contracted as follows: Ar for Armando, Am for Amelia, and Al for Alexandra. In addition to interview quotations, observation quotations and document sources are denoted with participant names contracted, source of data, date of data collection, video segment, and time stamp at the beginning of the quotation.

This chapter contains three sections: The first section discusses how laboratory activities impact Hispanic students in terms of three dimension of learning science; the second section addresses the aspect of negotiation process impacting Hispanic students in the same science learning dimension; and the third section examines the challenges that Hispanic students experience participating in this particular learning environment.

Table 12

Impact of Laboratory Activity on Hispanic Students' Science Learning

Major findings	Ar	Am	Al
<u>Impact of Laboratory Activities on Student Science Learning:</u>			
1. Impact of laboratory activities on conceptual understanding			
a. Providing sufficient time to complete scientific investigations was critical to improving students' conceptual understanding.	O* I* D*	O	
b. Creating active dialogues between teacher and students, and among students promoted students' conceptual understanding.	O	O* D*	I
c. Students' desire to collect enough information provided opportunities to improve their conceptual understanding.	O	O*	
2. Impact of laboratory activities on science practices			
a. Student-centered teaching approaches supported the students' learning of science practices.	O*	O	
b. Encouraging meaningful dialogues among students fostered the students' learning of science practices.	O*	O	
c. Using learning tools such as KWL chart, representations, writing, and consulting experts contributed to their learning of science practices.	O D	O* D*	
d. Effective pairing of students promoted their understanding of science practices.	O	O	O* D*
3. Impact of laboratory activities on understanding of argumentative components			
a. Engaging students in active dialogues between the teacher and students and among students promoted their understanding of the argumentative components.	O*	O	
b. Engaging students in active writing promoted their understanding of the argumentative components.	O* D*	O D	

*Examples of data sources used as evidence to support the theme.

Table 13

Impact of Negotiation Process on Hispanic Students' Science Learning

Major findings	Ar	Am	Al
<u>Impact of Negotiation Process on Student Science Learning</u>			
1. Impact of negotiation process on conceptual understanding			
a. Creating opportunities for students to consult with experts helped refine their conceptual understanding.	O* D* I*	O O I	
2. Impact of negotiation process on science practices			
a. Encouraging students to write reflections helps articulate their science practices.	O* D* I*	D I	
b. Explicit instruction about question-claim-evidence facilitated their science practices.		O*	
c. Whole group negotiation impacted students' communication of information more than small group negotiation.		O* I*	
3. Impact of negotiation process on their understanding of argumentative components			
a. Working in groups promoted their understanding of argumentative components.	D* O*	O	
b. Providing time for group debriefing after a presentation contributed to students' understanding of the argumentative components.	O*	O	

*Examples of data sources used as evidence to support the theme.

Table 14

Challenges of Hispanic Students while Engaging in an Argument-Based Inquiry Classroom

Major findings	Ar	Am	Al
Challenges			
a. Confusion between data and evidence	O*	O D	
b. Classroom routines and decisions	FN		
c. Administrative decisions of the school		O*	O*
d. Issues associated with group conformation or pairing up students			O
e. Language issues			O D

*Examples of data sources used as evidence to support the theme.

For the three students who participated in this study, the two aspects of this argument-based inquiry impacted their learning in science under diverse circumstances such as teacher, classroom, and student's particular characteristics. In what follows, I provide a brief background information on the students, hence giving important information to make sense of their performance in each of the lessons where they participated in terms of the aspects of this particular approach. Then I describe the themes that emerged from the analysis of the data in each aspect of laboratory activities and cooperative negotiations.

Getting to Know the Students

Three students in an elementary school agreed to participate in this study. I selected a school that was participating in the Science Writing Heuristic grant project (SWH). The SWH is an approach that promotes students to build scientific practice, understanding of disciplinary ideas, and engagement of argument through posing questions, gathering data, and generating claims supported by evidence (Hand, 2008). In this project teachers participated in workshops during Summer 2010 and 2011. I selected this school because it had the criteria for selecting participants who were disadvantaged Hispanic students learning in an argument-based inquiry. There were approximately 20 Hispanic students in the school and only three of them agreed to participate. Two of them were in fifth grade during Fall 2011 and the third student was in fourth grade. I continue observing the last mentioned student until she was in fifth grade (Fall 2012). Pseudonyms were assigned to individual students for confidentiality.

Armando

Armando is a male student who was 10 years old at the time of this study. He was born in the United States and his parents are from Mexico. At home Armando speaks Spanish and English and he lives with his mother and father. Both of his parents only completed middle school. Armando is able to speak English as fluently as a native speaker and Spanish proficiently. All of the interviews with him were conducted in English. He has a shy personality but socialized very well with his friends especially during team work. He demonstrated a high engagement in the science class although he preferred not to participate in asking questions or being the leader of the group when he had whole-class negotiations. He was very supportive to the group in terms of conducting their science investigations.

Amelia

Amelia is a 10-year-old female student who participated in one semester when she was in fifth grade. She was involved in two science lessons on life science. She was born in the United States and her parents are from Mexico. She never participated in ELL (English Language Learner) classes. At home she speaks English and Spanish. When I interviewed her she asked me to conduct the interview in Spanish. She was not talkative with me and has a shy personality. Although she was shy to talk to new people she was happy to be part of a team in the classroom. She was very engaged in the science lessons and very committed to complete the science work, making extensive research, and rehearsing her presentation with her partner. Amelia had infrequent participation in class discussion but when she raised her hand it was to provide great comments and contributions to the class. In group presentations, other members of the group answered questions. Amelia had this experience of learning science in the context of argument-based inquiry just for one semester. I tried to have more observations, but the system in how the science classes were organized in the school changed. Previously, Mrs. Smith taught science to the entire fifth grade group (in total there were four) but at the beginning of the spring semester the school administration decided that each teacher would teach science to their own class. So in Amelia's case there was no continuity of learning science in the context of an argument-based inquiry. Amelia's new teacher, Mrs. Thomas, did not teach science using the Science Writing Heuristic approach (SWH).

Alexandra

Alexandra is a 10-year-old female student who participated in this study for 1½ years. I first observed her when she was 9 years old in fourth grade and then I continued observing her in fifth grade for one semester. Alexandra is a student with a lot of energy to participate in class and very social. She enjoys her science class and her favorite lesson was the human body. The first part of my observation in her science class was not used for this study since her teacher did not conduct the science class as is proposed for this approach. At that time this teacher was preparing students for the state test and he taught the science class by reinforcing reading skills through reading science books and answering questions by stations. This task was conducted in groups of three or four students. The following semester I observed Alexandra in one lesson about changes in matter. While she started the spring semester she also started some tutoring in reading, math, and ELL (English Language Learner). The science class was the time period that the school chose for tutoring and special classes. Alexandra was born in Mexico and came to the United States when she was young (specific age is not clear). Her parents completed elementary school and her first language was Spanish. When I first started to collect data in the school there was no ELL class, but when the school moved to another facility many things changed and one of them was the inclusion of an ELL program. At the beginning of this study her language of preference for the interviews was Spanish. Later we had the interview in both languages. Alexandra participated in this lesson about matter because her tutoring ended at that time. Since I observed her for one lesson I invited her to continue in the project when she was in fifth grade. So I observed

Alexandra for two lessons in Spring 2012, and because the science class conflicted by 20 minutes with her tutoring, she was always late to the science class. Table 15 summarizes these three participants' characteristics.

Table 15

Summary of the Participants' Characteristics

Participant	Age	Grade	Teacher	Parents' level of education	Gender	Language spoken at home	Free and reduced lunch program participation	Special program participation
Armando	10	5	Mrs. Smith	Middle school	male	English and Spanish	Y	N
Alexandra	10	4-5	Mr. Jones and Mrs. Smith	Elementary school	female	Spanish	Y	Reading, writing, math, ESL
Amelia	10	5	Mrs. Smith and Mrs. Thomas	High school	female	English and Spanish	Y	N

The Impact of Laboratory Activities on Student Science Learning

This research investigated how the Hispanic students' science learning emerged while engaging in the two main aspects of an argument-based inquiry. The first aspect described in this section is the laboratory activities. The aspect of the laboratory activities in an argument-based inquiry such as science writing heuristic is defined as the process in which students work in groups to pose questions, create claims, and use evidence through a scientific investigation (Hand, 2008). There is a process of data collection in which students have hands-on activities, create claims, and examine data to look for evidence.

This activity promotes the generation of dialogue among the members of the group to discuss and complete the science activity for the next stage of negotiation process.

Impact of Laboratory Activities on Conceptual Understanding

The qualitative analysis from class observations and video transcripts while Hispanic students participated in this context revealed several main findings to be significant in their gaining of conceptual understanding. The analysis shows an impact on Hispanic students' conceptual understanding when they have sufficient time to complete their investigation, when they engaged in active dialogue, and some student-specific characteristics. These themes will be discussed in detail in the section below.

The science units that students explored were related with the core ideas of physical science (such as understanding and applying specific knowledge of sound and magnetism) and the core ideas of life science (such as understanding structures, characteristics, and adaptations of organisms that allow them to function and survive within their habitats). For the case of conceptual understanding on the different topics several categories were developed. The rubrics helped to clarify standards based on performance quality and describing levels of quality from significant to limited.

Providing sufficient time to complete scientific investigations was critical to improving students' conceptual understanding. Laboratory activities supported these students to develop conceptual understanding of a science lesson especially when they had sufficient time to complete their scientific investigation. For example, Mrs. Smith spent several days having students design and conduct experiments. During that time, students also were able to explore the big ideas of the lesson under exploration by analyzing and discussing with peers. The time invested in each scientific exploration in the classroom was related with the lesson's guiding question. For some lessons in this study the teacher provided the guiding question, and for other lessons let the students develop their own. Mrs. Smith allowed the students to design their own experiments in a plausible manner and select the materials that they will use. Students never worked individually and received support from other members in the group. So regarding the testing time in the lesson on magnets in which Armando was involved, the teacher indicated:

Teacher	You are the experts now, you spent however many days testing magnets. Listen. So you need to provide proof. So you need to bring in all those pieces of evidence from the data that you collected. (Ar.Ob.02092012.MOVO4A.00:58)[4]

During that session Armando had the opportunity to discuss with his team members about how to design the testing part, what materials to use, and which person would do the different steps in the experiments. For the first part that involved testing and observing, students invested two science periods of 45 minutes each. During that time students followed their testing plan by sticking magnets to several materials in the classroom. This activity was one of their favorites and they observed several phenomena working with magnets. Students were amazed by how magnets strongly attracted some

[4] Observation quotations and document sources are denoted with participant names contracted, source of data, date of data collection, video segment, and time stamp at the beginning of the quotation.

metals or repelled when they tried to put the north or the south pole together. In the course of the magnet testing while Armando was collecting data he also could talk to his team, ask questions to the group members, and discuss some ideas about this concept. For example, during those 45 minutes Armando was able to infer the concept of magnetism based on his observations. He did not provide a complete definition of the word magnetism but could infer from his observation that magnetism is a force that helped his magnet to carry other metallic materials with which they were working. The following excerpts show the inclusion of the word magnetism in his observation:

Armando	See if they can all fit. Here. Whoa, look at how much it can carry of these. Look at how much it can carry. Look at all this it can carry. That's a lot of **magnetism**. (Ar.Ob.02022012.MOVO46.09:39)
Armando	I think one of our evidence was, magnets can't stick to other things that are besides metal, because there's no **magnetism** between the magnet and the other thing. (Ar.In.02232012.05:10)

A second core idea emerged when students were working in the construction of their claim. This idea was how magnets work when they have opposite poles. On the third day of this investigation students had completed the testing part and the teacher gave them the whole science class to sit together and gather all the data to create the claim. Having another 45 minutes was propitious for students to analyze the data and compare with experts. In addition, the teacher could come to each group and revise their evidence and encourage students for improvement of the claim. The excerpt below shows Armando's group discussing with the teacher the idea that all magnets have two poles, north and south. The north and south poles always attract each other, but a pair of the same direction repels or pushes each other away.

Mrs. Smith	So you think metal and magnets are made of the same stuff. Okay, why would that cause them to stick together?
Student	Because like if there's metal and magnets, **we** found out that if two magnets are two different kinds of magnets, then they come together. But if like those are south and **we** had another south magnet they would not attract together because like if they're made with the south material. (Ar.Ob.02092012.MOVO4A.12:18)

For this lesson students completed their laboratory activities in four days. The core ideas that the teacher had in mind were inferred, spoken about, and investigated in the books through a considerable time for discussing, sharing ideas, and revising concepts. Time was important to promote Armando's learning that in an interview after that experiment he expressed the main thing he learned from the magnets' investigation.

Researcher	Do you think that you have enough time to complete your assignment?
Armando	Yeah.
Researcher	Do you finish on time?
Armando	Yeah.
Researcher	Did you have time to make observations and collect your data?
Armando	Yeah.
Researcher	Did you have time to state your claim in your small group?
Armando	Mm-hmm.

Researcher	Did you have enough time to look for your evidence?
Armando	Yep.
Researcher	What sources do you check to compare your findings with experts?
Armando	One of the resources we use, one of them was the books, the textbooks, and science textbooks. And around the room.
Researcher	So finally, what did you learn about magnets? If you, do you have sisters or brothers?
Armando	Only a sister.
Researcher	If you need to tell to your sister about magnets, how are you going to say to her? What are you…?
Armando	I would say, magnets are a good thing because like they help people too because if they need something to stick together to hold something, then they attract iron and could just produce the magnetism inside and stick it together, and then you could do whatever you want with it. (Ar.In.02232012.11:45)

Another lesson observed in which Armando participated was the lesson of sound. Students also spent a lot of time in the process of laboratory activities. Here the process was a little bit more challenging since there were four minilabs to explore and make conclusions about the nature of sound. For this lesson students spent three days of their 45-minute long science class. Since the testing was organized as four minilabs, students had to pay careful attention to what happened in each station and write observations.

The testing centers or minilabs were intended to have student explore how sounds differ when made in different substances. So they were organized as Center A: tuning forks and paper roll; Center B: yardsticks; Center C: water and stethoscope; and Center D: string and cup (Figure 5).

How does sound differ in different substance?

(How does sound change in different materials?)

Center A: Tuning Forks, paper roll

Center B: Yardsticks

Center C: Water stethoscope

Center D: string, cups

How might these different materials have sounds that are different? What does the kind of materials have to do with the kind of sound you hear?

Figure 5. Minilabs for the experiments on sound and guiding questions.

The teacher's learning goal for this lesson about sound was to show students that energy exists in diverse forms like sound and this can differ in different substances. Students observed how sound can change in different mediums through the minilabs. Based on the teacher's lesson plan and students' learning goal, the three core conceptual ideas that were the focus of the inquiry activity about sound included the type of energy, the nature of sound, and sound's transmission in different mediums.

By conducting an investigation through the process of laboratory activities, Armando was able to investigate, discuss with his peers, and understand by himself the core concepts of this lesson before he consulted with the experts on his ideas. Armando discussed ideas such as understanding the concept of energy as sound while conducting observations, making predictions, and also through dialogue with his team group.

Armando was able to describe his initial ideas about sound using scientific vocabulary. Many initial ideas came to his mind through the process of laboratory activities. For example, concepts like sound energy, the energy of vibration, and sound properties were presented in this dialogue:

Andrea	Why are you putting a pencil? Why do you need to stir it?
Armando	So you can make vibrations in the water. No, hit that thing and then, wait.
Julie	I want to make bubbles. (Ar.Ob.03292012.MOVO51.07:04)

Another example also shows Armando getting ideas about vibration:

Fred	You should hit this on the table and then put it up to your earring.
Armando	No, that would hurt.
Fred	No, come here.
Armando	No wait, later, later. Dude, you can actually see that thing vibrating. (Ar.Ob.03292012.MOVO51.11:03)

In addition, Armando confirmed additional concepts regarding the nature of sound and how sound is produced. This knowledge was acquired not only from the data that they collected but from the experiments of the other groups in the classroom:

Armando	Because like, I don't know, we just like. Samira, the girl in the group, she just like, I don't know, she was just writing vibration. We felt it a lot. Like with every group we felt and heard vibration. (Ar.In.04242012.05:24)

Armando also noticed in this process of observation that energy is classified into different forms and one of them is sound energy.

Armando	Because the harder you hit it, the more vibration you feel and when there's more energy in the vibration, it like makes a bigger noise and that. (Ar.In.04242012.07:24)

Another core idea that Armando discussed during laboratory activities with his team was how transmission of sound occurred through a medium. Armando had the opportunity to have a dialogue with his peers and explore through observation of the four minilabs.

Armando	Testing. We did what it sounds like in water. We did soap, what it sounded like in soap, what it sounded like when it hit together. (Ar.Ob.03292012.MOVO52.07:39)

Armando	Now that sounded cool, you should write that down.
Armando	Write down how they sounded when they hit each other?
Samira	Loud. How?
Armando	I don't know, let me see. I can't get my pencil. Put like, put what they sounded when they hit the floor, what you felt in your hand.
Samira	Loud and soft sound. (Ar.Ob.03292012.MOVO52.09:39)

The laboratory activities included several tasks in which students had the opportunity to explore and understand the big ideas about the phenomena under exploration. After their discussion and data collection it was time to write their claims and evidence section and finally compare their findings with information provided by experts.

Overall, students learned several key concepts of the target unit doing science by themselves. The experience of doing science required a considerable and intentional planning that Mrs. Smith implemented in each of her lessons having in consideration the amount of time needed to complete each task of the scientific investigation.

Creating active dialogues between teacher and students and among students promoted students' conceptual understanding. One characteristic observed during the participation of students conducting their experiments under the argument-based inquiry approach was active teacher-student and student-student dialogues. The classrooms conducting the laboratory activities through the approach of argument-based inquiry were very noisy either because it was part of the experiment or because students were always talking about their observations. Mrs. Smith never asked students to be quiet except when she noticed they were working off-topic or to announce that it was time to clean up and change activities. Mrs. Smith never said directly to the students what to do or what conclusions to reach from the data they collected. She always approached students with questions that prompted their thinking. So students were always highly encouraged to find the answer to the questions and go through the whole process in order to construct their knowledge based on the big idea. For example, in one class where Amelia participated, the teacher was having a conversation with students about the experiment on owl pellets and the information collected from a special guest that they invited to talk about wild animals. Mrs. Smith was talking about what the guest speaker said and how the guest speaker brought several owl species and samples of pellets made by owls. She was trying to prompt the students to make their reasoning about their claim that "an owl made the pellet" not just because the expert said so, but because she wanted them to connect the ideas gained during the experiment and observations.

Mrs. Smith	What about the owls? Are the owls big enough where they might eat things? Think about Big Mama and think about Spirit. Okay? Could they eat a little bird too? So that's just something to think about as well. Other ideas? Why you are still convinced that it's an owl and not anything else? Joel?
Joel	Because you told us that an owl made it.
Mrs. Smith	I didn't necessarily say that.
Joel	You said it and you said that an owl makes pellets.
Mrs. Smith	Okay, Amelia?
Amelia	I think it's an owl pellet, because the one that we took apart looks the same like the one that, um, that the lady brought. And she said an owl made it.
Mrs. Smith	Okay, so she brought us a whole bunch of samples, and so she was talking about the samples, and do these look pretty similar to the ones that you worked using? Okay, so that's what their rationale is, that they look pretty much the same. Carol, something else? (Am.Ob.10102011.MOVO3D.05:19)

Mrs. Smith was prepared with questions and suggestions to foster student learning of the specific core concepts in the science classroom. Her strategy was to let the students talk even though there were a few issues with misbehavior or students not doing what they were supposed to do.

Another characteristic in Mrs. Smith's classroom was to encourage students to have dialogue among themselves. For example, in Amelia's case she was able to explore the core concepts of habitat and ecosystem during laboratory activities. Animal habitats was the first unit that teachers taught in fifth grade during the fall semester. The big idea of this lesson was 'How does an animal's habitat affect the animal?' One important activity to engage students in argument-based inquiry approaches was to explore students' prior ideas and connect those ideas with the experimental design.

The analysis of Amelia's understanding of the concept of habitat was carried out by looking at three categories using a rubric based on teachers' science learning goals, state standards, and the next generation of science standard (NGSS). For the aspect of laboratory activities in Amelia's case I was looking at three core ideas about the lesson on habitats as explained in Table 8. More details about this rubric are in (Appendix E). The first core idea consisted of understanding the ecosystem concept by identifying how animals and plants are related in the food chain and if students could provide an example of an ecosystem. The second core idea was the concept of habitats, and the third core idea was the niche concept that was more closely related to the experiment on the owl pellets.

For exploring students' understanding of this lesson all of the videos and transcripts related with the laboratory experiment were selected. Most of the data came from the class observations such as videos and video transcripts where there were a great amount of meaningful student-student dialogue. The meaningful dialogue allows teachers and students to be active in the creation of a common understanding by making explicit the overlap between their conceptual frameworks (Kinchin, 2003). The first core idea analyzed was Amelia’s understanding of the ecosystem concept. There was not any indication of Amelia expressing the concept of ecosystem specifically. However, in the dialogue with her partner in the consulting an expert stage, Amelia identified that plants and animals are related by the food chain, which is part of that understanding. In addition she provided an example of ecosystems, talking about biotic factors such as plants and animals and abiotic factors such as nutrients as is shown in this example:

Amelia	I got, wait, this. Here. Owl, mouse, mouse. Yeah. Did you already put mice and prairie dogs or something?
Callie	All right.
Amelia	Ew, it says. It says, when you eat corn and chicken, you are part of food web that includes an owl, a weasel, mouse, as well as chickens and corn. That means we eat owls, and weasel, and mice.
Callie	An owl, a weasel, a mouse. That means like they’re listing the stuff, like. (Am.Ob.10042011.MOVO30TOD.01:19)

For the second core idea about understanding the concept of animal habitats, the analysis reveals Amelia showed an understanding of the concept of habitat and she was curious about several aspects of this topic. To assess this core idea I focused my attention on the dialogue that the teacher had with the students when she was exploring students’ prior ideas. For example, the teacher asked the class if they knew what the word ‘habitat’ meant. Many students raised their hands and one of those was Amelia. She was able to provide part of the idea and the teacher took advantage of the definition that Amelia provided to emphasize a complete concept about habitats.

Mrs. Smith	Does anybody remember or know, what does the word habitat mean? Who can explain it? James?
Student	It's like a shelter.
Mrs. Smith	A shelter or home. Does anyone else have anything else they want to add to that? Amelia?
Amelia	The place where the animals live.
Mrs. Smith	The place where the animals live. Anyone else?
Student	Habitat is like their, where they live and [inaudible].
Mrs. Smith	Okay, what she said, I don't know if you heard over here, what she said is that habitat is like the place where they live, which agrees with both what James and Amelia's ideas, but then she said if you take them away, it's like taking you away from home. Okay? So a habitat is an animal's home and the area where it lives. (Am.Ob.09082011.MOVO11.02:35)

Amelia showed also an understanding that habitats are very important for an animal's life, providing an example when the teacher asked students about habitats:

Amelia	If an animal's put in a zoo, then they don't have all the stuff that they have in their habitat.
Mrs. Smith	So a zoo habitat is very different from the things that they have in their other habitats. I challenged my homeroom class to create some, so you guys can too. Lizzy.
Lizzy	Um, it's kind of like the red wolf lives in a snowy place, and if you took it to a desert, it might sweat to death because of its thick fur. Like, it depends on the body temperature.
Mrs. Smith	So there's cooler places, but hotter places…?

Lizzy	Might make them die or something. Like, if it's a totally different place than they're used to. (Am.Ob.09082011.MOVO11.04:35)

Amelia was very motivated and curious about this lesson on animals and their habitats, so she wrote in her notebook additional ideas that she wanted to know:

Do animals have to have a certain habitat?

How many animals hibernate?

Is everywhere a habitat for an animal?

How do animals make their homes?

Amelia also mentions another idea related to habitat and that was the concept of "food web." This concept is not explicitly talked about in the dialogue, but Amelia mentioned trying to connect the idea of food web with the owl pellet investigation:

Amelia	Did we get some research? What is this book? Let me see.
Callie	It's owls.
Amelia	Where's the owl that we're looking for? They talk about an owl… Did it talk about an owl's food web or something?
Callie	There it is. That's what I thought.
Amelia	Did it talk about anything of like what they eat? Oh, yeah.
Callie	What page was that? That was page, where's the page number, 13. 14, no wait.
Amelia	Yeah, it's with 13.
Callie	It was page 12.

Amelia	Look, look. But do they have something about… Does it have something of them…? It's small. Look, a baby owl. Baby owl. (Am.Ob.10042011.MOVO30.08:26)

For the third core idea about the niche concept there were many notions related with this idea, but it was not an explicit example of the definition of this concept from the students neither for the teacher. However, Amelia, through laboratory activities and in a collaborative way, was able to find out the owl's role in the ecosystem as predator:

Amelia	So is that it? Is that all we need?
Callie	I don't know.
Amelia	We should get more information.
Callie	Yeah, since we only have two things of information.
Amelia	Look, it says, it says something. It says, she **is able to kill prey** such as rabbits and squirrels that smaller owls can't.
Callie	Yeah, but that doesn't say if it's, if our thing, if owl pellets or not. We already know that your owl makes an owl pellet.
Amelia	It could be a mouse because it was so small. (Am.Ob.10042011.MOVO30TOD.8:26)

Through laboratory activities Amelia understood how owls' feeding habits, diet, and the process to create the pellet are related. So she explained their findings to the teacher. Mrs. Smith was amazed with that finding and told them that the idea was strong enough to use it as a piece of evidence.

Amelia	Do we have to fill out the whole page?

Mrs. Smith	No. What do you guys have so far?
Callie	Um, owls eat mice and prairie dogs, and they are the broken down food that's turned into a soft mass and passed on into the intestines to be digested.
Mrs. Smith	So that's a pretty strong piece of evidence there, isn't it? It goes with what you're thinking? Okay. (Am.Ob.10042011.MOVO30.10:12)

Overall, through the process of laboratory activities and under the condition of having teacher-student and student-student dialogues, these students could explore the core ideas of the lesson under study. For Amelia's case, she was very committed to completing her task, and her partner was supportive and committed too. They divided responsibilities about searching for information to be part of their evidence, and discussed the ideas they found in the book. In addition Amelia was aware of finding as much information as possible to use as evidence. Amelia also was aware of selecting that information in an accurate way by double-checking with her teacher. For this part Amelia showed a good understanding of the core idea of the lesson.

Students' desire to collect enough information provided opportunities to improve their conceptual understanding. Students had the opportunity to check for evidence using extra resources such as books, internet, and guest speakers if they were available. This part of the exploration in the argument-based inquiry approach occurs at the end as the final part of completing laboratory activities. Through this process students have the opportunity to expand their conceptual understanding and clarify misconceptions. Students spend the entire 45-minute class exploring and looking for information to complete the science task. To do this task they were free to explore books and find as much information as possible. The analysis reveals that some students in this project showed their desire for conducting a good search of information. For example, Amelia was so concerned about finding specific owl's information that she went to the classroom library several times. She was a little bit disappointed because she could not find information related to owls that would help answer her research question:

Amelia	I just got, I just got prairie food chains. Where's… I can't find anything.
Callie	I don't want this. No, I'm looking for owls.
Amelia	They don't have anything in here about owls. Oh, here's an owl. There.
Callie	All right, it says… owls eat mice and prairie dogs.
Amelia	Owls eat mice and prairie dogs. (Am.Ob.10042011.MOVO2F.15:16)

After several minutes of extensive review, Amelia and her partner found some information that was valuable for their investigation such as owls' preferred prey. However, Amelia was aware that the information that they just found would probably answer part of the question but not the entire question, which included finding the animal that made the pellet and its food web. So she discussed with her partner about looking for more information because they only had a few pieces of information:

Amelia	So is that it? Is that all we need?
Callie	I don't know.
Amelia	We should get more information.
Callie	Yeah, since we only have two things of information.

Amelia	Look, it says, it says something. It says, she is able to kill prey such as rabbits and squirrels that smaller owls can't.
Callie	Yeah, but that doesn't say if it's, if our thing, if owl pellets or not. We already know that your owl makes an owl pellet.
Amelia	It could be a mouse because it was so small.
Callie	Yeah.
Amelia	What else? We need something to prove. Are we done with this book? Callie.
Callie	Huh?
Amelia	Are we done with this book?
Callie	I don't know.
Amelia	Because we need more information.
Callie	Owl pellets. I think we're done with pellets.
Amelia	Do we need anything else?
Callie	I don't know. I don't think so.
Amelia	Okay. What else? Is this it?
Callie	I guess so.
Amelia	So we don't need nothing else?
Callie	I don't think so. (Am.Ob.10042011.MOVO30.11:24)

As noticed in the dialogue Amelia asked her partner several times if they needed anything else to complete their evidence part or if they needed to look for more information. She asked her partner seven times and the answer that she received was consistently "I don't know" or "I don't think so." Both of them did not know about the amount of information to include in their science package since there was not any rule or specific amount required. Amelia wanted to do her job so well that she even asked Mrs. Smith if they needed to fill the whole page, but the teacher answered "no." For this aspect students were encouraged to look for sufficient and strong information that was able to support the claim regardless of the quantity.

Amelia's excitement and commitment to read was apparent in her responses. One important activity for Amelia is to complete and reshape her claim and evidence. This commitment to searching for information was consistent in other lesson in which she participated. For example, on the excerpt below she shows that she explored many books to refine her claim and evidence and in looking for that purpose she learned important big ideas in the lesson of "human-changed environment."

Researcher	Do you have any agreement or disagreement? No? How did you complete your reading? What books did you read?
Amelia	I read several books.
Researcher	Do you remember, what did you find in the books?
Amelia	One way to increase production is simple to increase areas of farmland and the amount of water used.
Researcher	So how many books did you read?
Amelia	Six.
Researcher	Six books, wow. So how many ideas? Can you give me one big idea that you find that helps you to support your claim?
Amelia	Um. Some experts believe that… food will reduce the amount that, the amount of food will reduce…
Amelia	…pollution to chemicals used in farming. (Am.In.03292012.11:19)

The desire to collect enough information allowed Amelia to explore many possibilities that caused her dissatisfaction because the ideas she found did not necessarily connect with the big idea and the research question.

Impact of Laboratory Activities on Science Practices

In this section I present results of how laboratory activities of an argument-based inquiry impact elementary these students' science learning in terms of science practices. The sources of data to conduct the analysis and obtain the results for this section were students' lesson observations, video transcripts, and writing samples. Three themes emerged to describe and interpret the participants' learning impact with this specific context. First, student-centered teaching approaches supported the students' learning of science practices. Second, encouraging meaningful dialogue among students fostered the students' learning of science practices. Third, using learning tools such as KWL chart, representations, writing, and consulting experts contributed to their learning of science practices.

Based on what is explained in the K-12 framework, crosscutting concepts, core ideas, and science practices are three dimensions in which students should be proficient in science. Science practices describe "behaviors that scientists engage in as they investigate and build models and theories about the natural world" (NRC Framework, 2012, p. 30*)*. As is suggested by the framework, this dimension involves eight practices applicable to science and engineering. These practices were evaluated in the laboratory activities performance of the three Hispanic students. The eight practices are shown in Table 9 and for this study the focus was only on science practices.

Student-centered teaching approaches supported the students' learning of science practices. During the data collection of this project I had the opportunity to see three Hispanic students' learning under different teaching styles and exploring several topics in in their classrooms. The data of this project was collected under different conditions. For example, I observed one of the participants (Alexandra) when she was in fourth grade and at that time Mr. Jones was her teacher. Then when she was in fifth grade she started in Mrs. Smith's class. For the other two students in this project Mrs. Smith was their teacher since she taught fifth grade. These two teachers had different experiences using this approach. For example, Mr. Jones had the control of the classroom and his approach was for the end of the lesson to be teacher-centered. However in Mrs. Smith's class, students were allowed to design their own investigation by having conversations among themselves and generate their own ideas. These two situations showed several differences in the characteristics of the classroom. For example, in Mr. Jones' class, his voice was predominant and he decided what and how students should do in the science activities. He also interrupted the class several times for behavior issues. Most of the time his class was quiet and if there was some noise he start counting "3, 2, 1" to alert students to be quiet and on task.

On the other hand Mrs. Smith also had classroom behavior, but she solved the issues without interrupting the course of the class. She drew the attention of those students that were doing something different from the science task and they quickly refocused. Mrs. Smith let the students choose how to approach the experiment, what materials to use, and explore the resources for themselves. She always approached students to verify their design and prompted them with questions to negotiate any ideas that students had.

What follows are descriptions of the differences between an argument-based inquiry that became a teacher-centered approach and one that was aligned with the purpose of the approach and the constructivism view of learning, and how they influence Hispanic students' learning of the science practices.

The first example is Alexandra's experience in fourth grade learning the lesson about matter taught by Mr. Jones. This lesson was about matter and it was the first lesson in his experience that he intended to do as argument-based inquiry. At the time, teachers in the school were concerned about preparing students for the state assessment test. So, they decided to do more reading in the science class and those readings were about the core science ideas that they were supposed to do in the regular class. So he encouraged students to remember the ideas about matter that they previously read in order to explore their prior knowledge using a conceptual map, which became a semantic map at the end. Students responded that they read about solids, liquids, and gases. The teacher then asked the students to write what they knew about solids on sticky notes. He emphasized that they should not worry about being right or wrong and encouraged students to talk each other at their tables.

For this lesson, the idea was to introduce the topic of matter and the description of liquids, solids, and gases. Mr. Jones could explore students' prior ideas although there was not a lot of interaction among students. After Mr. Jones announced to students that they will do an experiment about matter, he organized the class in groups of two and gave them a "science package" which is the SWH students' template that provides students with questions to help them in their scientific investigation. The experiment is related with the unit of properties of matter. The big idea that the teacher wanted to explore is "Things in our world can exist in different states." For this lesson, the teacher designed the scientific investigation using water, a cup, and Alka-Seltzer® tablet. In addition, he provided the research question to the students which was "How will the tablet change?" The teacher continued to explain the second step of the template that guide students to write their beginning idea.

Mr. Jones	Marcia and Rich, up here. You and your partner, your beginning idea. Before we do the experiment, you believe what? What do you believe will happen to that tablet, or to the water, or to both? What do you believe? Write it in. Talk to your partner and write it in. (Al.Ob.04242012.MOVO5D.7:00)

For the next stage of this experiment Mr. Jones asked the students to write on a sheet of paper the words water and tablet. He wanted students to write down their respective properties before he asked the students to take the tablet and put it in the water. In this lesson each step has been directed by the teacher and the students have not had any opportunity to decide on or provide ideas for the design of the experiment. As is noted in his speech, the lesson was about what he wanted students to do. In this classroom Mr. Jones's voice was prevalent and only a few times could a student's voice be heard.

Mr. Jones	Okay. Nobody should have dropped theirs in. What **I want you to do** right now, we just described water. Now describe the properties of the tablet.
Alexandra	That's what I'm doing.

Mr. Jones	Talk to your partner, write them down. Describe them.
Alexandra	Right here, no right here, look, doesn't it look like it?
Mr. Jones	Now, nobody has to be a perfect artist. But you're going to have to both write about it and draw it. So you have your cup. Okay? You have water in there. And you have our tablet. Because I broke them off, not everybody's the same. Now, listen. On your blank sheet of paper that you just, look, he even wrote one, two, three, the stages of what he thinks is going to happen. Okay? A lot of you did this. **This is what I want you to do**, this is your observation, alright? Now. **I want you** all to hold up your tablet. Hold up your tablet. (Al.Ob.04242012.MOVO5E.8:11)

The teacher then called the attention of the classroom to proceed with the experiment. They had to write down their observations and the teacher indicated to them to write what they saw, felt, and smelled. The class was stopped because the teacher saw students still talking about the tablet fizzing in the water and he wanted them to focus in the next step of writing their observation.

Mr. Jones	We have all these other people talking. We're trying to work on certain things, so I know it is cool watching it fizz, but we have to be focused. We talked about this before the experiment started. When students are ready to share out, we need to be respectful. (Al.Ob.04242012.MOVO5E.10:56)

Mr. Jones called the attention of the students to review the question and what students observed during the experiment. He asked Alexandra to remind the class of the question and Alexandra responded that the question was "How will the tablet change?"

Mr. Jones then explained to the students that they will have a new experiment. He again asked students to remember those ideas that they said in the last class about how the tablet would change. Some students said that the tablet bubbled, fizzed, disappeared, and melted. The teacher repeated all of the ideas and added that maybe the tablet disappeared and became water. During this questioning time Mr. Jones continued telling students ideas regarding the tablet and also refining ideas for them.

Monica	We thought it would melt.
Mr. Jones	You thought it would melt, you thought it would disappear, you thought it would melt and become water maybe? Okay.
Faith	We thought it would make a sound.
Mr. Jones	Okay, so they thought you would hear the reaction. You think it would turn to vapor. Some people thought it would turn to water. What's one of our states of matter?
Class	Gas.
Mr. Jones	Okay, so you thought instead of becoming water, vapor is a watery mist. Vapor, okay. So you guys have your because. Why do you think it will fizzle? They think that it will, you said the tablet will melt in the water because when it. (Al.Ob.04062012.MOVO5E.8:10)

He continued asking what students observed, and they said that they observed that as the tablet bubbled it faded away. The teacher then asked the students if the tablet was smoke or vapor. He said that they needed to record those observations and went directly to write those ideas on the whiteboard. Student then copied from the whiteboard to their science package.

Mr. Jones	Okay. Let's take what you just said and let's put [inaudible] let's say that the important data that [inaudible]. Okay, first of all, remember, when I asked you to describe the tablet, oh, here it is. No, I'm going back to write it. What do we know about the tablet? Okay, tablet, it was hard. We observe the tablet was hard before I put it in [Writing on the board].
Student off-camera	So it's a solid.
Mr. Jones	So it's a solid, so the tablet was a solid, okay. (Al.Ob.04062012.MOVO60.16:00)

All of the teacher's questions about what happened to the tablet when they dropped it in the cup were preparing the students to make their claim based on their observations. He encouraged students to think what they believed to be true based on the experiment. They had to explain based on their data what they believed and provide a reason. Alexandra had a short discussion with her partner because the teacher was always guiding the students and did not provide sufficient time for a student-student dialogue:

Alexandra	So what do you believe?
Chris	I believe that…
Alexandra	Okay, so.
Chris	Because I see it with my own two eyes.
Alexandra	Okay, so because. Because. Okay. I believe. Okay.
Mr. Jones	Perfect, right. You're writing, what do you believe now, what do you believe happened when you put that tablet in the water? You take a guess. What? What happened when you put it in the water?
Chris	What? (Al.Ob.04062012.MOVO61.18:25)

For the second part of the science activity the teacher introduced a supporting experiment using a bottle, a tablet of Alka-Seltzer, and a balloon. For this experiment the teacher planned to do a demonstration for the whole class. The teacher asked the students what they thought would happen to the balloon when it was put on the opening of the bottle. Some students said that the balloon would go up. The purpose of the experiment was to challenge students' claims regarding what happened with the tablet. He asked to students to sit and observe:

Mr. Jones	Okay. Those of you who think it just turns into a liquid [inaudible], right? Okay. So right now, we're going to see if we can support the whole idea that it's a gas, right? Okay. Let's see if we can support that. Okay. I'm going to stand back here, in front of the classroom, just turn in your seat. What I want you to do is I want you to hold this, Joe.
David	I can't see.
Mr. Jones	Just make sure, I'm going. Everybody sit, or we're not going to do this. Everybody needs to be in their seat. (Al.Ob.04062012.MOVO61.19:25)

For this lesson about matter the center of the class was the teacher and what he asked the students to do in their science class step-by-step. In general Alexandra and the rest of the students were excited to do the experiment but teacher concern about bad behavior and perhaps low expectations in the ability of the students to work independently did not offer opportunities for dialogue and give a more valuable learning experience to Alexandra in learning the practice of science.

On the other hand, a contrasting teaching style was analyzed in Mrs. Smith's classroom. An example of this was the lesson of magnets and sound where Armando participated. Armando was very comfortable working in a group and with different members. The common feature observed from this aspect of laboratory activities is that this student was able to understand that the process of learning science can be addressed by doing their own investigation.

Armando learned that research questions are important in the process and more significant is that he had to come up with his own. In most lessons analyzed, the KWL chart (The letters KWL are an acronym for what students in the course of a lesson already **k**now, **w**ant to know, and ultimately **l**earn) was used as a supportive tool to help formulate the questions, especially because he needed to look for the answer himself. Although there is a guiding question that the teacher provides, students as a whole group still generate questions that are selected at the end for being more interesting to explore. Armando expressed that he learns more when he looks for the answers himself rather that the teacher telling him. "To myself, because you get to keep looking everywhere for the answer" (Ar.In.02232012.08:02). In addition, formulating questions was an initial important step for Armando, who learned to create questions based on the experiment. For the sound experiment, there were several minilabs so the purpose was to have students thinking about a question while observing each minilab or center. "Like our whole group, there was three of us, so we thought of a question by looking at each of the centers" (Ar.In.05252012.06:25).

In all of the lessons observed, the testing part was the most engaging activity. Students worked in groups and each of them had a responsibility to bring the materials, collect data, and record data. For example, in the lesson about magnets, Armando was so excited to observe what happened with magnets when he or somebody from the group was testing. The testing consisted in exploring magnets using a variety of sizes of magnetic objects. Students wrote observations about the strengths of different combinations of magnets. Armando enjoyed playing with magnets during the testing part but he also had conversations and inclusion of new science terminology such as the word "magnetism."

Armando	Oh, let's try this. And while you put it, look at while it connects. Man, it won't stick to me. It works in the bag. Get a metal one. Look at it. Oh snap.
Samira	Can you see this?
Armando	Yeah. It connects, see, look.
Samira	Oh, oh, they're going to fall.
Armando	See if they can all fit. Here. Whoa, look at how much it can carry of these. Look at how much it can carry. Look at all this it can carry. That's a lot of **magnetism.**
Samira	Okay, so one, two, three, four, five, six, seven, eight. It could carry eight of these balls. Well, seven of these balls, it could carry seven of these balls and one of these shapes.
Armando	This thing is, it's really good for doing this. It's like good for carrying all this. This is like really, like good. Look. (Ar.Ob.02022012.MOVO46.09:39)

For some lessons the testing part took a lot of time and was highly demanding based on the design of each activity. The sound lesson part of the testing was organized as four minilabs where students had to pay careful attention to what happened in each station and write down those observations. As explained in Figure 4, the testing center or minilabs were intended for students to explore how sounds differed when made in different substances. The testing part was also the opportunity for Armando and his group to formulate strategies to better collect data. For the entire testing procedure three students in the group decided to conduct their testing observing together in each center. “Well, we just did, we all just did one center at a time. Like three of us just did the same one” (Ar.In.05232012.11:20).

The aspect of laboratory activities also gave Armando the opportunity to learn about science practice in term of using evidence to support a claim. Students work independently and also discuss with each other. The formulation of the claim is clear for Armando and his group: “We got it [the claim] by, um, we got it from thinking of all the things we did with the magnets. And so we wrote and then we got the evidence” (Ar.In.05232012.08:13). On the other hand in the sound lesson that was the last one for the year it was visible that Armando was confused about the nature of the evidence and data so he asked his team:

Armando	Isn’t the evidence like…?
Travis	What we heard.
Martha	No, just read that for the evidence part, which is going to be the last part, and then.
Armando	Isn’t the evidence all the testing that we did?
Martha	We need to write the date on.

Armando	Isn't the evidence what we did, like testing and everything? Like all the stuff we did with the tuning fork stuff?
Martha	No… (Ar.Ob.04122012.MOVO55.02:00)

In general Armando gained a sense of the practice of science. Several factors were involved. Mrs. Smith provided enough time for the testing part and for the other practice she gave almost the whole time period for science class. In addition, students were engaged and discussing the findings among their groups and writing them down to be ready to communicate their result to the audience. Mrs. Smith was always approaching the small group while they were working. She was always prompting with questions and negotiating the evidence with students. When she though students needed to provide more evidence she did not say so directly but through questions such as: Do you think that information should be part of your evidence? Why is that phenomena happening? Leading the student-centered teaching approach for Mrs. Smith in the context of argument-based inquiry offered these students a learning setting to support them in the learning of the science practices because students were actively engaged in their investigation and involved in metacognitive activities such as writing and designing their investigation.

Encouraging meaningful dialogues among students fostered the students' learning of science practices. Dialogue was constantly present through the science exploration of each of the lessons especially when the teaching approach of the class was student-oriented. Dialogue among students in the teams in which these students participated contributed in some way to students' learning the practice of science. One learning aspect of these dialogues is to learn to listen to each other and respect other students' ideas especially for the practice of designing the experiment. For that practice students were allowed to design how they were going to test something in order to collect data. For accomplishing that task they discussed what steps to follow in the experiment and what parts they were observing and discovering. For example, when Armando was exploring magnets, his team was inferring from the observation about what sticks to magnets if they tested several materials available in the classroom and asking why some of the magnets were repelling the objects when placed in a specific way. As is shown in the dialogue below, each member of the team was included and each contribution was valued during the construction of their knowledge of testing. Everyone contributed in a serious way to the process and was focused to complete their observations.

Armando	Wait, I got more. Oh, I got it stuck. I got it.
Travis	Guys, you left our cup over there.
Armando	That's mine, and that's yours.
Travis	Guys look, if you put those bowl to this magnet, look at what it does.
Armando	It reflects--it repels, right? Dude, get some of this. Will it work with both? Dude, it's not my desk. That's cool. Look at this, [Samira, Samira], look.
Samira	It's sticking up when I put it like that.
Armando	Look at this, it's got some funky hair.
Samira	See if it sticks to the cabinet.
Armando	Here.

Samira	Guys, come on. We need to know if it sticks to the cabinet.
Armando	Okay. Let's go.
Samira	You guys ready to see if it works? (Ar.Ob.02022012.MOVO46.03:25)

In another example when students were constructing their explanations and elaborating their claims and evidence, they were also engaged in dialogue. This dialogue shows that students still needed more clarification and clear examples about how to elaborate evidence. They thought evidence was the testing that they did without explaining how. Three students were talking and one of them was Armando. In the dialogue, Armando was the student that contributed to the elaboration of the evidence. He provided the concept of magnetism and included part of the observation that they did in the classroom. Students were open to listening and they negotiated and recorded the idea in their science package:

Samira	Okay, here's our claim. We find that magnets can't stick to anything other than metal. And then evidence that we know this because we tried it.
Martha	Because we had testing things done.
Armando	Shouldn't we write because magnets only have magnetism that can stick to metal, but not to something that ain't metal?
Martha	And nothing else stuck to magnets.
Armando	Because of magnetism don't stick.
Samira	Wait, say it again. "Because we have testing done and nothing else…"

Martha	Sticks to magnets except metal. (Ar.Ob.02092012.MOVO4A.06:30)

Dialogue between peers in argument-based inquiry laboratory work shows how students help each other to clarify ideas and understand the data collected for their analysis. In the example, students were double-checking their observations after testing for the lesson of sound. In this lesson the testing part was exploring four centers that had different materials to test. This is an example of Armando refining ideas in his group.

Armando	What did you mean from this? What did you mean from this, “don’t hear anything”?
Samira	We didn’t hear anything because when we put the stethoscope in the water, we didn’t hear anything.
Armando	Oh yeah. But you could, when you use the stethoscope, you could hear the heartbeat.
Samira	Except that wasn’t part of center C.
Armando	What was it?
Samira	Because we were supposed to use the water and the stethoscope.
Armando	Oh yeah. (Ar.Ob.04122012.MOVO55.17:25)

Armando also learned through the process of laboratory work to listen carefully to other students’ ideas and being aware and questioning those concepts. He did not understand why they had the word “vibration” in their observation so many times.

Armando	We used a lot of vibrations.
Martha	Because every sound has a vibration.

Armando	Wait, I still need to copy that.
Martha	Vibration…
Armando	Wait, “the tuning forks onto the desk.”
Travis	Whose is that?
Martha	It’s mine.
Travis	You sure about that?
Armando	Wait, didn’t we, wait. Didn’t we already put that? Look. “At Center A we put hitting on desk” and desk again? Here.
Samira	Where? Tuning fork onto the desk and felt and heard vibration.
Armando	And here, desk again.
Martha	“We hit the tuning fork onto the desk again, we put it in water and it made a splash.”
Armando	Oh, yeah. Onto the desk… wait, I skipped a line. Oh, no. (Ar.Ob.04122012.MOVO56.03:17)

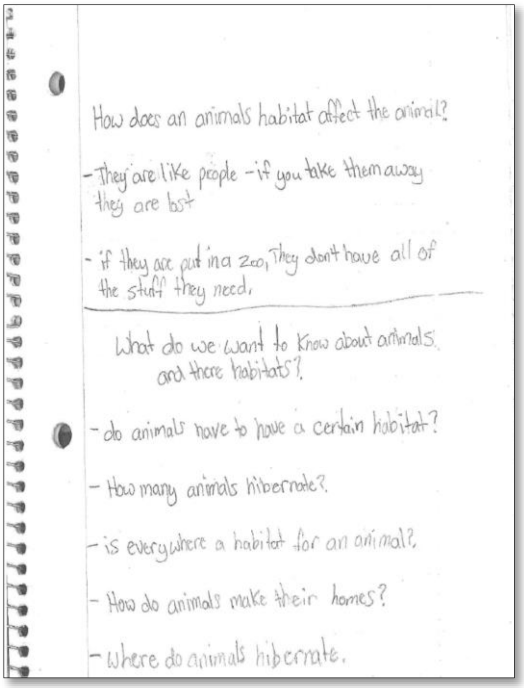
This dialogue during the laboratory activities showed a lot of interaction among Armando’s team members which helped him to understand and include in his writing the importance of vibration in the nature of sound. Also, through meaningful dialogue and collaboration among peers, Armando was engaged in the science lesson of talking about the topic, discussing what concepts should be included, and asking help for clarification of topics.

As seen in the example, the dialogue among students promoted Armando to improve his ideas in the different science practices. In the dialogue it is observed how students evaluated their ideas, especially Armando, who was unconvinced of the evidence for magnets. The dialogue among students helped Armando and his team to have mutual support and achieve a common understanding using questions, statement interactions, and feedback.

Using learning tools such as KWL chart, representations, writing, and consulting experts contributed to their learning of science practices. An Argument-based inquiry learning context strongly promotes the use of language. In fact this approach is grounded in the philosophical tenet of *there is not science without language (*Lemke, 1990; Norris & Phillips, 2003). Language is important for science progress and knowledge development. Therefore, several forms of language are involved in this specific context, creating learning opportunities for students. For example in this study many ways of language constitute effective learning tools for students' improve their science learning. These learning tools include: 1) KWL, 2) developing representations, 3) using writing for planning an investigation and recording observations, and 4) consulting experts and are important keys for engaging in argument from evidence. The next section presents how this learning tools were beneficial for these students during their experiences conducting laboratory activities. Several examples were captured during observation of the enacted lesson, from their science notebooks and structured SWH template.

KWL chart (What I Know/What I Want to know/What I Learned). In the results that follow, I present some examples of how the KWL chart was an important tool for promoting students' science learning. To illustrate the use of this tool, I selected the examples from Amelia's engagement in her science lesson about animals' habitats. For the practice of science in laboratory activities, these students were exposed to several science practices suggested by the NGSS, such as asking questions, developing models, planning and carrying out investigations, analyzing and interpreting data, constructing explanations, engaging in argument from evidence, and obtaining, evaluating, and communicating information. The science practice that was not found in any of these students performance was using mathematic and computational thinking.

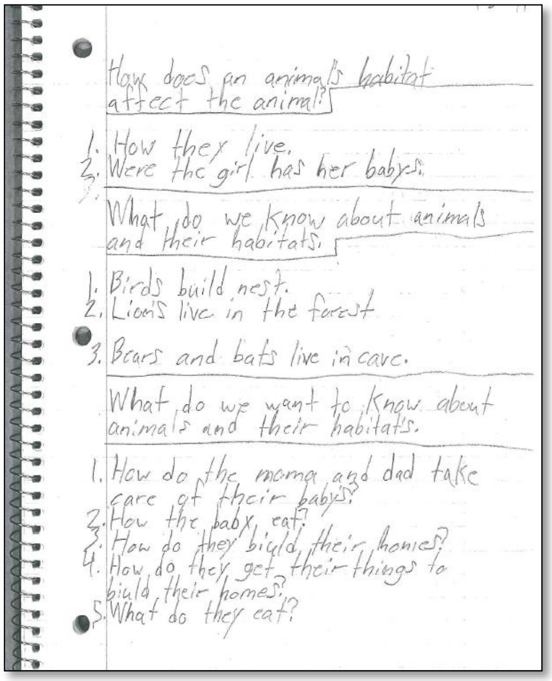
For example Amelia and Armando had the opportunity to participate in the generation of questions using the KWL chart to explore what students knew about habitats. The teacher encouraged the class to write down those ideas in their notebooks; specifically, how the animal's habitat affects the animal. Some ideas that Amelia wrote in her notebook are shown in Figure 6.


How does an animals habitat affect the animal?
-They are like people -if you take them away they are lost
- if they are put in a zoo, they don't have all of the stuff they need.
What do we want to know about animals and there habitats?
- do animals have to have a certain habitat?
- How many animals hibernate?
- is everywhere a habitat for an animal?
- How do animals make their homes?
- where do animals hibernate.

How does an animal's habitat affect the animal?
-They are like people - if you take them away they are lost.
-If they are put in a zoo, they don't have all of the stuff they need.
What do we want to know about animals and their habitats?
-Do animals have to have a certain habitat?
-How many animals hibernate?
-Is everywhere a habitat for an animal?
-How do animals make their homes?
-Where do animals hibernate?

Figure 6. Amelia's habitat questions and ideas based on the KWL chart.

Amelia was very active in this process of participating, providing ideas, and writing. In class she was raising her hand and Mrs. Smith was taking her ideas and writing them on the whiteboard as a contribution to the whole class. Armando discussed with one of his classmate about his interest in animal habitats and how they survive as it is seen in Figure 7.



How does an animal habitat affect the animal?

1. How they live.
2. Were the girl has her babys.

What do we know about animals and their habitats?

1. Birds build nest.
2. Lions live in the forest.
3. Bears and bats live in cave.

What do we want to know about animals and their habitats?

1. How do the mama and dad take care of their babys?
2. How the baby eat?
3. How do they biuld their homes?
4. How do they get their things to biuld their homes?
5. What do they eat?

Figure 7. Armando’s habitat questions and ideas based on the KWL chart.

By doing the KWL chart, the teacher explored the students’ prior ideas and for this lesson in particular, which was the first of the semester, the teacher provided the research question to the students. The question was “What do you think made this object? What would the animal’s food web look like?” The teacher allowed the students to design and conduct their own investigation. They were exploring owl’s pellets to find out what kind of animal made something like the pellet and what kind of animal was inside the pellet, and from that infer what food the animal that made the pellet eats.

Developing representations. When conducting laboratory work, students generated pictorial representations to create a physical replica of their experimental procedures to show their understanding of the core idea under exploration. Although this science practice of “developing and using models” was not common for the participants of this study, a few of them were presented and were significant in students’ learning. Teachers are highly encouraged to include models and representation when they are teaching using argument-based inquiry. The students in the classroom were involved in the creation of representations during laboratory activities. The creation of representations in some of the lessons had different learning goals, such as gaining an understanding of the concepts of ecosystem and food chain, the representations of the procedure of the matter experiment, and the encouragement of the student to use his or her creativity to better represent the phenomena.

One example of this representation was in Amelia’s case. She had the exercise of creating a multimodal representation during the lesson on animal habitats. For this lesson the teacher asked students to create a model as a way to assess what students learned about the ecosystem and food chain. Amelia decided to create a diagram of the food chain identifying the role of the animal and plants on the food chain in which the predator was an owl. Figure 8 shows Amelia’s diagram of an owl’s food chain and her understanding of the role of each species in the chain.

Figure 8. Amelia's diagram of the food chain of an owl.

In the figure Amelia describes owls as predators that hold the position at the top of the food chain. The diagram also shows that owls' hunting habits are frequently during the night so rats and mice are their usual prey. In addition, the diagram shows the sources of the energy of the prey animals, such as plants and fruit.

Another example of creation of representation was in the lesson on matter in which Alexandra participated. This representation was created in groups, so they divided the task according to who drew and completed the picture. The representation created in the matter lesson was to help students understand the procedure and represent their observation of the Alka-Seltzer® that was dropped into the water cup. Figure 9 shows the procedure for the changes in matter.

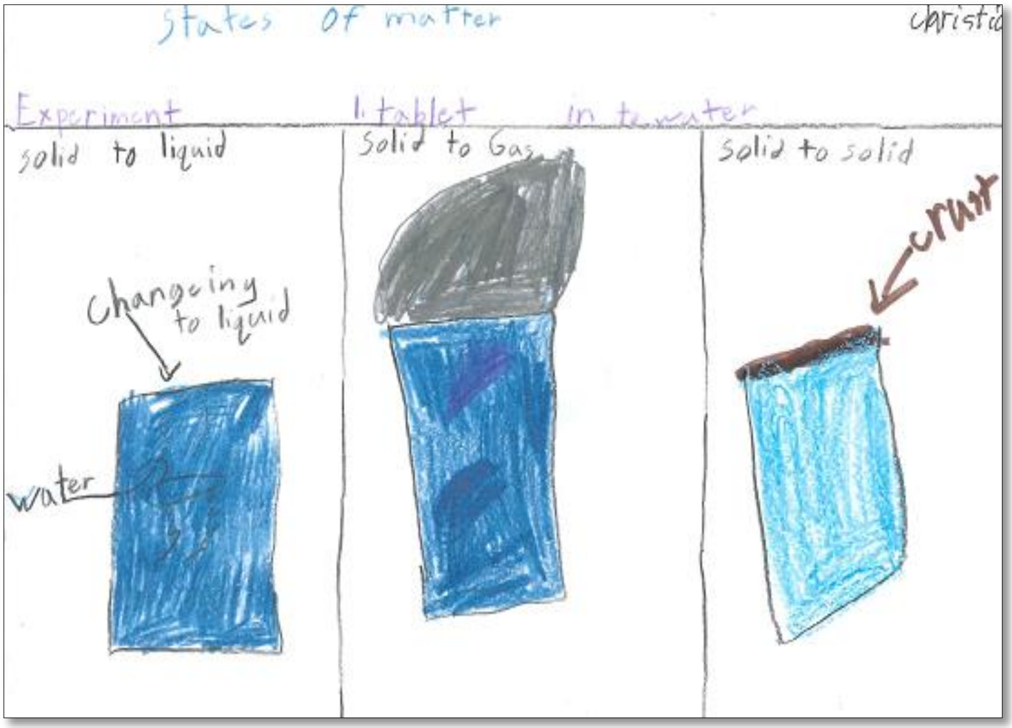


Figure 9. Alexandra and her partner's diagram of the states of matter experiment.

The diagram shows how Alexandra and her partner represented the materials used for the experiment, the step-by-step procedure of the experiment, and the description of how the three states of matter changed under certain conditions. Although this lesson was highly teacher-centered, students were motivated to draw and use colors. The students really appreciated this experience in the classroom while doing this experiment. For Alexandra it was one way of connecting science and art, which was one of her favorite subjects. As she stated:

Researcher	Oh. What subject do you like most?
Alexandra	Um, science and art?

Researcher	You like science.
Alexandra	Yeah.
Researcher	Why do you like science?
Alexandra	Because you get to learn about the human body. And the reason why I like the human body, because I want to take like something that your body doesn't really used to.
Researcher	Why do you like art?
Alexandra	The paintings in my art class, like use colors in the school. (Al.In.04192012.06:22)

In addition to the model of the state of matter experiment, for the second part of the lesson of matter, the teacher introduced another model to the class. It was a fizz-inflator to demonstrate that matter can exist in three states. This was a demonstration that the teacher did for the whole class (Figure 10).

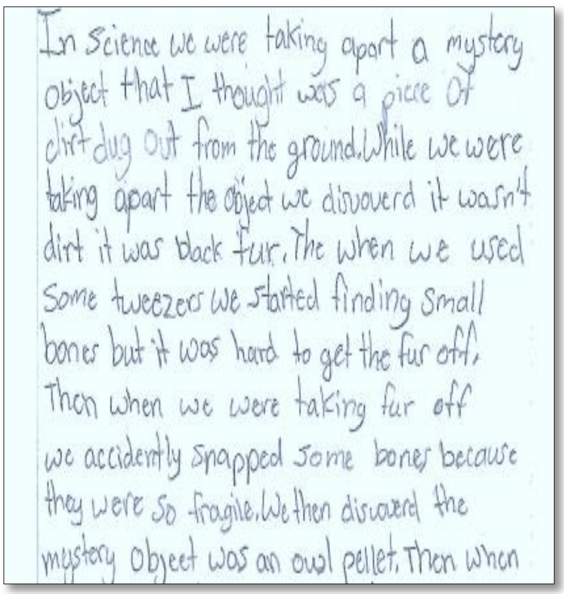
Figure 10. The model of the fizz-inflator.

Taken from (http://www.sciencebob.com/experiments/fizzinflator.php)

For this part of the experiment, by having the demonstration with the fizz-inflator, the teacher wanted to challenge students' claims regarding the question "How will the tablet change when dropped into the cup of water?" Students were amazed by the demonstration, especially the moment the tablet started dissolving energetically, during which a chemical reaction releases carbon dioxide gas. The carbon dioxide was observed as gas bubbles that helped the balloon inflate. The model helped to explain how matter can exist in three states. Students could see the gas through the formation of bubbles. They could also see an increase in liquid, since they measured the volume of water in the bottle before they dropped the tablets and noticed a rise in water level after the pill was dropped. They also noticed a small piece of solid that was a remnant of the Alka-Seltzer® tablet that did not dissolve. The teacher called that solid a “crust.”

Using writing for planning an investigation and recording observations. Learning science in an argument-based inquiry approach requires the use of language in its different expressions. Students talk through dialogue to clarify, construct, and negotiate knowledge during the science practice. Students also create pictorial representations to describe procedures or understand core concepts, and students use writing as a tool to learn science and improve language. All of these language expressions have been involved in the process of laboratory activities. Writing practice was encouraged in the classrooms where these students participated but not in a consistent manner. An example of how writing improved language through narrative and descriptive genre was while Amelia was learning about animal habitats. The teacher encouraged students to write as a way to assess their learning, and Amelia showed in her writing what she truly understood about the practice of planning an investigation and recording observations.

The practice of planning and carrying out an investigation was one that encouraged all students to be comfortable and motivated in solving the research question. For the experiment on animal habitats, students needed to observe the exterior and interior of an owl pellet. They needed to separate objects in the pellet such as bones, fur, and feathers because they needed to identify different types of prey. In addition, student needed to infer what animal made that pellet based on the small animals they sometimes found in the pellet. This procedure was done in groups of two students. At this stage of the investigation the teacher let them work on their own and sometimes approached each group to ask them questions. In addition, she checked if students were on task and reminded them that they needed to record their observations for the experiment. For this part Amelia described what the testing plan was and how she carried out the investigation in her notebook (Figure 11).


In Science we were taking apart a mystery object that I thought was a piece Of dirt dug out from the ground. While we were taking apart the object we disvoverd it wasn't dirt it was black fur. The when we used Some tweezers we started finding Small bones but it was hard to get the fur off. Then when we were taking fur off we accidently snapped some bones because they were So fragile. We then discoverd the mystery object was an owl pellet. Then when

"In science we were taking apart a mystery object that I thought was a piece of dirt dug out from the ground. While we were taking apart the object we discovered it was not dirt it was black fur. Then when we used some tweezers we started finding small bones but it was hard to get the fur off. Then when we were taking fur off us accidentally snapped some bones because they were so fragile. We hen discovered the mystery object was an owl pellet". (Am. Doc. Page 35)

Figure 11. Example of Amelia's science notebook where she recorded her observations about the animals' habitat experiment.

As Amelia's writing sample shows, there is an intended purpose, which is to explain to a specific audience how the experiment was carried out. In this case the audience was the teacher. Therefore the inclusion of writing activities in the course of learning science promotes several skills that these students could take advantage of for their learning development. These activities should play a major role in the science classroom.

Consulting experts is an important key for engaging in argument from evidence**.** Consulting an expert is one of the phases that helps students find information to compare how their ideas are different or similar. This phase is done when students complete the formulation of their claims and evidence. Several sources can play the role of experts, for example, the internet, textbooks, newspapers, and guest speakers. Hence, students were able to explore many books from the classroom library and talk with guest speakers. During the time of data collection, Mrs. Smith made the effort to bring a guest speaker to all students in fifth grade. So Amelia, Armando, and Alexandra had the same experience of participating in the guest speaker's talk about wild animals.

The guest speaker was invited when students were learning the lesson about habitats and working on the owl pellet experiment. The guest speaker was an expert in wild animal rehabilitation, helping wildlife such as turkey vultures, owls, raccoons, hawks, falcons, bald eagles, and deer return to their natural habitat. For her presentation she spent one hour talking to students about the project of helping rehabilitate animals because they are injured, orphaned, or impaired. She brought various examples of animals, including several species of owls and other wild animals. Students were attentive to the speaker's explanation and stories on each animal that she brought. She also brought owl pellets and explained how they were made.

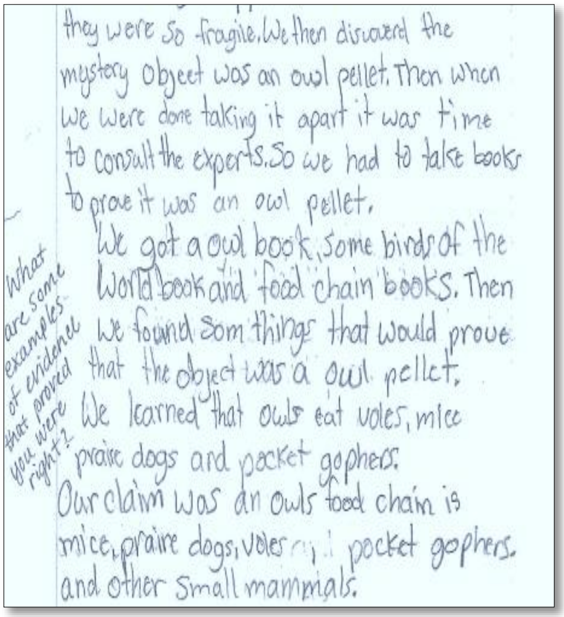
The guest speaker's information was important for students to confirm that the pellet was made by an owl. In addition, students felt supported by the information provided by the speaker since it strengthened and validated their arguments. Another aspect that the speaker covered was about how owl pellets were made. She explained that owls swallow their food as a whole piece. In their digestive system owls cannot digest bones, fur, or insect exoskeletons, so these items take the form of an oval mass that later is regurgitated under a perch or nest.

One example of how the speaker's information supported student learning of science practice such as constructing evidence, gaining new vocabulary, and gaining confidence is seen in Amelia's case. After Amelia and her partner collected their observations, it was time to analyze and interpret their data, which is another science practice from the eight that NGSS recommends. For analyzing data, Amelia and her partner recorded their observations to compare to what the experts said. Based on her group's observations, an owl made the pellet. These ideas were emphasized when they found several pieces of information from the experts. They read several books and found information about owls' food chain. Amelia and her partner discussed what was the best information to support their findings. Their data was recorded in the science package in a descriptive way. Amelia was able to record her observations by working collaboratively to make sense of the phenomena.

For the next stage, students compared their data with the experts and the information found was used as evidence to support their claim. The following is an example of Amelia and her partner looking for information in different sources for their analysis:

Amelia	These are pellets. Owl pellets, this is an owl pellet.
Girl purple shirt	Intestine…I have to finish that. You can turn the page.
Amelia	So is that it? Is that all we need?
Callie	I don't know.
Amelia	We should get more information.
Callie	Yeah, since we only have two things of information.
Amelia	Look, it says, it says something. It says, she is able to kill prey such as rabbits and squirrels that smaller owls can't.
Callie	Yeah, but that doesn't say if it's, if our thing, if owl pellets or not. We already know that your owl makes an owl pellet.
Amelia	It could be a mouse because it was so small.
Callie	Yeah. (Am.Ob.10042011.MOVO2F.18:45)

As the investigation continued, Amelia’s next stage was constructing an explanation and making a claim based on beginning ideas, data collected, and the research question. For constructing an explanation, Amelia and her partner created a claim based on the research question and the data that they found. Amelia’s claim was “an owl food chain is mice, prairie dogs, voles, pocket gophers, and other small mammals” (Am. Doc. Page 35). This claim effectively answered the research question “What animal made this object and what does its food web looks like?” In addition, Amelia and her partner constructed their explanation based on what they observed and information from the books that were used as supportive evidence. An example of this stage is shown in Figure 12.


they were so fragile. We then discoverd the mystery object was an owl pellet. Then when we were done taking it apart it was time to consult the experts. So we had to take books to prove it was an owl pellet.
We got a owl book, some birds of the World book and food chain books. Then we found som things that would prove that the object was a owl pellet.
We learned that owls eat voles, mice praire dogs and pocket gophers.
Our claim was an owls food chain is mice, praire dogs, voles, pocket gophers. and other small mammals.

What are some examples of evidence that proved you were right?

"They were so fragile. We then discovered the mystery object was an owl pellet. Then when we were done taking it apart it was time to consult the experts. So we had to take books to prove it was an owl pellet. We got an owl book, some birds of the world book and food chain books. Then we found some things that would prove that object was an owl pellet. We learned that owls eat voles, mice prairie dogs and pocket gophers. was an owl's food chain is mice, prairie dogs, voles, pocket gophers, and other small mammals".

Figure 12. Amelia's construction of the claim for answering the research question about owls and their food chain.

The last stage for learning and being engaged in science practices included participating in argument for evidence and communicating information. For the argument practice, Amelia and her partner presented their findings about the owl's experiment in front of their group and refined their reasoning based on information from books and a guest expert who visited fifth graders to talk about wild animals. In her presentation in front of the group, Amelia provided her claim and evidence. Amelia and her partner received critiques from the audience; there were a lot of questions, but the audience agreed with their findings in the end. For communicating information the argument-based approach involved included one stage for presenting, discussing, criticizing, and negotiating ideas. Amelia had a discussion with the entire classroom when she presented her findings, and after that the teacher asked students to meet in groups of three to talk more about their claims and evidence.

Overall, Amelia was engaged in the practice of science while conducting the owl investigation and very active working in a collaborative way with her partner. The only science practice that was not present in this entire lesson was the practice of using mathematical and computational thinking. There was a lot of meaningful dialogue with her partner specifically about what information was reliable from the books to support their claims. Her partner was also engaged so there was dynamic work with the end goal of looking for information regarding owls. The teacher gave students plenty of time and the responsibility to do their jobs. There was minimal intervention from the teacher in this step of exploring alternative resources or consulting experts. Figure 13 shows the summary of these findings.

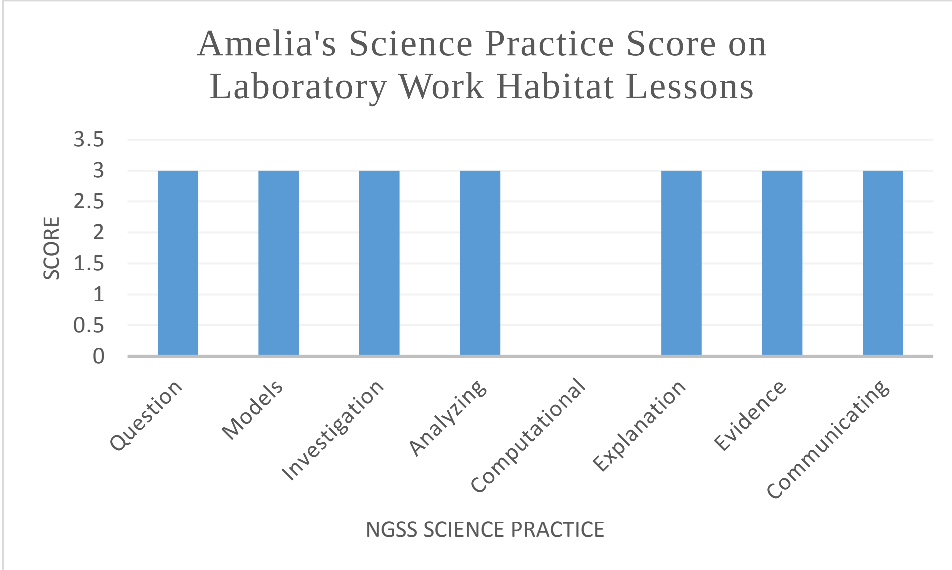


Figure 13. Amelia's science practice score chart when she was participating in laboratory work.

Effective pairing of students promoted their understanding of science practices. The experience of students participating in an argument-based inquiry required students to work in groups or pairs to create an intellectual partnership that promotes teamwork. In addition, collaborative work occurred during the engagement of the students in the laboratory activities to provide the foundations for dialogical interactions which have shown benefits for students learning constructions (Ford & Wargo, 2012). Students participating in an argument-based inquiry require different levels of cognitive demands such as performing procedures, communicating understanding, analyzing information, and negotiating ideas to make connections that require a more intimate scale of interaction (Cavagnetto, Hand, & Norton-Meir, 2010).

As seen in the findings about laboratory activities discussed before, the Hispanic students in this study had the opportunity to work with and learn from their peers. Effectively pairing students in their science activity promotes their social learning to respect and listen to each other. For those students who struggle, that kind of interaction might be beneficial since they can construct learning from their more proficient peers. The Hispanic students in this study worked in groups and also in pairs. How students were paired up or grouped by the teacher is not clear. However, the way that Armando and Amelia were paired for the different lessons observed in this study worked effectively.

In Alexandra's case, the pairing up did not work well in the lesson on habitats that was conducted when she was in fifth grade and Mrs. Smith was the science teacher. Alexandra's partner who I called in this study as "Michael" is a male, white student. He worked with Alexandra for the lessons of habitats. During science he and Alexandra argued about the responsibilities of writing and during conversations he was always talking about things that were not related to the academic task assigned. Therefore, Alexandra and her partner did not work as a good match, so the learning process was not significant. This was another situation that was worsened by Alexandra's conditions of having limitations with the English language and mathematics. For Alexandra was a challenge to work with her partner. He looked like he was not fully connected with the science work. For example, when Alexandra was talking about the task they were doing, he responded with answers that sounded illogical or had nothing to do with the task. This created more difficulties for her conducting each practice of science inquiry. Even though

Alexandra had a lot of academic limitations, she made an effort, but working with her partner made the situation more challenging.

Alexandra	I think the animal was an owl that made it. Or a bird. How about a bird?
Michael	Bird. A crocodile? Crocodile skin. It looks like it has tires on it, mini tires, like the tire pattern. Like seriously, it looks like a crocodile.
Alexandra	How do you spell bird? How do you spell, I don't want to.
Michael	A bird, just say it's a rotten egg. It looks like a rotten egg that looks all mushy and stuff.
Alexandra	Okay, you write something that includes some animals on that. Okay, so you just put an animal that looks.
Michael	A rotten egg.
Alexandra	But it has to be an animal that would make it.
Michael	I know, a rotten egg. What's two times two?
Alexandra	Four? No not four. Yes it is.
Michael	Fifteen times two.
Alexandra	We're in science.
Michael	Okay, it looks like a rotten egg. (Al.Ob.09112012.MOVO56.13:42)

For Alexandra, working in groups is meaningful. She said that "she has a lot of friends in the classroom and it is very helpful for her to work in small groups because she can ask her tablemates questions about spelling or the meaning of something that she does not understand" (Al.In.04262012.01:19). She is clear that her tablemates are her first source of clarification of ideas and if they cannot help she will ask the teacher. That was a rule that students followed in the classroom. In Alexandra's experience in learning science through argument-based inquiry, her fourth grade teacher asked students to make teams of two members. The same happened for her teacher in fifth grade. Regarding these two experiences, sometimes Alexandra was not satisfied. She expressed that her partner was not focused in the task or not very interested. So she stated:

> I feel kind of fine working with the group. But sometimes they look at something, like they look up at the ceiling, they look at the desk. Sometimes they just goof off. I feel kind of hard when I do the question on my own, because let's say if you need some help, but you can't get help, you can't go over there and go over here. But at least I made some tablemates, so they can help me. (Al.In.04262012.05:18)

During the habitat lesson, Alexandra was still in tutoring for math and reading and usually those activities took 20 minutes of her science class. She came late to the classroom and usually the science class was already going on. The science class was scheduled for 45 minutes so she only spent 25 minutes conducting experiments and participating. During that time she was engaged and motivated but sometimes she could not complete her science work. Most of the time for the habitat experiment she was the person that wondered about the animal that made the pellet, read the books, compared with experts, and also did the writing. She felt that there was not so much collaboration from her partner who spent more time in the class than the 25 minutes that she spent. In addition, she explained that her partner was so uninvolved in the process that she did almost all of the writing.

> Um, I feel kind of, well, I feel like I'm just doing all the work sometimes. (Al.In.10092012.03:18)Because, my partner, right? Because he was going to sleep and that, and I'm the only one that did all the writing. (Al.In.10092012.04:28).

Consequently, when it was the moment for their negotiation in front of the class the result was not the best for either of them. In their science package there was no information about their evidence and how they compared their findings with the experts. Alexandra said that they found some evidence in one book and asked her partner to write the evidence down but it looked like he did not do it. She divided the work since she had to leave the classroom for her tutoring so she explained:

> No. When he presented it, I don't know, because I wasn't there that time. Because he didn't like work on it, didn't write too much evidence, so if I was there I would write like all the evidence that we did, that we tried to like do for what happened. Like what's in it, what happened, and how did we get it. (Al.In.10262012.03:25)

Regarding the practice of constructing explanations, even though Alexandra had many inconveniences as previously described, she did experience the practice of constructing explanations. She was able to provide a claim that she wrote in her science package and discussed it with her partner in the classroom. So her claim was "an owl made it [the pellet] because owls eat rats and an owl would make something like that" (Al. Doc. Page 4). This claim answers the research question about what animal made the pellet, although Alexandra and her partner did not explain deeply what the food web of the animal looked like. This conclusion was made based on Alexandra and her partner's observations of what was inside the pellet. Based on their observations they saw bones and fur that had the form of a mouse. They also found in a book the skull and bones that belong to a bird.

Alexandra	Right here, right here Michael. Michael.
Michael	Okay. Measure by one, two, three, four, five. Wait a minute, so we have to get five.
Alexandra	Where did my bracelet go? Oh, it’s right here. Thank you, Jesus Lord. Okay, so. Do you want me to read it for you? Okay, so it’s 44 wide.
Michael	No no no no. Two by…
Alexandra	I think it wasn’t.
Michael	It’s two inches, let’s find two inches. Oh my god, I think I got it, I think I got it.
Alexandra	Jeez.
Michael	It might be that.
Alexandra	Wait, did it have the, wait it is. You know why, because I saw that, and every single one has a yellow one or orange one, beak. But let me just look at the, whatever these are. All sizes, shapes, colors. Colors are, okay. (Al.Ob.10022012.MOVO5B.03:47)

Although they made observations, took measurements, and made research from books they did not record that information. They did not decide who would write and that affected them a lot for their communication of the findings. Alexandra and her partner had the opportunity to engage in argument-based inquiry by explaining their question, claims, and evidence. However, they were not committed to write down parts of the information they found. They did not record what evidence made them think that an owl made the pellet:

Alexandra	Okay. Michael, really. Michael. Michael. Michael, do this.
Michael	Okay, write down…
Alexandra	I'm not writing.
Michael	It wasn't an egg. No, you've got to write down.
Alexandra	No I don't.
Michael	Yeah. I'm not at my desk. You've got to write it down.
Alexandra	Only put the questions from the books that you have examples blah blah blah, okay. Okay.
Michael	Okay, write down.
Alexandra	No you write, you write this, I write the book, and I write the author. You write these, you write these, and I write that. Okay?
Michael	No, you've got to write the quote from the book.
Alexandra	What book is that? Thank you.
Michael	I've got to read it. Give it to me. You're mean.
Alexandra	You're mean too. At least your sisters are nice. (Al.Ob.10022012.MOVO5B.07:07)

For this practice, Alexandra had the opportunity to obtain information from books and from an expert in wildlife animals who was invited by the teacher. However, Alexandra and her partner argued so much about responsibilities in the group that they did not complete the task.

Alexandra	Okay, what are we doing?
Michael	We have to read books. Look for…
Alexandra	Owl, okay. I'm just going to look at babies, okay, babies. How they hatch. So that's on page 20. 18…

Michael	That’s mean, you’re making me do all the work.
Alexandra	Oh wait, it’s not an owl like, “that have white rough…”
Michael	Rough shells. Shells.
Alexandra	These things are…
Michael	Shells are like the eggshells, you know. (Al.Ob.10022012.MOVO5B.03:07)

In addition, all students were expected to present their findings in front of the whole class in order to discuss and negotiate ideas. All students were encouraged to write down their findings but this was not possible in Alexandra’s group. In the process of negotiation, Alexandra and her partner had their turn to present. Alexandra did not contribute as much to the process and the audience asked questions to which she was unable to respond. The audience recommended that they needed to provide more evidence about why they said that the animal was an owl and how they knew that the prey was a mouse.

Alexandra	So like more details, like.
Justin	Yeah, like, I don’t want to be mean, but you need to start checking and get down like the words with the looks.
Alexandra	Uh, Justin, then you.
Justin	I was going to say, I don’t think you have enough evidence.
Alexandra	I agree with you.
Justin	You’ve got some evidence that’s all right, and I don’t disagree with what y’all found or anything, I’m just lost. (Al.Ob.10162012.MOVO5E.06:17)

Although Alexandra was engaged in the whole process of the laboratory activities, the writing part was crucial to connect all the things that they did and being involved in the process of argumentation. Neither Alexandra nor her partner took responsibility for the process of writing. One reason for this is that it was difficult for her to remain updated about what was going on in the classroom when she missed the first part of the science class. Second, she felt uncomfortable writing since she was always aware about spelling issues. Third, as the results indicated previously, the way to group students for science activities might be a factor to work effectively during an argument-based inquiry approach. The result of this unsuccessful matching was seen with a poor presentation for both of them and many critiques from the audience to improve their work.

Impact of Laboratory Activities on Understanding of Argumentative Components

In this section, I describe how laboratory activities of an argument-based inquiry approach impacted three elementary Hispanic students' understanding of argumentative components. From the analysis of video, video transcript, and documents two themes were found across all participants. These themes are: engaging students in active dialogues between the teacher and students and among students promoted their understanding of the argumentative components, and engaging students in active writing promoted their understanding of the argumentative components.

Engaging students in active dialogues between the teacher and students and among students promoted their understanding of the argumentative components.

The argumentative components of the Science Writing Heuristic approach (SWH) were presented in the laboratory activity aspect. The vehicle for gaining that understanding was the engagement of the group in the science experiment and the discussion of ideas among the group members. For example, while conducting the laboratory work about magnets, Armando was involved in a lot of student-student and teacher-student dialogue. After students completed the testing section, it was time to create their claims and analyze the data to select the evidence that supported their claims.

In their dialogue and through the analysis of the videos, it is noticeable that some of the students in Armando's group enjoyed doing the testing more, other students took on leadership, and others were aware of what they should write in their science package. For this section the teacher allowed students to spend the whole science class time so students could discuss and analyze their claims and evidence and organize who would present each section.

Through the dialogue, students were aware of the research question and that they needed to answer it. The research question is explicitly in their minds and guiding them through the whole science investigation.

Teacher	What's your research question?
Armando	Um.
Travis	We're not done yet.
Armando	Nope. We're sticking with one main question and that is do magnets stick to metal? Um, yes. (Ar.Ob.02022012.MOVO47.00:02)

There were several conversations among Armando's team members and sometimes they talked about off-topic aspects but immediately came back to their science task. They discussed with each other what the claim was and organized the information to be ready for the presentations. They read it several times among themselves and also to the teacher as she approached the group to revise their work.

Dialogue was also present when students were analyzing which pieces of evidence they would select. Although students were aware of the evidence as part of the argumentative components, in their conversation it was evident that they were confused about what evidence was and what data supported their claim. One students said that their evidence was the "test that we did" or because "we tried it." However Armando was not satisfied with what some of his team members were saying, so that he suggested writing another idea that included how the concept of magnetism was the property of attracting certain metals:

Samira	Okay, here's our claim. We find that magnets can't stick to anything other than metal. And the evidence that we know this because we tried it.
Martha	Because we had testing things done.
Armando	Shouldn't we write because magnets only have magnetism that can stick to metal, but not to something that isn't metal?
Martha	And nothing else stuck to magnets.
Armando	Because of magnetism don't stick.
Samira	Wait, say it again. "Because we have testing done and nothing else…" (Ar.Ob.02092012.MOVO4A.04:28)

Teacher-student dialogue was possible during laboratory work since the teacher was always coaching students by asking them open-ended questions, especially about claims and evidence. Mrs. Smith approached Armando's group and one member of the group talked to her while the others listened to her carefully. Mrs. Smith wanted to take a look at what students had as evidence to support their claim. So in dialogue with Armando and the other members of the group, Mrs. Smith checked student progress in terms of the development of the claim and selection of evidence. In addition, Mrs. Smith formulated more questions to the students to make them think and elaborate more regarding their statements. That situation can be seen in the dialogue below.

Mrs. Smith	Well, we're not here yet. Let me see your other page. Tell me what you think.
Samira	Okay, our claim is we find the magnets couldn't stick to anything other than metal, because we have testing done and nothing else sticks to magnets except metal. We think it's the same things that are made with metal that the same things are made with magnets.
Mrs. Smith	So you think metal and magnets are made of the same stuff. Okay, why would that cause them to stick together?
Samira	Because like if there's metal and magnets, we found out that if two magnets are two different kinds of magnets, then they come together. But if like those are south and we had a north magnet stick, then they would attract together because like if they're made with the south material, then it'd cause it to come together.
Mrs. Smith	So do you think that should also be a part of your evidence?
Samira	Yeah.

Mrs. Smith Okay, and then what specific things can you put in from here. Like specific examples to make it more believable? Because if you were to list some of these things that you tried that did stick and did not stick, it's going to make your evidence paragraph stronger and more believable. So we still have some more work to do to add to that. (Ar.Ob.02092012.MOVO4A.12:18)

Overall, in the progression of the laboratory activities and through meaningful dialogue, Armando developed significant learning about the argumentative components since he and his group learned the core element of argumentation. There was a testable question and the claim was valid. The evidence was partially reliable since their reasoning needed more work or elaboration. It is also observed that students were able to make connections among these core elements.

For example, Armando's group claim was a plausible answer to the research question "Do magnets only stick to metal?" They stated that "we find magnets cannot stick to anything other than metal." Students said "We believe our claim was proven. We believe this because we have testing done and nothing else sticks to magnets except metal. We think it is because metal is made of the same thing as magnets." Students' reasoning from the data as evidence needed to be elaborated more because they created evidence from the data, although they did not make a strong explanation of the events. At this stage there is not any example that shows students making sense of their explanation, such as making connections between observable events and including theoretical concepts.

The last category of the analysis of students' arguments was the level of rhetoric reference of reasoning. In their discussion it seems that there are several levels of rhetoric reference of reasoning. One student said that their group's evidence was the "test that we did" or because "we tried it." According to the rubric used in this study to analyze understanding of argumentative components, this level is called inclusive reasoning, which is considered the lowest level. In addition, it is observed in Armando's case that there is a third level of reasoning that is called interpretive reasoning. In this level students interpret the significance of the data for explanation. Armando was not satisfied with what some of the members of his team said to put in their science package as evidence to support their claim that magnets stick to metal.

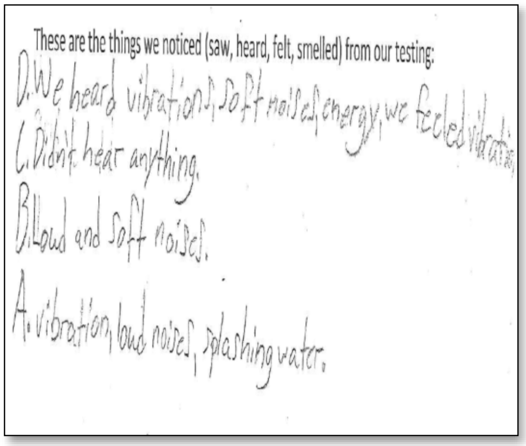
Engaging students in active writing promoted their understanding of the argumentative components. The analysis of the videos and video transcripts reveals that students were often engaged in active writing during laboratory activities. The laboratory activities were not mere situations in which students had fun with hands-on activity. Students were responsible for recording every single aspect that they observed and making sense of the argumentative components. Several examples are seen in the lessons in which the three Hispanic students participated. For example, in the lesson of magnets and sound, Mrs. Smith spent considerable time to allow students to finish their writing and record what they learned from the different observations captured from the different centers.

After students completed the data collection, the teacher encouraged them to go over the page of their science package (SWH students 'template') to come up with a claim. Hence, students met with their groups not only to talk about the construction of the claim but also to write it down as a parallel process. The teacher explicitly guided students to go back to their beginning ideas and review them. She also made students wonder if their beginning ideas were the same or changed in some way. She guided students to analyze their observations, create their claim and evidence, and write the story of what happened. Since this was an activity of working in groups, the rule of this part was that everybody should write and pass the pen to have equal participation of each member of the group.

All the students came together in their groups to discuss and clarify ideas about what information was valuable to record for their presentation in the stage of cooperative negotiation. In doing this exercise Armando took the opportunity to clarify the meaning of the evidence and in what part of writing the paper he should put that information. For this activity they were using “The Testing Presentation Planning Form” that the teacher created in order to facilitate students’ reading during presentation. While the dialogue occurred, students were writing as seen in the following example and in Figure 14.

Armando	What did you mean from this? What did you mean from this, "don’t hear anything"?
Mallory	We didn’t hear anything because when we put the stethoscope in the water, we didn’t hear anything.
Armando	Oh yeah. But you could, when you use the stethoscope, you could hear the heartbeat.
Mallory	Except that wasn’t part of center C.
Armando	What was it?
Mallory	Because we were supposed to use the water and the stethoscope.

Armando	Oh yeah. (Ar.Ob.04122012.MOVO55.10:54)



These are the things we notices (saw, heard, felt smelled) from our testing:
D. we heard vibrations, soft noise, energy, we felt vibrations.
C. Didn’t hear anything
B. Loud and soft noises
A. Vibrations, loud noises, splashing water.

Figure 14. Armando’s writing about the testing part.

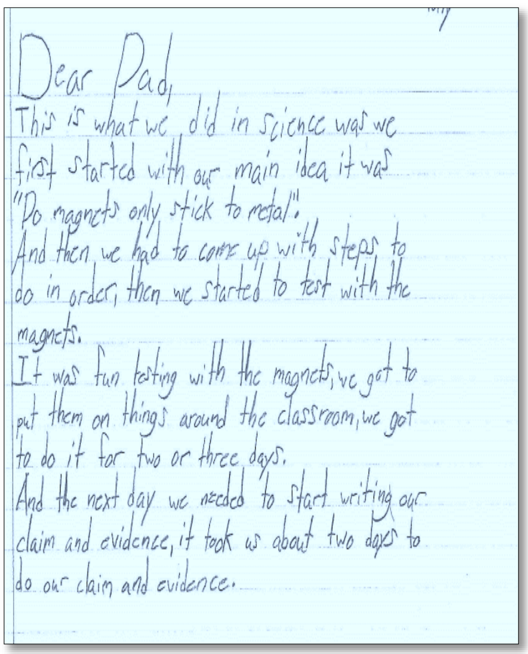
Armando and his group continued their discussion and he wanted to make sure that he had a clear understanding of their testing, elaboration of the claim, and inclusion of evidence to write better in his presentation planning. In his writing, he organized the main points of the group observation in a concise manner. Writing was critical for understanding the core of argumentation emphasized in this learning approach. In an interview, Armando articulated that the teacher always emphasized to them to write to elaborate ideas regarding the creation of the question, claim, and evidence:

Researcher	How did that question come to your mind?
Armando	Well, it didn’t really, like my teacher, she like, she had a, we asked questions. And we **wrote** them on the board and then we picked one of them that we wanted to.
Researcher	Okay. How did you get that claim?

Armando	We got it by, um, we got it from thinking of all the things we did with the magnets. And so we **wrote** and then we got the evidence.
Researcher	What did you discuss?
Armando	We discussed like, like if, can magnets stick to other things. And so we tested it and we **write it down**. No, only if it has like magnet inside.
Researcher	How did you find the evidence? Where?
Armando	Like around the room, like, our teacher said to **write down** all the things that we do with the magnets, to write them down.
Researcher	Can you remember one evidence that you find to support your claim?
Armando	I think one of our evidence was, magnets can't stick to other things that are besides metal, because there's no magnetism in the thing [other material]. (Ar.In.02232012:05:10)

This dialogue reveals that Armando understood the concept of question, claim, and evidence and how to develop each of them in the classroom while they accomplished laboratory activities. One common feature analyzed from the interview above is that each element of the argumentative component is attached to the writing practice. Conducting their investigation in each of the lessons, students were encouraged to record all of the information as a group. In this classroom in particular, there was a first stage where students wrote, as much as possible, all of their observations, ideas, interpretation, and information from the expert, which reinforced the generation of the argument, thinking and working as a scientist, and communicating scientific ideas (Hand et al., 2009). To ensure that everybody in the group understood everybody's written ideas and avoid confusion because of other people's handwriting in the group, a second stage of writing was observed. In that stage, students met again and discussed those concepts to better elaborate in their own “testing planner presentation.” In that stage, Armando was able to restructure every aspect of the argumentative components. The dialogue among the members of the group was important to gain an insight of the ideas before he wrote down the information that pertained to each element of argumentation.

After students gave their group presentations, there was another stage of writing that was less structured compared with the templates that students used during laboratory activities. This stage of writing was more open for students in that they could make a story. The teacher suggested to write a letter to somebody from their family telling what they learned during the lesson. Armando wrote a letter to his dad in which he told him about his learning about magnets. Armando’s letter is shown in Figure 15. Although he did not provide an example of what was the claim or what evidence that he used, he was able to include the words beginning ideas, testing claim, and evidence. He was able to show the big picture of his understanding and inclusion of those words to his scientific vocabulary.



Dear Dad,
This is what we did in science was we
first started with our main idea it was
"Do magnets only stick to metal".
And then we had to come up with steps to
do in order, then we started to test with the
magnets.
It was fun testing with the magnets, we got to
put them on things around the classroom, we got
to do it for two or three days.
And the next day we needed to start writing our
claim and evidence, it took us about two days to
do our claim and evidence.

Dear Dad,

This is what we did in science, we first started with our main idea. It was "do magnets only stick to metal". And then we had to come with steps to do in order, then we started to test with the magnets. It was fun testing with the magnets, we got to put them on things around the classroom, and we got to do it for two or three days. And the next day we needed to start writing our claim and evidence, it took us about two days to do our claim and evidence.

Figure 15. Armando's letter to his dad about the magnets.

The activities of writing in the context of SWH allowed these students not only to recall information from the laboratory activities but combine science knowledge (questions, claim and evidence, data content specific: magnets) and rhetorical knowledge. The active writing described in this theme is viewed as a learning task which promotes students to reframe, transform, or constitute their knowledge (Berieter & Scarmalia, 1987; Galbraith, 1997). In the task of Armando writing a letter to his dad he had to rethink how he would communicate the ideas to his father in order to describe the science part in an understandable way. As seen in the letter, Armando showed an understanding of the argumentative components that reflects his knowledge transformation or constitution in a significant manner.

In summary, the data analysis suggests that laboratory activities of the argument-based inquiry in this study impacted students in their science learning when they have opportunities in the classroom of engaging in activities that take in account time to complete tasks, students' characteristics and incorporation of language activities such as dialogue, representation, learning tools, and active writing. This activity should go along the parameter of this approach in order to help these students to construct a better understanding of the core ideas of scientific knowledge. A summary of the main findings of this section is shown in Figure 16.

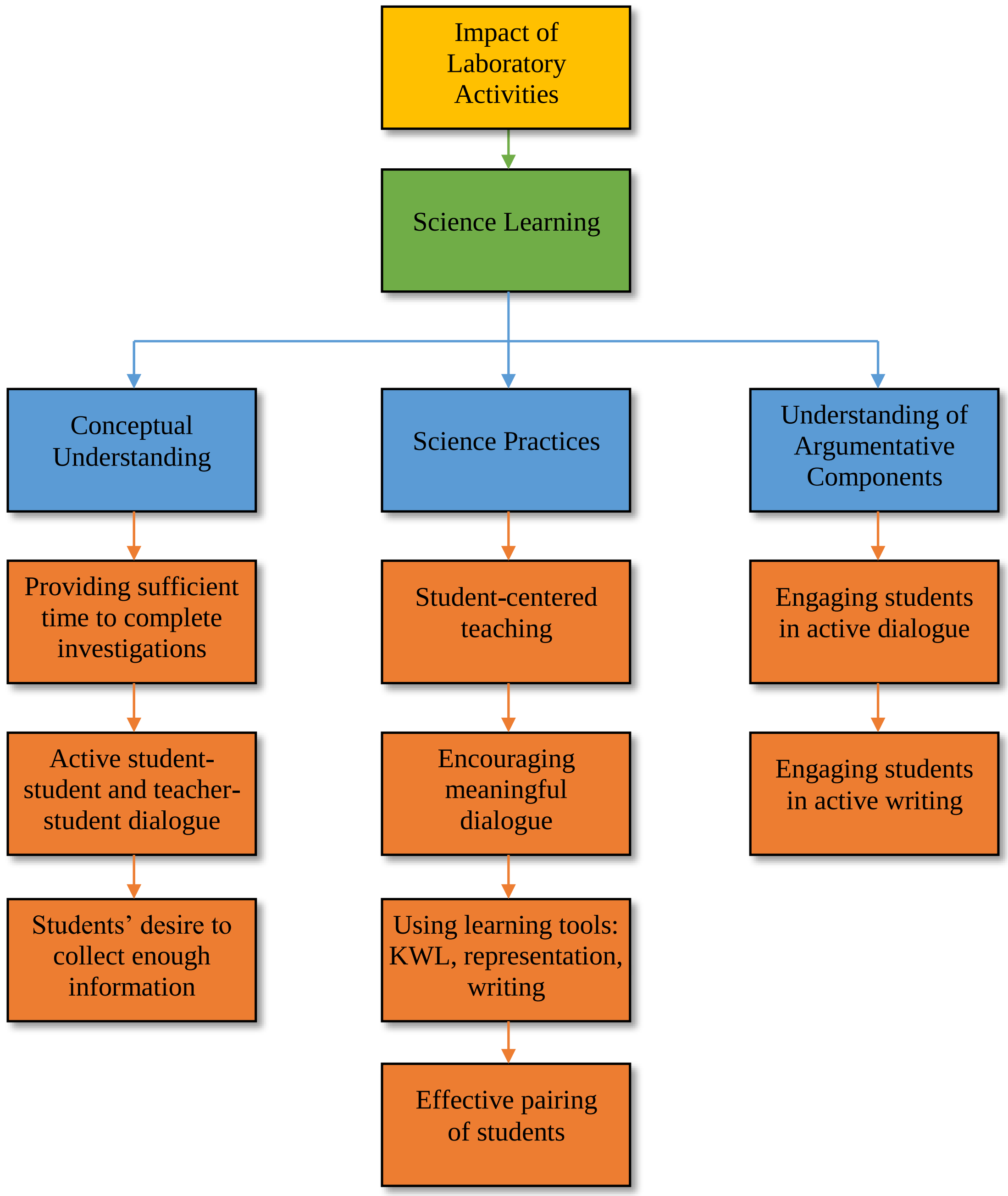


Figure 16. Summary of the main findings for impact of laboratory activities on students' science learning.

Impact of Negotiation Process on Student Science Learning

This research investigates two main aspects of an argument-based inquiry. The second aspect described in this section is the negotiation process. This aspect of the approach is defined as a phase in which students communicate their findings through negotiation of meaning (Crawford, Krajcik, & Marx, 1999). The dynamic of the negotiation can vary according to teacher experience and desire; it can also be in the form of group presentation or small group discussion. This activity promotes the generation of dialogue among the members of the group to discuss and defend their arguments. The purpose of this dialogical interaction of students and teachers is to reinforce students' scientific knowledge, since they have the opportunity to reflect through writing activities and see how their ideas changed or remained the same. In the sections that follow, how negotiation opportunities impact these Hispanic students is discussed in terms of conceptual understanding, science practices, and understanding the argumentative components.

Impact of Negotiation Process on Conceptual Understanding

The results for this section indicate that Hispanic students gained significant conceptual understanding in science when effective learning tools were accessible to them. In the context of an argument-based inquiry approach, opportunities to consult with experts through searching in books and having an actual expert in the school fostered the understanding of the disciplinary core ideas.

Creating opportunities for students to consult with experts helped refine their conceptual understanding. The negotiation phase requires students to present their question, claim, and evidence in an environment of careful listening of ideas, respecting others' turn to speak, and providing reasons for agreeing or disagreeing with presenter arguments. The dynamic varied according to the teachers' decisions based on knowing their students in terms of experience, ability to work independently, and classroom behavior. In the lesson observed in this study, Mrs. Smith and Mr. Jones mostly chose whole class discussion for the cooperative negotiation phase of their lesson. However, Mrs. Smith decided to try another approach for the sound lesson and that was having students negotiate in small groups. For the example, students had the opportunity to negotiate about the concept of habitats, human-caused environmental change, and sound. Through negotiation, students engaged in different levels of negotiation of meaning that allowed them to first make connections among the question, claim, and evidence; second, compare their explanation with the teacher or fellow students; and finally, compare their new understanding of science content ideas to those established by the scientific society such as books and other instructional resources.

One example of how the stage of consulting an expert is important for these students' learning the core concepts is in Amelia's performance in the habitat lesson. For Amelia, her group was the last one to present and they had more options to complement information since there was a guest speaker in the school to talk about wild animals, especially owls. While analyzing the science content in the negotiation process as a whole group, in Amelia's presentation she included information that was more closely related to understanding the niche concept and part of the understanding of the ecosystem concept. For example, they included the food web of the owl in their presentation. This idea helped them to infer what kinds of animal bones were inside the pellet and the type of predator.

Amelia	The food web of owls is voles, mice and other small animals. (Am.Ob.10062011.MOVO33.01:06)

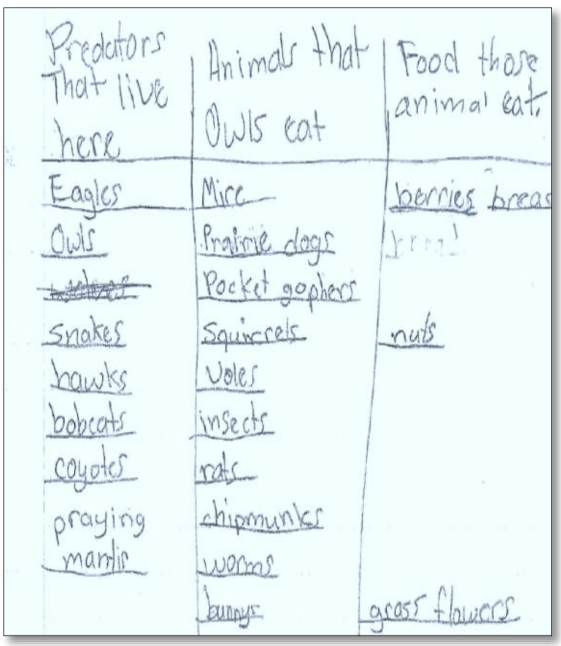
For the niche concept, Amelia and her partner learned what owls eat and what are its diet and habits. Amelia's group was the only group who presented evidence about the process of owl digestion and formation of the pellet. In order to achieve that, they did an extensive search in the classroom library and combined the information with what they learned from listening to the guest speaker, an expert on animal wildlife. Mrs. Smith invited her to present to the whole fifth grade and the speaker brought multiple owl species to the class. The guest speaker explained her work with wild animals to the students. She also explained owls' eating habits to them and showed them samples of owl pellets. So the speaker explained to the students:

> Expert: I'm a wildlife rehabilitator. That means I'm a person who takes care of wild animals that are in trouble: orphaned, injured, lost, or displaced, and releases them back to the wild. Now, let me ask you a few questions and I'm going to ask you questions on and off and you might have this real need to talk a lot. (Am.Ob.10072011.MOVO37.10:07)

> Expert: Her [the owl's] talons are that strong. So her talons are capable of catching the prey that she eats and killing it almost immediately, and then with her very strong beak or mandible, she can tear it apart and eat it. It goes into the crop, and then later it separates and she can spit out an owl pellet. And the rest goes into her body. (Am.Ob.10072011.MOVO37.00:03)

Amelia: There the broken down food is turned into a soft mass and passed on into the intestine to finish being digested. Page number 16, title of the book, Owls, author, Sandra Marco. (Am.Ob.10062011.MOVO33.01:06)

In addition, after this negotiation Amelia had the opportunity to write a reflection about this experiment where she included information that complemented the core idea of an owl's food web, and also she identified the owl's role in the ecosystem in a list that she prepared (Figure 17).

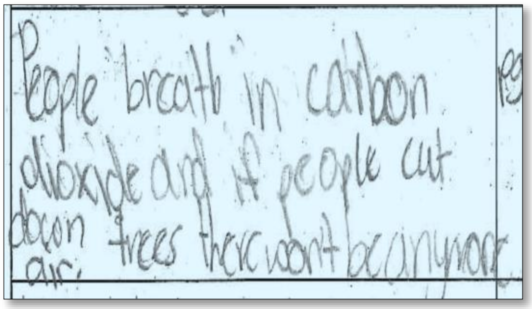


Predators that live here	**Animals that owls eat**	**Food those animals eat**
Eagles	Mice	berries breas
Owls	Prairie dogs	
	Pocket gophers	
snakes	squirrels	nuts
hawks	voles	
bobcats	insects	
coyotes	rats	
	chipmunks	
praying mantis	worms	
	bunnies	grass flowers

Figure 17. List from Amelia's food chain.

Overall, Amelia covered the major concepts of habitats and ecosystems most of the time. There was the integration of observing, searching in the book, and writing and presenting in front of the class. One characteristic of Amelia's effort in science class was that she was always committed to including enough information from the book that aligned with her claim.

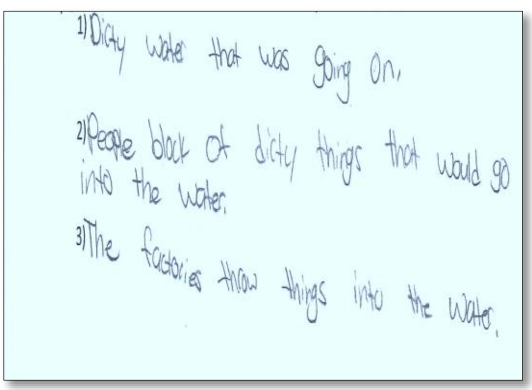
A second lesson that reveals Amelia gaining significant conceptual understanding because of consulting experts was the lesson about environments. The big idea was "organisms cause changes in the environment in which they live." The teacher's learning goal was founded in the statement that humans can change the ecosystem and the changes can be beneficial, neutral, or detrimental. There were several demonstrations made by the teacher and by the group of students. For the negotiation, students were given a complete science package, which is the template that students follow for this approach, where they describe the positive and negative impacts of human changes to the environment. For example, for the positive impacts Amelia's group showed an understanding of their own impacts on the environment since they state in their claim "People can clean the earth and try to block things off. People can take care of the earth by stop littering and turn off power when people are not using it." They also indicated that one positive way to take care of the environment is through reforestation efforts since trees soak up carbon dioxide from the air, producing life-giving oxygen in return. Figure 18 is an example of a piece of evidence that supports the claim. "People breathe in carbon dioxide and if people cut down trees there won't be any more air."



People breathe in carbon dioxide and if people cut down trees there won’t be any more air.

Figure 18. Example of using evidence to support a claim about the environment.

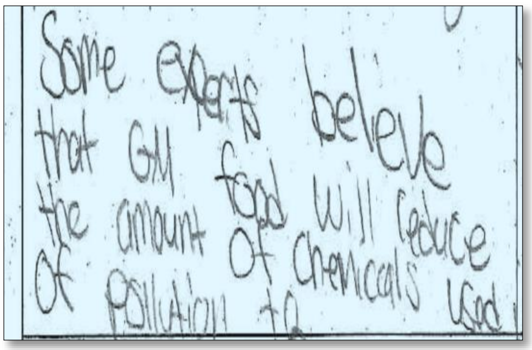
Amelia’s group also included the importance of cleaning waterways. They also state that people are responsible for putting chemicals in the water through several processes such as farming. They are clear that that contaminated water goes to the river and oceans (Figure 19).



1. Dirty water that was going on.
2. People block of dirty things that would go into the water.
3. The factories throw things into the water.

Figure 19. Example of using evidence to support a claim about cleaning waterways.

Another concept mentioned was that humans are looking for strategies to reduce the amount of pollutants that goes to the air or to the water. They found information about genetically modified (GM) food that will reduce the amount of chemical use in farming and limit the risk of pollution to water supplies (Figure 20).

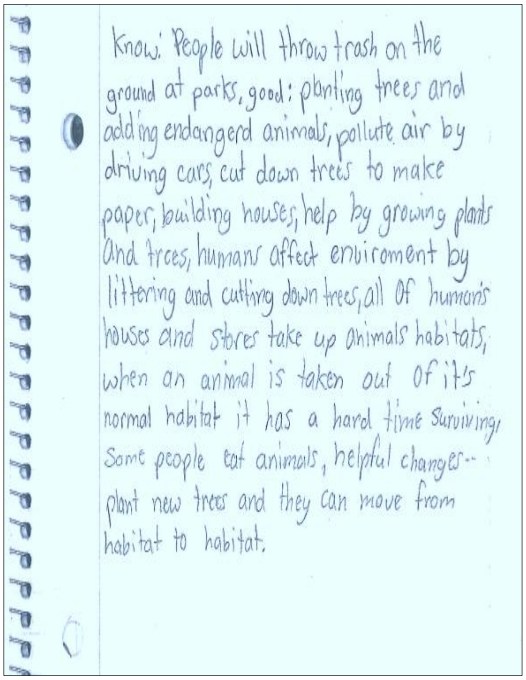


Some experts believe that GM food will reduce the amount of chemicals used in farming and limit the risk of pollution to water supplies.

Figure 20. Example of using evidence to support the claim about reducing pollutants.

Amelia is a committed student who likes to work hard in the classroom and has a great connection with other students when she is working as part of a group in the science project. She is very engaged in the process of learning science by conducting her own investigation. From the three participants who I invited to this project, Amelia was the only one who wrote a lot specifically in her reflection about what she learned in the science class. She also participated in the class and was a good listener when the teacher and other students were talking. In addition, she was eager to raise her hand and contribute to the class when the teacher asked questions to the class.

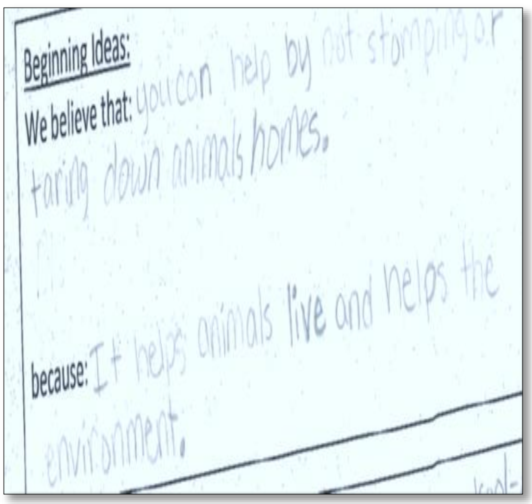
For the topic of environment she achieved the learning goals that the teacher had in mind based on the rubric of “Content Knowledge of Environment” designed for this analysis. The lesson covered the core ideas of the positive and negative impacts of humans on the environment. In her one page reflection she was able to tell the story of what she did in science and what important aspects she learned from that experience (Figure 21).



Know: People will throw trash on the ground at parks, good: planting trees and adding endangered animals, pollute air by driving cars, cut down trees to make paper, building houses, help by growing plants and trees, humans affect environment by littering and cutting down trees, all of human's houses and stores take up animals habitats, when an animal is taken out of its normal habitat it has a hard time surviving. Some people eat animals, helpful changes--plant new trees and they can move from habitat to habitat.

Figure 21. Amelia's reflection of the lesson of how humans affect environment.

A third example of how incorporating opportunities to consult experts impacted conceptual understanding was examined in the lesson of environments where Armando participated. Students were exploring the question of how people affect the environment and the big idea was human-caused environmental change. Through the process of negotiation during whole group discussion, students presented their findings based on their questions, claim, and evidence and beginning ideas. They had to observe, discuss, and consult scientific sources to compare how their own ideas differed with them. In this lesson students were learning how human changes to the environment caused positive or negative impacts in it. Armando and his group mentioned several aspects of human-caused environmental change. Through negotiation Armando and his group came up with some ideas on conserving animals' environment and showed an awareness of taking care of it. Those ideas are reflected in their research question "How can you help by not destroying animal shelters?" The students' beginning ideas showed their awareness of the consequences since they state in Figure 22 below:



Beginning ideas: We believe that: you can help by not stomping or tearing down animals homes.

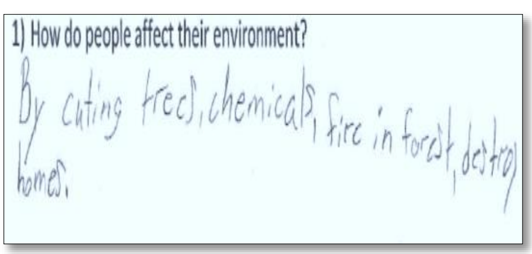
Because: It helps animals live and helps the environment.

Figure 22. Armando's beginning ideas of the lesson on human-changed environments.

In addition, students through their negotiation showed that humans can change the environment in a positive way by protecting animal habitats and species. Armando's group mentioned in the class that one way to maintain ecosystems is through cleaning waterways and reforestation efforts: "We saw them drain the chemicals and take out tractors to help animals survive. They also planted trees and grass and then plugged the sewer pipes that lead into the river" (Ar.Ob.11152011.MOVO36.01:06). They also mentioned that humans can protect species as a positive action for the environment when they consulted the experts: "Marine nature reserves help protect wildlife creatures like unicorn fish" (Ar.Ob.11152011.MOVO36.02:06).

For the negative impacts of humans on the environment, Armando's group mentioned that the liberation of carbon products yields the global warming process: "Driving your car can affect polar bears and coral reefs. Burning fuels such as greenhouse gases, which are the main causes of global warming" (Ar.Ob.11152011.MOVO36.00:33). They also remarked how the water is contaminated for some places in the community and how natural areas can also be contaminated: "Water wasted in hotels, and bad pollution of coastal waters and lakes close to visitor attractions" (Ar.Ob.11152011.MOVO36.00:33).

Students were able to cover several issues about humans and environment; while they did not mention as much regarding contamination of the soil, in general the core ideas of organism changes to the environment in which they live were covered. Armando showed that understanding through answering some assessment questions at the end of his presentation (Figure 23).



1. How do people affect their environment?
   By cutting trees, chemicals, fire in forest and destroying homes.

Figure 23. Example of Armando's understanding of people affecting the environment.

Also, Armando expressed that:

> Because, because like people, in farms, fields, country, cities, sometimes they have floods and if they or you are close to a river or ocean or something, then they, it made like, when it rains hard, like thunder, like that, then maybe sometimes the oceans or the rivers close to houses may flood hard (Ar.In.03292012.03:18).

The lesson about sound also showed the role of consulting experts in students' conceptual understanding. The big idea was to understand and apply knowledge about sound. Based on this big idea the teacher's goal was to concentrate on three core concepts that included the understanding of energy as sound, the nature of sound, and the transmission of sound through a medium. For the first core idea, Armando was able to describe the concept of sound using technical vocabulary; this knowledge emerged after he made connections among questions, claim, and evidence as is shown in this example:

> We heard lots of vibrations and those vibrations are usually in every sound. (Ar.Ob.04132012.MOVO57.13:56)

Comparing this concept about energy as sound when consulting his science book Armando also learned that:

> When we consulted the experts, we found these pieces of evidence. Sound waves transfer energy from one thing to another. (Ar.Ob.04132012.MOVO57.13:56).

For the second core idea through this negotiation Armando learned about the nature of sound:

> Sound can't be translucent or, what's that word? Okay, translucent or apock [opaque]. It can be transparent. Some sound waves sometimes become thermal energy. (Ar.Ob.04132012.MOVO57.13:56)

And for the third core idea about how transmission of sound occurs through a medium, in the negotiation Armando explained:

> Sound can travel through solids, liquids, and gases. We believe our claim is proven or we believe this because we mostly heard vibrations when we tested everything. Sound has mostly vibrations in it. When we hit the tuning forks on a table, it vibrated. When it hit the yardsticks on everything that we could, we felt vibration. (Ar.Ob.04132012.MOVO57.13:56).

In the context of argument-based inquiry guided by a science writing heuristic approach these students had opportunities to search for and scrutinize information to compare and make their evidence stronger. In looking for such information students had access to several textbooks and they needed to critically select the information that best supported their claims. This stage also gave students confidence about their arguments when they were ready to communicate to the public.

Armando	Some sound waves sometimes become thermal energy. Sound can travel through solids, liquids, and gases. We believe our claim is proven or we believe this because we mostly heard vibrations when we tested everything. Sound has mostly vibrations in it. When we hit the tuning forks on a table, it vibrated. When it hit the yardsticks on everything that we could, we felt vibration. And when we put the stethoscope in water, we heard nothing.

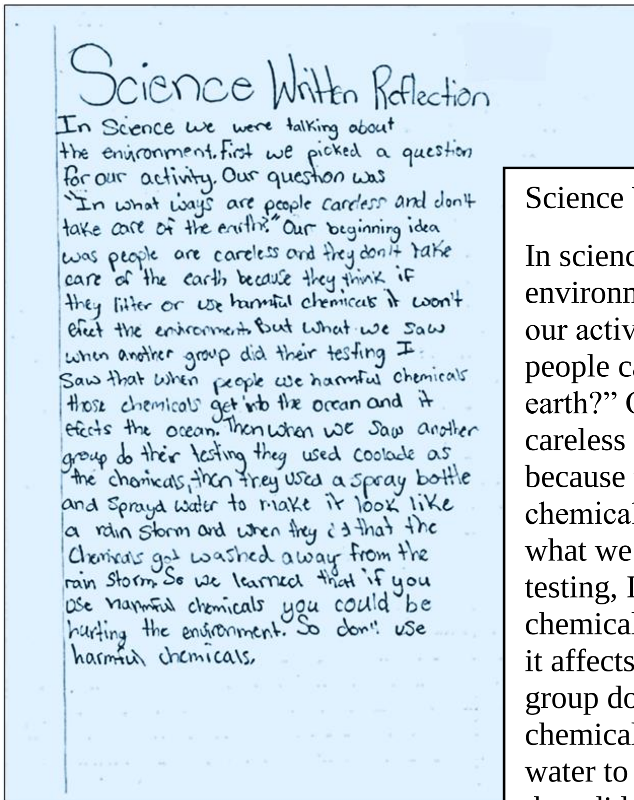
Phillip	What was your claim?
Armando	We heard lots of vibrations and those vibrations are usually in every sound.
Casey	Wait, wait, what?
Daniel	Can you repeat it?
Casey	Is that right?
Armando	Yeah, we heard lots of vibrations and those vibrations are usually in every sound. (Ar.Ob.04132012.MOVO57.13:56).

Through the stage of consulting experts Hispanic students explored and captured information to construct their conceptual understanding. Overall, students demonstrated in their dialogue, science package, and writing reflection that they understood the science concepts they were learning. Consulting experts serves as a learning tool for students which offers many possibilities of capturing the big ideas associated with their lesson's guiding question rather than only looking for facts and definitions of concepts.

Impact of Negotiation Process on Science Practices

In this section I describe the results in regard to how negotiation process impacted these students in their science learning practices. My analysis in this aspect is based on three of the eight practices of science and engineering that the NRC Framework identifies. My analysis is aligned with the reasoning framework in evaluating these three Hispanic students' understanding of how scientific knowledge is developed. These eight practices are not separate but connected and overlap as is explained by the NGSS. However, for the purpose of answering the research question of this study I focused my attention on the practices that were very related with the aspect of negotiation process, which includes constructing explanations, engaging an argument for evidence, and obtaining, evaluating, and communicating information. The result reveals that students gained significant learning of science practice in the aspect of negotiation process. The science practice learning was associated with the following themes: encouraging students in writing reflections; the teachers' explicit explanation about question-claim-evidence, and communicating findings as a whole group.

Encouraging students to write reflections helps articulate their science practices. For the second lesson, Amelia and her group had the negotiation phase through the whole class presentation. They communicated their findings orally as a presentation in a group of four members. The data collected was qualitative based on observations from the presentations of four different groups and the teacher's demonstration of how humans affect their environment. Amelia's group obtained their information from observation, reasoning, and consulting experts. Amelia's group collected enough information that during their presentation students from the audience agreed with their explanation and supporting expert evidence. Students communicated their findings orally and each of the members of the group had the responsibility to take a specific section of the science activity. They also had the opportunity of writing a group reflection and as an individual about their learning (Figure 24).


Science Written Reflection
In Science we were talking about
the environment. First we picked a question
for our activity. Our question was
"In what ways are people carless and don't
take care of the earth?" Our beginning idea
was people are careless and they don't take
care of the earth because they think if
they litter or use harmful chemicals it won't
efect the enviroment. But what we saw
when another group did their testing I
saw that when people use harmful chemicals
those chemicals get into the ocean and it
efects the ocean. Then when we saw another
group do their testing they used coolade as
the chemicals, then they used a spray bottle
and sprayd water to make it look like
a rain storm and when they did that the
chemicals got washed away from the
rain storm. So we learned that if you
use harmful chemicals you could be
hurting the environment. So don't use
harmful chemicals.

Science Written Reflection

In science we were talking about the environment. First we picked a question from our activity. Our question was "In what ways are people careless and do not take care for the earth?" Our beginning idea was people are careless and they do not take care of the earth because they think if they litter or use harmful chemicals it won't affect the environment. But what we saw when another group did their testing, I saw that when people use harmful chemicals those chemicals get into the ocean and it affects the ocean. Then when we saw another group do their testing they used Kool-Aid as the chemicals then they used a spray bottle and spray water to make it look like a rain storm and when they did that the chemicals got washed away from the rain storm. So we learned that if you used harmful chemicals you could be hurting the environment. So don't use harmful chemicals.

Figure 24. Science written reflection of Amelia about human-caused environmental change.

In Amelia's writing reflection after e negotiation, she illustrated an increase in the understanding of complex concepts such as human impact on the environment and the learning of new vocabulary. In this sample Amelia shows concern about how humans change the environment in many ways. Based on her observation from other groups' demonstrations she emphasized how the use of excess chemical discharge into the waste water system in the end affects the oceans. In this writing sample Amelia also shows a clear order of ideas and interpretation of questions, beginning ideas, observations, reasoning, and conceptual development.

As seen in the examples above through writing reflection, Amelia was able to enhance her memory since she was able to remember and explained in her own words how people can take care of the environment. As seen in the previous examples, writing was also an excellent tool used in the classroom to promote Amelia's confidence in her writing and in her science practices. She included in her reflection an explanation based on observations. "They do not take care of the earth because they think if they litter or use harmful chemicals it won't affect the environment. But what we saw when another group did their testing, I saw that when people use harmful chemicals those chemicals get into the ocean and it affects the ocean." Amelia in her reflection also included the science practice of obtaining and evaluating data. "So we learned that if you used harmful chemicals you could be hurting the environment. So don't use harmful chemicals." Finally, for the practice of communicating information she was able to articulate a writing reflection taking into account that the audience in the case of the reflection was Mrs. Smith.

The writing reflection task was another opportunity for these students to become scientifically literate, not only by getting the learning the concept as Amelia obtained but also learning how science is developed. Through involvement in the activities of writing

Amelia was able to evaluate information and communicate her thoughts on current environmental issues which have an impact on her thinking (Holliday, Yore, & Alverman, 1994).

Explicit instruction about question-claim-evidence facilitated science practices. During the first lesson in fifth grade about environments, Mrs. Smith explained how the students would learn science and become familiar with terms such as questions, claim, evidence, and negotiations. The environment lesson was the first unit for fifth graders in which they had several activities. Mrs. Smith explained to the students that they were going to do science based on the big idea of environments. She explained that the way they would do science was the same way they did last year (some of these students previously had a teacher who was trained in the approach of the SWH. She asked the students if they remembered the terms "questions," "claim," and "evidence." She continued by saying that they would start the science activity with the question: "How does an animal's habitat affect the animal?" Mrs. Smith started the science class in exploring students' prior knowledge by asking students to write what the word habitat meant to them. Many students came up with some ideas such as "habitat is how animal lives," "the shelter," "they use it to protect themselves," and "how it affects the animal?"

After exploring students' ideas about habitats, the teacher continued asking questions to the students to explore their background knowledge. The teacher asked the students to make a list of everything that they knew about animals and their habitats. For example, Armando was working with two other students. His first question was "Okay, so number one is how they live" (Ar.Ob.09082011.MOVO13.04:35). In addition, Armando was interested in knowing about animal reproduction: “Where they have their babies” (Ar.Ob.09082011.MOVO13.04:35). So he insisted on exploring ideas about animal reproduction: “I don’t know, maybe where the bird has her own babies” (Ar.Ob.09082011.MOVO13.04:35).

Mrs. Smith also explained to the students that they could use evidence to support their claims by consulting different sources that would work as expert sources.

> And we want to think about what pieces of expert evidence can we find that prove that we’re on the right track? Or maybe we find something that proves you’re 100% wrong. So we have lots and lots of types of experts that we’ll bring in throughout the year. Sometimes we’ll use live video streaming from the internet, or sometimes we might find somebody to Skype, or sometimes we might find somebody to bring in. This time, we’re going to start with books. (Ar.Ob.09082011.MOVO13.01:00)

For the first section, the teacher explained and reviewed the process of doing science through the science writing heuristic and the importance of making claim and evidence. She emphasized the negotiation part where students have to present and expose their ideas, questions, claim, and evidence. “So that’s what we’re looking for. And then our last final job is to decide do we agree with what they’re saying and do we accept it to be true based on what we know and what we’ve learned of their evidence and all of that stuff” (Ar.Ob.09082011.MOVO35.01:00).

For Amelia, Armando, and the rest of their classmates, Mrs. Smith’s explanation of the science approach was useful. In particular, for Armando and Amelia, this was easy because they were familiar with learning science in that way. When they were in fourth grade, their science teacher taught using the same approach. In addition, after each explanation of the phases of this approach students paid attention to the teacher, what they were doing, and answering what the teacher was explaining. There was an easy transition between science activities using this approach. Mrs. Smith spent the class time making sure students were ready to go through the whole process and creating and promoting an environment where students felt comfortable participating and asking questions. Students showed great interest in each phase and Mrs. Smith made clarifications any time students needed them. For example in the excerpt below Armando had a question. Mrs. Smith was ready to answer each student's questions.

Mrs. Smith	Yes sir?
Armando	What does that mean?
Mrs. Smith	What that means is that you're going to take a sentence or two from the book that proves that you're right. So what are you seeing in this book that proves you're right? What did you see in this book that you're like "Oh, that's what we were talking about?"
Armando	Like…
Mrs. Smith	Where are you talking about, which one?
Armando	This. (Ar.Ob.10042011.MOVO31.13:43).

Mrs. Smith provided explicit instruction to the students in every lesson especially in the first lesson of the year. In a systematic way by having students involved in the explanation of the science heuristic approach, the explicit explanation provided clear guidelines to identify what students needed to do before starting the laboratory activities and the negotiation process. As was shown in the previous theme, students were able to identify key concepts, strategies, skills, and opportunities to get involved in the science practices.

Whole group negotiation impacted students' communication of information more than small group negotiation. In most of the lessons observed in this study, students conducted their negotiations process as whole groups. In a whole group dynamic students present their finding group by group to the rest of the class. The audience is very active and respectful. Student wait for their turn to ask questions which can be to clarify concepts, to challenge ideas and to provide feedback to praise students for their excellent contribution or to ask to improve their concepts. Most of the time students guided this stage of the approach and the teacher made few interventions. The example below shows how students were participating in a whole class discussion.

Armando and his group were presenting about the lesson on human-changed environment. The question was "How can you help by not destroying animal shelters?" For their claim they had "you can help by not destroying animals' homes and by not putting anything bad in the lake." The evidence that they presented included: "We saw them drain the chemicals and take out tractors to help animals survive. They also planted trees and grass and then plugged the sewer pipes that lead into the river." They also reinforced this evidence using information from books: "When we consulted the experts we found these pieces of evidence. Water wasted in hotels, and bad pollution of coastal waters and lakes close to visitor attractions. Driving your car can affect polar bears and coral reefs. Burning fuels such as greenhouse gases, which are the main causes of global warming." After the group finished this presentation the class had the following discussion:

Matt	Well you guys said that when you drive cars that's going to harm the animals, then how do you expect people to help that?
Pamela	To like help it? Like, probably if you have oil spilling out, probably get an oil change because it's probably done once a month or something. Did you have your hand up?
Ricky	How do your claim and evidence match?
Mary	Because like, putting anything bad means like pollution in the water, so what we, like most of this stuff is about fuel and pollution in the water.
Ricky	So do you guys believe your claim?
Mary	Yes.
Ricky	And evidence matched up? And why?
Pamela	Yes because like we, when we saw the pollution we saw lots of things that were bad, so that was kind of like.
Mrs. Smith	Any other questions for them? Do you think their claim and evidence made sense? Do you think they have enough evidence to support their claim? So thinking about that, so how many of you think, what Kyle? (Ar.Ob.11152011.MOVO37.03:15)

As is seen in the example of whole class discussion or negotiation, students from the audience were very active in asking questions for clarification of ideas and reiteration of question, claim, and evidence. The audience was curious about the presenters' awareness of their own impact on the environment. They even asked the presenters to speculate about people causing global warming and how they can help to prevent response to that phenomena. In addition, presenters were able to defend their ideas and answer every single question with their best effort.

In contrast, the dynamic of negotiation appeared to change when small groups were utilized for negotiation instead of whole class discussion. For example, Mrs. Smith decided to do something different in designing opportunities for negotiation. For the last lesson in which Armando participated, she decided to make the negotiation process in small groups. For the unit of sound each member of the original group was reorganized. So the members of Armando's original team of three were relocated in different groups. The teacher divided the class in three big subgroups, each of them with eight students. The negotiation part this time was different in this way; instead of having a presentation in front of the whole group, each subgroup would discuss their findings, claims, and evidence.

Each group was located in a different part of the classroom. Students were seated in their chairs making a circle. The idea in this new strategy was that the teacher was trying to have student-student discussions and more participation. Students were able to work alone and organize whose turn it was, but still some behavior issues persisted. In Armando's group there was a boy that was not doing the required task. The rule was that each student has their turn to talk, present their claim and evidence, and ask to the group if they agree or disagree. The teacher approached each group to guide or prompt some questions and Armando and the students in the group listened carefully. In doing this approach of negotiation, students were able to work by themselves although the teacher was checking what they were doing. For example, Mrs. Smith approached Armando's group and directly asked him if he agreed or disagreed. Armando provided his answer to agree with one of his team member's claim by saying:

Mrs. Smith	So Armando, what did you think?
Armando	I agree.
Mrs. Smith	How come you agree?
Armando	Because all of their stuff matched together with their claim. (Ar.Ob.04132012.MOVO57.13:56)

For this part Armando showed a little discomfort with the fact that he had to present but after a few seconds he started his presentation to the group. The communication part is not Armando's favorite aspect of inquiry and he has explained that during the first lesson it was uncomfortable, but over the time after having the sound lesson he felt more confident:

> Because the early one [habitats] you have to sit in front of the whole class in your group and that was like… it was hard for the other kids because everybody was watching them and in this group this time it was better because it was not the whole class just a couple of kids watching and hearing. (Ar.In.04232012.3:00)

In the small group discussion, students have more opportunities to understand the science practice mainly in the aspects of using evidence to develop reasonable explanations and communicate scientific information to demonstrate understanding of the core ideas. For the first aspect aforementioned Armando and his team revised their data to elaborate the claim that "we heard lots of vibrations and those vibrations are usually in every sound" (Ar.Ob.04132012.MOVO57.13:56). Armando and his group also had a strategy to get to the point of elaborating a claim and understanding what it means. "By putting our observations of what we did, and our test, and our beginning idea together (Ar.In.02022012.03:00) […] and claim is like, like if you're doing something, then, first you have to get stuff from something, and your claim is the answer for it" (Ar.In.02022012:07:43).

At this stage of working in the unit of energy, specifically in the sound lesson Armando showed an understanding of what makes evidence in science work: he made some reasoning from his data and also integrated theoretical components.

> Armando — Some sound waves sometimes become thermal energy. Sound can be heard as vibrations when we tested everything. Sound has mostly vibrations in it. When we hit the tuning forks on a table, it vibrated. When it hit the yardsticks on everything that we could, we felt vibration. And when we put the stethoscope in water, we heard nothing. (Ar.Ob.04132012.MOVO57.13:56)

Moreover, Armando shows good sense about how data can or cannot be evidence to support his claim. He explained that he found several pieces of evidence for this lesson about sound but not all of them answered their question:

> Armando — Um, like. Oh. Like, all this right here. There was still more but we couldn't really fit it, so we just used kind of half. (Ar.In.04192012.11:06)

For the second aspect of understanding inquiry practices in which students communicate their ideas to each other, the small group approach worked differently compared to other lessons that were communicated in front of the whole class. In this case so much freedom made them elaborate less about their questions to the person who presented, including less debate to agree or disagree among them, less peer feedback of giving positive insight or constructive criticism about changing the question, and less elaborating on better claims and evidence. When Armando finished his presentation to his small group it was time for the negotiations and students started saying that they agreed with what Armando presented about sound and the reason was "his evidence matched his claim." They did not elaborate in what ways the claim matched the evidence, or challenged with more questions the information that he presented.

Emily	Do you agree or disagree with Armando? With Armando, not your packet. Do you agree with Armando or disagree?
Phillip	I agree.
Emily	Explain why you agree.
Philip	Because his evidence matches his claim.
Emily	Okay, do you agree or disagree? Daryl, do you agree or disagree? Do you agree?
Daniel	Yes.
Emily	Then explain why you agree.
Daniel	I disagree. Psych.
Emily	Why?
Daniel	I think it matches.
Armando	What?
Emily	What matches what? (Ar.Ob.04132012.MOVO57.13:49)

When it was the turn of the other student to present Armando did the same. He did not elaborate in his agreement or delve into the ideas that were presented for the other students in the small group. For example one of the students that I named Simone completed her presentation of claim and evidence. As usual students limited their answers to say "I agree because your evidence matches your claim" or as Armando said "you have a lot of writing." Simone was not satisfied with that answer and encouraged Armando to elaborate and be specific in his answer:

Simone	We believe our claim was proven because the experiments that we did showed that the sound moved through objects.
Armando	Okay.
Simone	Okay, you go second. And Armando.
Armando	What?
Simone	Talk about it, do you agree or disagree?
Armando	I agree.
Simone	Why?
Armando	Because it had a lot of writing and that's it.
Simone	No, pick something specific in my writing, something that I mentioned. (Ar.Ob.04132012.MOVO58.14:49)

They remained in the discussion about whose turn was next because Armando did not want to have the responsibility to elaborate on more ideas and neither did the other students:

Sandra	It's his turn and then him.

Armando	What about him, he hasn't talked?
Sandra	Yeah, it's going to be you, you, you, and then me.
Phillip	What about Tracy?
Sandra	And then them.
Brandon	Oh, I forgot about them two.
Armando	Yeah.
Simone	So say what.
Armando	I agree because, huh?
Simone	Okay, why do you agree?
Armando	Because, wait.
Simone	Come on.
Armando	I forgot. (Ar.Ob.04132012.MOVO58.14:49)

Simone and Sandra asked several students to provide feedback but they kept saying the same things and Simone was putting more pressure on them to hear more ideas related to what she presented.

Simone	Okay, Dylan.
Dylan	I agree because she had good details.
Simone	Like what?
Dylan	Huh?
Sandra	Like what, this whole thing? What?
Dylan	What?
Sandra	Okay, what? What did he say?

Dylan	I think you had good details in your claim and evidence.
Armando	Why does everybody keep saying 'claim and evidence'? (Ar.Ob.04132012.MOVO58.14:49)

After this conversation Sandra said that it was Phillip's turn to provide some feedback and say if he agreed or disagreed. Although Armando did not provide a good reason to say why he agreed with Simone he was also putting pressure on Philip. Simone really wanted to know on what specific evidence and concepts the other students agreed with her.

Sandra	Okay, and now it's Philip's turn.
Armando	Oh boy.
Phillip	I agree because you have a lot of evidence to match your claim.
Armando	What?
Simone	What evidence, what kind?
Simone	Give specific details.
Simone	Which one?
Philip	Like, um.
Sandra	Just say something. (Ar.Ob.04132012.MOVO58.17:51)

Although Armando and the students communicated and presented their findings in a good environment of listening to each other it was not the same type of responses observed as when they were part of the larger audience. Students had good information to discuss and negotiate among them but since they were provided a lot of freedom to conduct this part of the process as an independent group section they were not ready to assume this level without teacher supervision for the entire time. They just wanted to finish quickly. In general, there was not efficient feedback of supporting or asking for more improvement from the audience. Most of the students from Armando's negotiation group limited their feedback to say common things such as "I agree or disagree with you because his/her evidence match his/her claim," "he has a lot evidence to back up his claim," "because he has a lot writing," "I agree because he has good details," and "your evidence matches your claim." Only two students elaborated more in their feedback and in that moment Mrs. Smith was watching the group:

Meriam	Oh. I agree because I think that your observations matched your claim.
Armando	But how?
Meriam	Like when you said, I mean, when you took the tuning fork and you put it in the water and you saw that it like vibrated, like splashing. That matched your claim.
Sandra	Oh, and one thing I forgot to say is, I don't know, when you hit it hard on a desk and you wait for it to be still, and then you put it in the water you can see it doesn't splash everywhere.
Meriam	It depends on how hard you hit it.
Sandra	And if you hit it hard it splashes everywhere. (Ar.Ob.04132012.MOVO59.02:08)

At the end there was more pressure for some students asking the others to elaborate better in their responses like Armando that paradoxically did not provide enough feedback to their peers.

Comparing and contrasting the two classroom organizations for negotiation of meaning, it seems that the two had a lot of benefits for providing students learning and gaining communication skills and confidence. However, students might need more experience and maturity to do small class discussions to not lose the feedback part that is an important practice in the scientific community which was seen in several examples of whole class discussion.

Impact of Negotiation Process on their Understanding of Argumentative Components

The negotiation process is the segment of this argument-based inquiry approach in which students discussed their arguments. The role of the teacher was to scaffold students with questions to generate more discussion and also provide feedback to students. In this stage the teacher's voice is heard less. Students are the start of this section with their roles as presenter or as part of an active audience who listens carefully and provides feedback on the concepts, structure, or information presented. Students from the audience agree or disagree with the presenters and from that feedback both parts get an additional opportunity to change and reinforce conceptual understanding and understanding the process of argument.

From this aspect two themes emerge: first, working in groups promoted students' understanding of argumentative components. Second, providing time for group debriefing after a presentation contributed to students' understanding of the argumentative components. These themes are explained in the next sections.

Working in groups promoted their understanding of argumentative components. Despite the few lessons observed, in Amelia's case, the analysis from the data suggested that she was one of the Hispanic students that benefitted the most in her science learning while participating in learning science in an argument-based inquiry approach. Amelia's understanding of the argumentative components was consistent in the two lessons observed. Based on the rubric of understanding the argumentative components, Amelia gained significant learning about this science core element. For the two lessons Amelia worked in groups. For the first lesson about animal habitats, she worked in a group of two and for the second lesson about human impacts on the environment, she worked in a group of four. In both lessons, the members of the group were different and Amelia always had the same commitment and responsibility to learn the lesson and complete her work.

In particular, Amelia showed significant growth in creating questions, claims, and evidence for her scientific investigations, and understanding the relationship among those components. For example, for lesson one, in Amelia's presentation, the three core ideas of argumentation were presented. The question to all of the students was the same: "What animal made this object and what does its food web look like?" This question was testable since students could use accessible material and work in the classroom. The claim for this question was valid since Amelia and her partner were able to answer the research question clearly with "Our claim is an owl made this. The food web of owls is voles, mice and other small animals." Amelia's evidence was reliable since she included observations from the experimental part, prior knowledge since she explained that she had previously seen an owl pellet, and pieces of evidence that they found in several books.

There were causal coherent connections among questions, claim, and evidence since Amelia was able to answer the question plausibly. The claim was supported by evidence and the evidence was created from experimental data and searching for information from expert resources. For the third core idea Amelia was able to present her explanation in a clear way. She explained the process of coming up with the idea of knowing the animal that made the pellet and how to infer its food web. She was able to include observable and unobservable events using ideas from books and explanations from the expert speaker who was in her class. For the fourth core idea about the level of rhetoric and reasoning, Amelia provided her reasoning explicity using the data collected and her prior knowledge from past experience, and she connected those ideas by interpreting evidence from expert sources.

For the second lesson about environment, in the negotiation process of the lesson, the core ideas of argumentation were presented. For this inquiry activity, students were free to select among several questions that they generated through KWL. In Amelia's group they decide to explore the question "In what way can people take care of the earth?" They conducted an experiment to answer this question in the classroom using materials that were accessible and safe. For example, in Amelia's group they used dirt, grass, school buildings, trees, hot cocoa, Kool-Aid, and water. The claim that they presented was "people can clean the earth and try to block things off, stop littering and turn off power when people aren't using it" (Am. Doc. Page 5). This is a valid claim that clearly answers the research question. The evidence for supporting the claim was reliable and based on the students' observations, reasoning, and information from experts.

Amelia's group presented several lines of evidence, one of which was "if farmers live near rivers and they put chemicals on the farm and they water them, chemicals getting in the river." Second, "because people do try to put up stuff to keep from having nasty chemicals go into the water and oceans." Third, "people breathe in carbon dioxide and if people cut down trees won't be any more air." Finally, "some experts believe that GM food will reduce the amount of chemicals used in farming and limit risk of pollution to water supplies." So students presented reliable evidence to support their claim about what people can do to maintain the environment. The three core elements of argument show in Amelia's case that she and her group members created causal connections among them since they are able to present a plausible claim that is supported by evidence from students' observations or data.

In Amelia's group for the argumentation process, they were able to present the scientific information clearly to the rest of the students in the class. Amelia and her group presented a clear explanation about how people contaminate the environment and how they can take care of it to stop the contamination. They presented several examples of contamination from their description; for example, while observing groups 1 and 2 they observed and recorded:

> Group 1: We saw chemicals in the water and they were flooding the earth. Also they were tearing down trees, grass, and buildings and wrecking the earth.
>
> Group 2: We saw chemicals in the water and litter everywhere. They also destroyed the trees and then they added new water they pick up the litter and they took out the cars to save oil. (Am. Doc. Page 6)

In addition, students were able to connect that explanation with theoretical components by using science concepts from expert resources. For the last criteria, Amelia and her group were able to present their reasoning interpretatively from their observation of the demonstrations of the teacher and other groups that were working on the lesson. Amelia and her group interpreted the significance of their data and communicated the message of "humans affect the environment by littering and cutting trees down." Working in groups to explore scientific investigations gave these students the opportunity of having significant conversations that scaffold the big ideas of the lesson and significant growth of understanding the elements of argumentation.

Providing time for group debriefing after a presentation contributed to students' understanding of the argumentative components. After every group in the class finished their presentation Mrs. Smith asked students to sit together in their groups and do some reflection about what went well and what they still needed to work on. She also asked them to write about whether the class agreed or disagreed. So Armando's group had a conversation in which some of them said that the audience agreed because their evidence matched their claim:

Rebecca	Okay, let's think this through. We think they agreed because?
Jennifer	They agreed because they said our evidence matched our claims. (Ar.Ob.11082011.MOVO37.02:15)

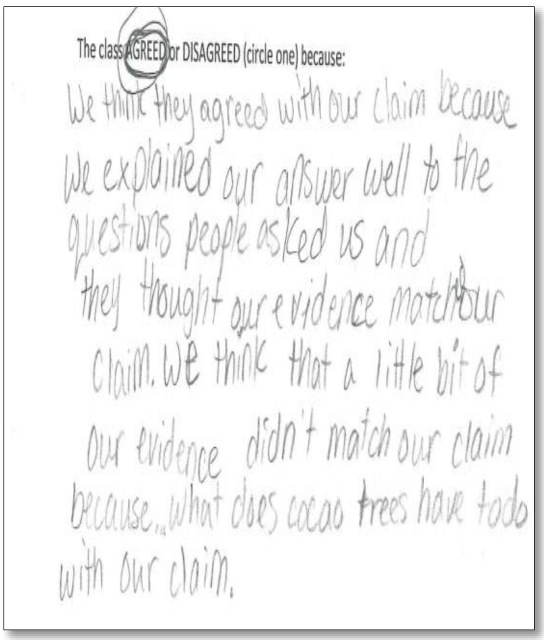
They continued talking and Armando took part in the conversation:

Armando	Okay, so we explained our answers to the questions people asked us.
Rebecca	Explained our answers well and…
Jennifer	Um, that's okay. (Ar.Ob.11082011.MOVO37.03:15)

After re-reading their papers they found what pieces they needed to work more on about their claim and evidence. In this part of the reflection Armando was participating and giving opinions. During this time the group was aware of having information that did not help in the process of claim and evidence.

Rebecca	What do you think we didn't do well?
Armando	What we didn't?
Rebecca	Actually I think a little bit of our evidence didn't match, like the trees.
Armando	How like the cocoa trees?
Rebecca	Because, read our claim, it's about lakes and rivers.
Jennifer	Excuse me.
Armando	Oh yeah, what does cocoa trees have to do with lakes and rivers? (Ar.Ob.11082011.MOVO37.06:15)

The opportunity for these students to talk in the small group to debrief and evaluate their experience allowed them to continue refining and extending their understanding of the argumentative component that was communicated to the whole group. By doing this activity the teacher was challenging students to enhance their learning (Knapp, 1992) to see by themselves if the claim answered the guiding question, and if the evidence was strong enough to support the claim. In addition students had another opportunity to socially interact, listen to each other, and write a reflection based on the discussion from the debriefing time. After Armando and his group reflected on the ideas of human-changed environments they came to an agreement and expressed in their writing, shown in Figure 25.


The class AGREED or DISAGREED (circle one) because:
We think they agreed with our claim because
We explained our answer well to the
questions people asked us and
they thought our evidence match our
claim. We think that a little bit of
Our evidence didn't match our claim
because...what does cocao trees have todo
with our claim.

The class agreed or disagreed (circle one) because:

We think they agreed with **our claim** because we explained our answer well to the **questions** people asked us and they thought our **evidence** matched our claim. We think that a little bit of our **evidence didn't match our claim** because what does cocoa trees have to do with our claim.

Figure 25. Armando's group writing sample after group debriefing about how humans change environments.

The debriefing time was another opportunity to strengthen students' collaborative work either for confirming good work on their ideas or detecting problems in their scientific investigation. For example, for confirming their good work they indicated in their writing sample that the whole class agreed with their findings and negotiations because they were able to answer the question. More specifically, they created a claim that answered the research question. Armando's group research question was "How can you help by not destroying animal shelters?" The claim for this question was "our claim is you can help by not destroying animals' homes and by not putting anything bad in the lake." In effect Armando and his group included the element of argument, and they also responded to the question in a specific manner focused specifically on animals that live in lakes.

On detecting problems in their scientific investigation, students were able to distinguish that although they had several pieces of information from the book to strengthen their evidence, not all of them were suitable for achieving that goal. Students' evidence was "we saw them drain the chemicals and take out tractors to help animals survive. They also planted trees and grass and then plugged the sewer pipes that lead into the river." Students included information from books as theoretical components against which to compare claim and evidence. Hence, students showed to have a reasonable judgment to choose information accordingly to be used in their scientific investigation. For example they found: 1) Water wasted in hotels, and bad pollution of coastal waters and lakes close to visitor attractions. 2) Driving your car can affect polar bears and coral reefs. 3) Burning fuels such as greenhouse gases, which are the main causes of global warming. 4) Coal is an important fuel for humans but mining it can destroy natural areas. 5) The tropical forest was replaced by cocoa trees to make chocolate. (Ar.Ob.02212012.MOVO4E.08:53). So from this example they indicated that among the information that they collected from reading books there was a piece of information that was not related with the question nor with the claim: "The tropical forest was replaced by cocoa trees to make chocolate." All of the members in Armando's group agreed that that piece of information would not be good evidence to support their claim because, as they indicated, there was not any connection between that information and the claim.

The nature of group debriefing was an opportunity for Armando to develop metacognitive skills through conversations in small groups and writing reflection based on those conversations. Through group debriefing students were able to think about their own thinking of questions, claim, and evidence by specifically making connections between claim, evidence, and information from the text. Encouraging students to get involved in group debriefing is one way to improve their sense of learning control and confidence of their understanding in argumentative components.

In summary, negotiation process impacted these Hispanic students' science learning in several ways. Their performance in each science area reflects the benefit of learning through this approach but also taking in account several factors that were present since the first lesson. The nature of dialogue between students and the teacher was essential to these students to make sense of the concepts that they were exploring, science practice, and argumentative components. In addition, the nature of the classroom dynamic toward student-centered learning allowed these students to explore their ideas and be responsible for their own learning. The teacher role was important to achieve these outcomes since she was scaffolding students with questions, negotiating ideas with students, and providing them with opportunities to use learning tools such as writing activities and inviting a guest speaker to present about science to the school. The summary of this section is represented in Figure 26.

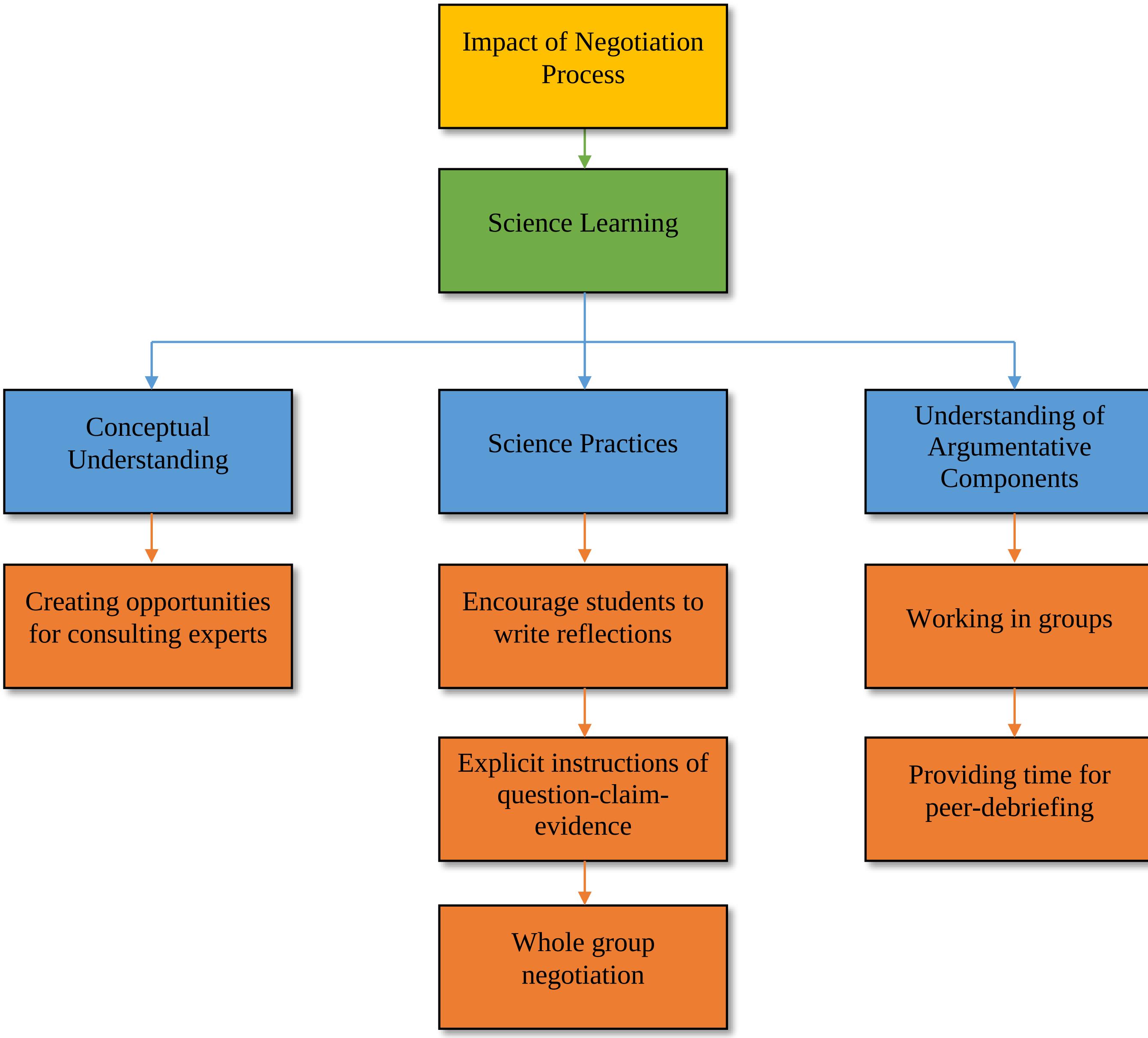


Figure 26. Summary of main findings for impact of negotiation process on student science learning.

Challenges for These Hispanic Students while Engaging in an Argument-Based Inquiry Classroom

Classroom observations, interviews, researcher's field notes, and writing samples provided a big picture of these students' learning of science while engaged in the Science Writing Heuristic. In addition, these sources provided information on the individual journeys of these students through the course of their participation in this particular approach. As the results of this study indicated, the SWH approach provided opportunities to these Hispanic students develop conceptual ideas and make learning gains in science practice and argumentative components. Because this study sought to understand in what ways Hispanic students learn science while engaging in an argument-based inquiry, several challenges related to the core element of the approach and systemic challenges regarding its implementation emerged. The findings suggest that there are particular challenges for each of the students who participated in this study. Some of the challenges were related to the elements that constitute this argument-based inquiry approach, such as having difficulties in identifying the difference between evidence and data. Other challenges were associated with their lack of language confidence when it was time for writing. Another set of challenges was related to teacher decisions in the classroom and school administration.

Confusion between Data and Evidence

Argumentation is a core component of the scientific knowledge development and science practices. However; it is a practice that does not often occur in the science classroom (Weiss, Pasley, Smith, Banilower, & Heck, 2003) and when the practice happens several struggles occur when creating claims based on tests and making connections and differentiation between data and evidence (Hand, Norton-Meir, Staker, & Bintz, 2009). Consistent with what researchers have indicated, the results of this study showed that students were not clear about the nature of evidence and data. Some examples of this challenge were faced by Armando and Amelia in their group when they were working on the lesson of magnets, environment, and sound (Armando) and animals' habitats (Amelia). This situation happened during their analysis of data to make the claim and develop the evidence. In the dialogue below Armando and his group discussed their claim and found out that magnets cannot stick to other materials that are not metal. The information as evidence that students provided showed their confusion about how to differentiate between them. Students talked about having some testing done but did not develop any connection of those observables events and their reasoning to better answer the question of how magnets work.

Ally	Okay, how do I know to support the claim with?
Armando	That's all?
Amanda	Well we know that it can't…
Ally	What is that?
Armando	It can't?

Ally	Okay, here's our claim. We find that magnets can't stick to anything other than metal. And then evidence that we know this because we tried it.
Amanda	Because we had testing things done. (Ar.Ob.02092012.MOVO4A.04:28)

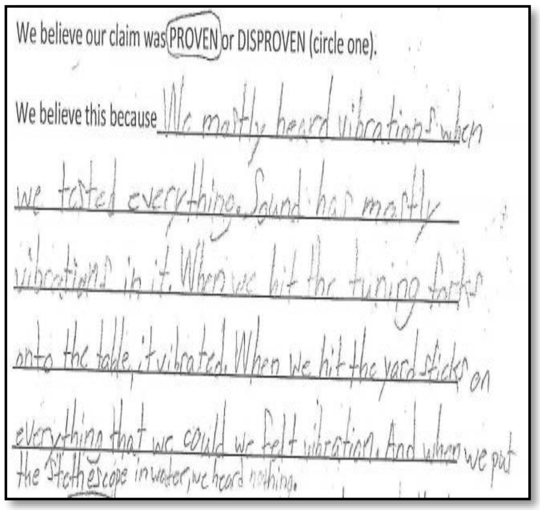
Although students collected numerous observations of magnets during their testing such as "it sticks to the clip up chart pins," "it sticks to some of the trophy," "it sticks to the bottom of the chair," and "it did not stick to pencils," they did not take into account how to use that information to build the story from the data. In addition to this struggle, sometimes students included information as evidence from books that did not contribute to reinforce the claim. For example, in their human-changed environment lesson their claim was "you can help by not destroying animals' homes and by not putting anything bad in the lake." They mentioned several pieces of information that supported the claim, but also part of their evidence was "the tropical forest was replaced by cocoa trees to make chocolate." This example pointed out that students did not make any logical reasoning that associated that information with the claim. However, through dialogue and group debriefing Armando and his group were able to identify this piece of information as not significant for their investigation.

This confusion about data and evidence persisted for the subsequent lessons. When students were completing the SWH template, which is a guide divided by sections for students to include beginning ideas, testing, observation, claim, evidence, reading, and reflection, they also struggled to decide in what section to put the evidence:

Armando	I thought we put the evidence right here.
Travis	Do we put this here? I mean, are we supposed to write this right here, our data where "We believe this because…"? [Beginning ideas section of the template]
Armando	Aw man, I thought the evidence, now I put the evidence right there. Look.
Travis	The evidence is really supposed to go there.
Armando	Then what's this?
Travis	The data. Wait. The data goes right, yeah, you got it two times. [Armando put data in both the data section and the evidence section]
Armando	Yeah. I know, I'm going to erase the front one.
Martha	No, no, no. You can write the evidence there and write evidence right here.
Mrs. Smith	Alright. What about you?
Travis	I'm writing my evidence. I mean, I'm writing my data. (Ar.Ob.04122012.MOVO55.15:00)

In the dialogue above students were able to collect data in the form of observations to evaluate the nature of sound in different mediums. From this experiment students had more chances to gather more data since there were four stations to test the characteristics of sound. Therefore, students had more options to examine more data and potentially turn it into evidence. As is reflected in the conversation students were organizing their science package by placing the information in the corresponding section. Armando and the other students in the group were unsure of what information corresponded to data and evidence, so they wrote it twice on the paper. At that stage for students writing evidence was the same as writing data as is shown the example.

However, after Armando wrote his reflection he was able to make the connection as shown in Figure 27.


We believe our claim was PROVEN or DISPROVEN (circle one).

We believe this because We mostly heard vibrations when we tested everything. Sound has mostly vibrations in it. When we hit the tuning forks onto the table, it vibrated. When we hit the yard sticks on everything that we could we felt vibration. And when we put the stethescope in water, we heard nothing.

We believe our claim was proven. We believe this because we mostly heard vibration when we tested everything. Sound has mostly vibrations in it. When we hit the turning forks onto the table it vibrated. When we hit the yard sticks on everything that we could felt vibration. And when we put the stethoscope in water, we heard nothing.

Figure 27. Armando’s claim and evidence reflection about the sound lesson.

Even though Armando had the challenge of differentiating evidence and data during the data analysis and building the claim and evidence relationship, he had the opportunity to refine those ideas during the reflection as is shown in his writing sample. He was able to write and tell the story by making an interpretation of the data that showed him a specific trend, which was “in every sound there are vibrations.”

Another example of this challenge differentiating evidence and data was revealed in Amelia’s work. She clearly did not rhetorically express the confusion as Armando did in his conversation, but when she was practicing with her partner before her presentation they included observations as evidence. Amelia and her partner were able to construct a claim “Our claim is an owl made this. The food web is owls and other small animals” which answered the research question "What animal made this [owl pellet] object and what does its food web look like?" In the dialogue with her partner Amelia discussed:

Amelia	Practice again.
Callie	Our claim is an owl made this.
Amelia	The food web is owls and other small animals.
Callie	The evidence was, when we first opened it, it smelled like poop. We moved away the fur and small bones. After a while, we found a skull. It was hard to get the fur off.
Amelia	Then we uncovered a jawbone. After that, we kept finding small bones. I've seen an owl pellet before, so I know that this was an owl pellet. (Am.Ob.10062011.MOVO33.01:06)

In her evidence Amelia used only data to support her claim but without interpretation that connected it to the second idea that she had previously seen an owl pellet. Amelia did not use the data to explain that the small bones that she found corresponded to small animals that an owl possibly ate, although she had that information as part of her claim. However, in the next class after the group debriefing she was able to make the connection among her observations, prior knowledge, and the guest speaker presentation about owls.

Amelia	I think it's an owl pellet because the one that she showed was one of the ones that we took apart and found fur and skull.
Laura	It was exactly the same that was right there.

Laura	I think, because I wasn't quite sure, when she first showed the pellet, that it coughs up [static] pellet, I thought oh, maybe we were wrong, maybe it was a hawk's pellet. Then when they said it's an owl pellet, I know it was because they said it was, and when we opened it apart, hawks don't eat what owls eat. It's not the same food web.
Amelia	Yeah, and that would go in exactly like the same, the… the lady that brought the owls.
Laura	The lady?
Amelia	Yeah. The expert. And she said those are owl pellets and they look exactly like the same that we took apart. (Am.Ob.10102011.MOVO3D.09:33)

As is shown in the examples Amelia and Armando struggled with the analysis of data and creation of evidence. In Alexandra's case it might be possible to find the same challenges, but there was a limitation to obtain data in the aspect of students constructing evidence from the different lessons in which she participated. The challenge of creating evidence from data and using only data as evidence can be associated with many issues. For example, although the teacher emphasized to students to create the evidence as *telling the story* of what happened, in her practice she gave more weight to the pieces of evidence from the experts and not to those created by the students as is seen in the excerpt below:

Teacher	Okay, but then if you think about some of the **evidence that you found from your experts**, read that one that says what magnets stick to.
Mary	Only a few materials…

Teacher	Okay, hang on just one second. I want you guys to listen to this because their claim says that magnets only stick to iron, okay? So listen to what the evidence that they're going to say. Now say it really loud.
Mary	Only a few materials are attracted to magnets. They are metals, iron, cobalt, and nickel.
Teacher	So what did you guys hear? Just a second, what did you hear there? Martha?
Martha	That more than one thing sticks to magnets, so not only iron. (Ar.Ob.02212012.MOVO4C.02:52)

It might be possible that students had a rhetorical confusion about the word evidence itself that was better developed when they were asked to tell the story as was revealed in Armando writing sample and Amelia's telling the story during the group debriefing example. The confusion could also have originated when students saw that in the negotiation section the teacher asked them directly for the expert's evidence and overlooked the evidence created from student data.

Classroom Routines and Decisions

As students were involved in learning science in the context of the science writing heuristic (SWH), the analysis of data reveals external situations that represented challenges in students' participation in the learning development that is fostered by this approach. Some of these external situations were associated with teacher classroom routines and decisions regarding students' make-up of the work that they missed. The result of this study reveals that Armando experienced that challenge in particular.

Armando was involved in the entire lesson about magnets. He worked very enthusiastically but he could not attend the last part of the science lesson in which students presented their work to the whole class because he was sick. Usually, the teacher spent two 45-minute science classes to complete that task. Although the teacher had many groups present and negotiate in front of the class, she wanted to complete the activity that day, so the class could then proceed to do math and be ready for another science topic the next week.

> Mrs. Smith Magnoleum, never heard of it. How many of you think that you can accept their claim because they have enough evidence? Okay, so I'm looking around the room, so I see most of you accept their claim, so we have a second learning statement about magnets to add to our poster. Alright, let's give them a power clap, one, two, three. And we got ten minutes, so the next group can go. Well maybe we'll have time for both of them and we'll just finish it up today, that would be nice. That would help us out to get to our goal for next week. And then we'd go into other kinds of science. Okay.
>
> Mrs. Smith Alright, let's give them a power clap, one, two, three. Thank you for your five extra minutes of attention. You're going to need your math notebook. (Ar.Ob.02212012.MOVO4D.12:10)

Students started to present quickly and one of the groups who presented were the members of Armando's group. Armando did not have another day to make up the negotiation part for the lesson of magnets. Therefore, he did not have the opportunity of discussing and debating his ideas in the class and getting the skills to communicate in front of the group, which was Armando's least favorite activity in this science learning approach.

Researcher	What do you find was challenging or required more effort or work for this experiment?
Armando	The, I wasn't here for it, but last time with a different kind of experiment we did... it was the one where we had to go up and tell everybody what you wrote.
Researcher	Does everybody agree with your claim? I mean, in the small group, because you were not here for the negotiation.
Armando	Yeah. Um, yeah. (Ar.In.02232012.01:25)

Based on the analysis of the data, there was not any option for Armando to make up that class. There was no other activity that the teacher offered to him in order to take advantage of the process of negotiation. Mrs. Smith took the decision to go and complete the negotiation without Armando in his group because she had other academic plans such as continuing with the math class and moving on to another science lesson. However, teacher decisions regarding what to do and what to say in the classroom are critical and have significant and persistent effect on students' learning intentions, behavior, and academic engagement (Stefanou, Perencevich, DiCintio, & Turner, 2004). Mrs. Smith asked Armando's group to present without him and Armando lost that opportunity. Below is the field note that I captured the day that Armando did not attend the school.

> For this lesson I went to the school for collecting the last part of the science lesson that was students present and make arguments based in their question, claim and evidence in front of the whole class. Mrs. Smith told me that "Today Armando did not come because he was sick." Then I asked her if would be possible to wait for him and his group to present the

> next class. She said that the lesson needed to be done and her plan was to complete everything that day. So I decide to stay and observed the other groups especially Armando' group. Armando lost the opportunity to defend his findings and get involved in the negotiation of ideas through questioning. The teacher did not have any plan to offer a make up to Armando or look for another strategy that allows Armando to take advantage of the rich conversation that the negotiation part generates. (Field Note: 02/21/2012).

How Armando was evaluated for his participation in this activity of the negotiation process is unclear for this study. Make up policies of the school indicates that "School work missed because of absence must be made up. Students will be given two (2) days for each day missed to make up work. Make up time may not exceed six (6) school days following the student's return" (from the district's student policies). The negotiating process was a great scenario for Armando to be engaged in rich scientific discussion where he could show the hard work that his group had. Unfortunately, no other assignment could fulfill the interaction and involvement of the group, the audience challenging students' ideas, and students defending their ideas or changing their thoughts based on audience feedback.

Administrative Decisions of the School

Several teachers of Robinson School were part of the grant *Efficacy of the Science Writing Heuristic* (SWH) approach. They participated in professional development focused on students in grades 4 to 6. In Robinson School there were four fifth-grade teachers. For Fall 2011 the school administration decided that for science class in fifth grade only one teacher would teach to the other groups. Hence Mrs. Smith taught science class to all students in fifth grade. In Fall 2011, Amelia and Armando were fifth graders. Mrs. Smith was the home room teacher for Armando but not for Amelia. Thus, this administrative decision affected her particularly. She had a good experience and significant learning when Mrs. Smith taught the science class. After one semester the school made the decision that each homeroom teacher will teach their own science class. So Amelia's homeroom teacher was not Mrs. Smith and her homeroom teacher did not teach science using an argument-based inquiry approach. So she did not have the opportunity to continue learning science as argument-based inquiry in which she had good experiences and good results regarding her learning.

Amelia's teacher was new at the school and the way she taught science was teacher-centered. In this study she is named as Mrs. Thomas. She formulated questions to the students and a common practice in her classroom discourse was IRF sequence (teacher initiation-student response-teacher feedback). There were few interactions between students during her science activity for investigating magnets:

Mrs. Thomas	Are all mirrors magnetic?
Student	No.
Teacher	Only some of them? Are all mirrors made out of the same thing?
Students	Yeah.
Teacher	So are they all magnetic?
Student	Yeah.
Student	No.
Student	No.
Student	I told you.

Student	I knew it. I knew it wasn't.
Teacher	But how many of you have a mirror at home that you can put magnets on? So why do you think this one isn't magnetic? It's a real mirror. Isn't yours a real mirror at home?
Student	No.
Students	Yeah.
Teacher	So why aren't they both magnetic?
Student	Because…
Teacher	Amelia?
Amelia	Some of them are plastic.
Teacher	Some of them might be plastic, this one's not plastic. Nope, definitely not plastic. (Am.Ob.02032012.MOVO48.07:19)

In her lesson of magnets, Mrs. Thomas explored students' prior knowledge using the KWL strategy but she did not ask students to write down in their notebook and express by themselves what they knew about magnets. Instead she asked students to write on post-it notes. After students finished writing on the post-it notes the teacher collected them and read them to the whole class. In the example above Mrs. Thomas asked questions, but those questions did not generate more discussion and students only answered yes or no.

In another lesson students were studying about energy. Prior to this study this lesson teacher had some sessions of reading about energy. Mrs. Thomas' class was not inquiry-oriented, although there was a guiding question to follow and observations to record on index cards. In addition Mrs. Thomas had absolute control of what to do, where to move, or what to write. In the experiment of energy she wrote the guiding question "How to make energy." She organized eight stations with different materials. Students were assigned with numbers from one to eight and based on that number students had to move to that particular station. Students had to collect observations and experiment with what they found in the station. Amelia and her partner were group number six so they needed to move to station six. On that station Amelia and her partner did not know what to do. In contrast to this situation when Amelia was in Mrs. Smith's class she did not collect data without any testing plan. Students always had a notion of what to do. The science class with Mrs. Thomas was different and Amelia was a little lost. This situation is reflected in the example below:

Jamie	I need this.
Amelia	I have no idea. If you put this in here, I don't know what this is supposed to do, but you can just put this right here like this, and that's it. Okay, I don't know.
Jamie	Oh my god, that camera's on us. Scary.
Amelia	What, what is this and this supposed to do with it?
Jamie	I don't know.
Amelia	I know what we could put. But like, we could put a straw or something, like the straw has energy to be put.
Jamie	It still has energy, though. (Am.Ob.02212012.MOVO4B.11:00)

Students only had five minutes per station to make experiments and make observations. Students had few dialogues while working in each station. Sometimes the teacher approached each group to ask what they were doing by asking questions or suggesting answers. The excerpt below captures some of the conversations between Mrs. Thomas and Amelia's group.

Mrs. Thomas	What are we figuring out?
Amelia	That, um, the metal object has energy for the straw.
Mrs. Thomas	Okay, it has energy to hold it. What if we, is there anything else we can do with these two so we can create energy of some sort?
Jamie	You can hit that and make noise.
Mrs. Thomas	Okay, so we can make noise. Which part is making the noise?
Amelia	This part.
Mrs. Thomas	This part. So, it's called a tuning fork. Tuning fork. (Am.Ob.02212012.MOVO4B.17:46)

To indicate that students had to change stations, she used a sort of song so that students could move to a different station. Again they needed to play with the materials they found with the station and report observations on the index card. In conducting this activity, students did not have freedom to move and collect data based on their own judgment:

Mrs. Thomas	Clap once if you can hear me. Clap twice if you can hear me. Clap three times if you can hear me. Okay, I need everyone's eyes and ears on me. We're going to rotate. Like I said, you probably didn't get a whole lot of time, but there's a lot of the same station, right? So you'll get a little bit more time. Okay. Remember, station one is right here, so if you were at station eight, this is where you come. So if you were number eight, you're now going to come over to the ones. Ones, fifth grade, hold on. Ones go to twos, twos go to threes, threes go to fours, fours go to fives, and fives go to six, six goes to seven, seven goes to eight. (Am.Ob.02212012.MOVO4B.13:57)

For the last science class in Mrs. Thomas' classroom observed in this study, the activity for the science class had changed. This time students were organized in groups of five and they were reading about temperature. Since the state test was approaching, some teachers spent the science class time to practice reading about science lessons. The approach was to make students read and answer the question "What is the difference between heat and temperature?" Students could use their books to answer those questions. Students were sitting in their chairs and doing their activity very quietly. The teacher asked them to answer the questions in their own words and giving direction of "what she wanted them to do":

Mrs. Thomas	Very good. Okay. So what **I want you to do** is on your paper, **I want you to write**, **I want you to** answer that question, describe the difference between heat and temperature. Zach already told us once, we just read through and talked about it again. **Now I want you to** write it. What is the difference between heat and temperature? And you can use page 6 to help you if you need to.
Mrs. Thomas	The difference between temperature and heat.

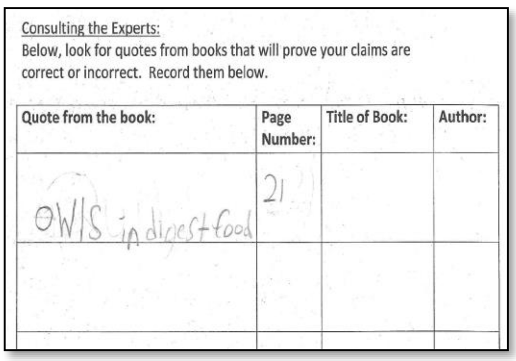
Amelia	Mrs. Thomas. Do we write down what it says in our own words?
Mrs. Thomas	In your own words. You can use some of the same words from there that works. Cate, don't hold the pencil in so hard. Okay, Brianna, are you finished? Can you read for us what you wrote? You can keep writing if you're not finished, that's okay. (Am.Ob.03222012.MOVO4F.03:22)

The above example illustrates how administrative decisions can affect students' learning opportunities. Amelia was one of the students who was actively engaged in the science writing heuristic approach. The results of this study indicate that Amelia was involved in rich dialogue where she constructed her own learning of the particular topic that they were studying. In addition, Amelia participated in a rich learning environment where she engaged in the science practices and the core elements of argumentations. In changing her science teacher Amelia experienced a different classroom with a different teaching approach as teacher-centered where students were sometimes doing hands-on activities, but without any further development of their knowledge, reading, and getting facts from the books. The practice of sciences and the element of argumentation were not observed anymore in any of the lessons observed when she was in Mrs. Thomas classroom.

Another administrative decision of the school affected Alexandra as well. Alexandra needed tutoring in math and reading, and English learning language support. She practically went through one entire semester without science class (Spring 2012). The next semester (Fall 2012), she only participated in the ELL program but still missed the first 20 minutes of the science classes that were 45 minutes in total. This situation caused her to be late and behind in the lesson which was reflected in the negotiation part when her group showed a lack of preparation in front of the class:

Alexandra	Read the evidence.
Mrs. Smith	Where's your packet at? Your science packet. Okay, we've got lots of stuff on that. No, don't, get your packet and give it to Alexandra. Do you have any expert evidence?
Alexandra	The evidence, um. Oh.
Mrs. Smith	Did you look in the books for expert evidence or no?
Alexandra	Mm-hmm.
Mrs. Smith	Okay, so what does that say?
Alexandra	I can't.
Mrs. Smith	Did you write it down, Michael?
Michael	No, we didn't get any of it written down.
Alexandra	It's right there.
Mrs. Smith	Okay, so let Alexandra read some.
Alexandra	I just, since I left I just did, well, from the point that we did, what we found on page 21 of one of the books, I don't remember the title, that the animals in, what's that?
Michael	I think that's what that is, you told me to write it down. (Al.Ob.10162012.MOVO5E.02:51)

Alexandra only worked in science class for 20 to 25 minutes and she was not able to capture all the ideas of being part of a science class. Because she participated in only half of science time period during laboratory activities it was not possible to capture the science concepts, the science practice, and the understanding of the elements of argumentation. As reflected in the excerpt above Alexandra and her partner did not formulate their claim and evidence and record them in their science package. Even though they had the chance of consulting the experts they did not record any of that information. Alexandra had to leave the classroom and asked her partner to write the information that she found about owls in one of the books that she read. Alexandra tried to write but she did not feel confident in writing activities. Figure 28 below shows that she tried to write but they did not continue their searching in the books.


Consulting the Experts:
Below, look for quotes from books that will prove your claims are correct or incorrect. Record them below.

Quote from the book:	Page Number:	Title of Book:	Author:
OWlS indigest food	21		

Quote from the book	Page number	Title of the book	Author
Owls indigest food…	21		

Figure 28. Alexandra’s consulting the experts section from her science package.

Alexandra was enrolled in math and reading tutoring and the ELL (English Language Learners) program in the school which was positive to help her in those areas. However, the time to provide this kind of support sacrificed her science learning time. She came back to science very enthusiastic and willing to work, but that was not enough to recover all the ideas that she missed during the first 20 minutes of the class every day. Moreover, Mrs. Smith did not take the time to briefly summarize what Alexandra missed and transition into the activities that students were performing. In addition to this administrative challenge of deciding that ELL classes were at the time of science, Alexandra had to face as an English language learner student three kinds of challenges during science class: learning everyday vocabulary, connecting specific vocabulary, and the language framework of inquiry (Bresser & Fargason, 2013).

Issues Associated with Group Composition or Pairing up Students

The results of this study indicated that group work generally impacted science learning in a positive way for the Hispanic students involved in this study. The nature of learning science in an argument-based inquiry context promotes cooperative learning during laboratory work and cooperative negotiations. Therefore, pairing up students to engage in the scientific activities requires that the teacher make the best judgment to organize the teams in an efficient way that contributes to their learning. Although pairing up students in the different activities analyzed in this study went well for Armando and Amelia, it was not in the particular case of Alexandra. In addition to the challenge mentioned before, Alexandra encountered the challenge of being in a group that was not efficient for her nor for her partner.

Although Alexandra had some limitations in terms of English and being late to class by attending tutoring sessions, she was always active and eager to learn. For Alexandra working in groups was meaningful. She said that she has a lot of friends in the classroom and it was very helpful for her to work in small groups because she could ask her tablemates' questions about spelling or the meaning of something that she did not understand. She was clear that her tablemates were her first source for clarification of ideas and if they could not help she would ask the teacher. For her experience about learning science through argument-based inquiry her teacher in fourth grade asked students to make a team of two members. The same happened for her teacher in fifth grade. Regarding these two experiences sometimes she was not satisfied. She expressed that her partner was not focused on the task or not very interested. For the experiment of habitats she tried to have a serious dialogue with her partner but he did not respond as she expected:

Alexandra	I think the animal was an owl that made it. Or a bird. How about a bird?
Michael	Bird. A crocodile? Crocodile skin. It looks like it has tires on it, mini tires, like the tire pattern. Like seriously, it looks like a crocodile.
Alexandra	How do you spell bird? How do you spell, I don't want to.
Michael	A bird, just say it's a rotten egg. It looks like a rotten egg that looks all mushy and stuff.
Alexandra	Okay, you write something that includes some animals on that. Okay, so you just put an animal that looks.
Michael	A rotten egg.
Alexandra	But it has to be an animal that would make it.
Michael	I know, a rotten egg. What's two times two? (Al.Ob.09112012.MOVO56.17:54).

From the example above, Alexandra was not involved in meaningful dialogue that supported or challenged her ideas. They always were arguing about who would write, who would draw, or who would read the books. As a result there was not a flow of ideas and it seems that at some point she gave up. Even though the purpose of cooperative learning is the use of small groups of students to maximize their own and each other's learning (Johnson, D.W., Johnson, R.T., & Smith, 1991), for Alexandra's team it was not the nurturing way of getting the benefit of collaborative learning. There were several examples like this from the beginning of the laboratory activities to the end of cooperative negotiation. Therefore, adding to all of the challenges that Alexandra had, the pairing up might influence her limited science learning.

Language Issues

One important aspect of students learning science in the context of an argument-based inquiry is being involved in an approach that demands the use of language such as reading, writing, talking, and creating representations in the science classroom. The context of argument-based inquiry provides students with opportunities of including writing as a rich experience in science to become flexible and fluid in their scientific knowledge (Wallace et al., 2007).

The practice of writing was embedded while these Hispanic students were involved in learning different lessons and conducting their scientific investigations. Using the Science Heuristic template was one way to prompt all students to create questions and beginning ideas, organize testing plans, collect data, make claims and evidence from their reasoning from data, and compare their findings with other sources (Hand, 2008). From that point students were encouraged to write a reflection to compare how their ideas changed after negotiation.

Another way to encourage students in the practice of writing was to get involved in different genre writing with different purposes and audience (Wallace et al., 2007).

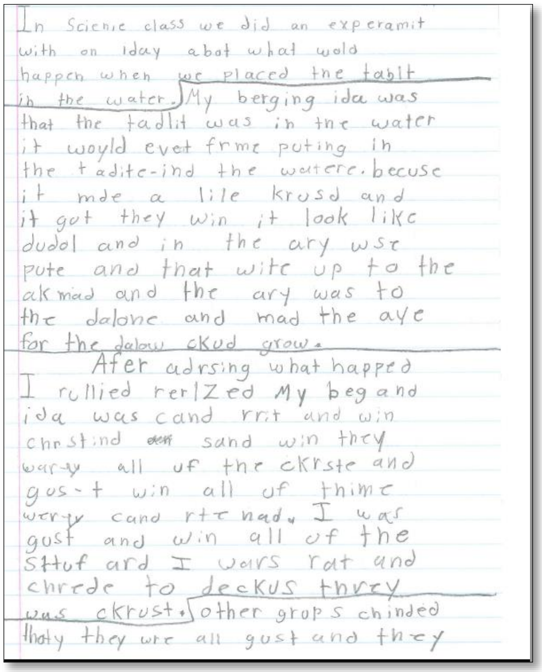
The result of this study indicated that writing was an effective learning tool to foster their scientific learning. However for Alexandra this was another challenge to face. Alexandra was a student who speaks with her peers well and loves to write when this task was individual. However, when she was working in a group she was not comfortable writing. One of the reasons for feeling uncomfortable was that she had some issues with expressing ideas while writing and mechanistic issues such as spelling, grammar, punctuation, syntax, and semantics of the language. She tried hard, but if she had the opportunity she always asked her teammate to write. Unfortunately, or fortunately for her the teammates did not like to write either so she was pushed to do it. She always double-checked the spelling with her teammate. The excerpt below show an example of asking help for spelling words:

Alexandra	Uh, the animal might be, uh. A mole. No. It might be a mole, moles are really small.
Michael	You are on [humming] KWWL. We are live.
Alexandra	Be quiet.
Michael	That'd be so funny, though.
Alexandra	Wait, how do you spell creature?
Michael	Could you erase that before you, no this, yeah? No, it has to be a specific creature.
Alexandra	I know.
Michael	But you're saying creature.
Alexandra	I know. After the creature, I'm going to write the animal.
Michael	How will we know what the creature is? You have to like, we believe it's probably a monkey or like.
Alexandra	We believe that the animal might be a, no.

Michael A monkey. (Al.Ob.09112012.MOVO56.13:36).

Another example that illustrates this issue was when Mr. Jones asked the students to write a reflection about the lesson of matter. Alexandra wrote two full pages where she told the story of what she did in her science class about the matter experiment. The analysis of the writing sample reveals that the language of science was present in terms of inclusion of scientific words such as experiment, beginning ideas, description of the observation of the experiment, and claim. She also expressed in her writing that the beginning idea of the lesson was “Things in our world can exist in different states.” In her writing she also communicated what happened to her Alka-Seltzer tablet and what happened with the experiment of the fizz inflator where the balloon expands due to gas formation.

The fact that she is willing to express her ideas by writing two full pages for her science reflection (Figure 29) suggests that the practice of writing does not represent a barrier of gaining specific science notions and structures such as the vocabulary and elements of argument-based inquiry. The way she writes is not comparable with the way she communicates orally. Several factors have been suggested to explain second language learner’s low level of competence (Borokdin & Faust, 2014).

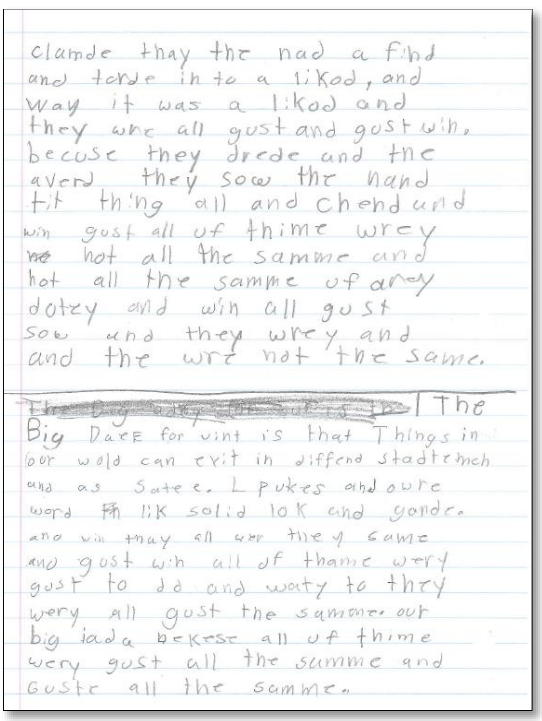


In scienie class we did an experamit with on iday abot what wold happen when we placed the tablt in the water.

My berging ida was that the tadlit was in the water it woyld evet frme puting in the tadite-ind the watere, becuse it mde a lile krusd and it got they win it look like dudol and in the ary wse pute and that wite up to the akmad and the ary was to the dalone and mad the aye for the dalow ckud grow.

Afer adrsing what happed I rullied rerlzed My beg and ida was cand rrit and win chrstind sand win they warey all uf the ckrste and gus-t win all of thime werey cand rte mad. I was gust and win all of the sttuf ard I wars rat and chrede to deckus threy was ckrust.

Other grops chinded thaty they wre all gust and they

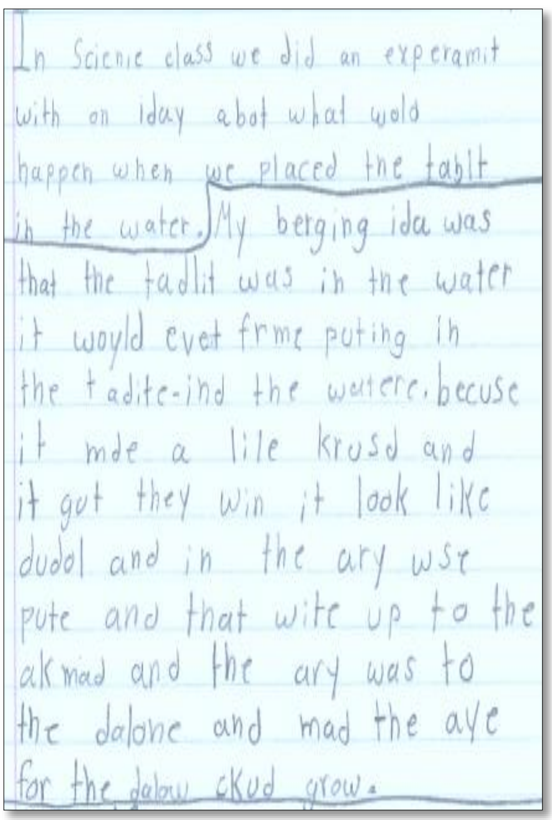


clamde thay the nad a find a torde in to a likod and and they wre all gust and gust win. becuse they drede and the averd they sow the nand tit thing all and chend und win gust all uf thime wrey not all the samme and not all the samme of arey dotey and win all gust sow and they wrey and and the wre not the same.

The Big DaeE for vint is that Things in our wold can exit in diffend stadtemeh and as satee. L pukes and owre word lik solid lok and yande. ano will thay all wer they same and gust win all of thame wery gust to dd and waty to they wery all gost the samme. our big iada bekese all uf thime wery gust all the samme and guste all the samme.

Figure 29. Alexandra's two full pages of writing sample of reflection about the lesson of matter.

The factors that researchers suggest to explain the low linguistic competence of L2 (second language) include: language anxiety, motivation, learner's style, personality traits, phonological skills and age of acquisitions (Borodkin & Faust, 2012; Giannouli & Pavlidis, 2014). Alexandra's data analysis exhibit some signs that might be related to some of those factors resulting in having difficulties in reading, low score on the state test, spelling difficulties, bizarre spelling that seldom can be identified, difficulties with vowel sounds, and difficulty processing rapid auditory inputs such as confusing consonants (b-d). Those difficulties are highlighted in Figure 30 below:


In Science class we did an experamit
with on iday abot what wold
happen when we placed the tablt
in the water. My berging ida was
that the tadlit was in the water
it woyld evet frme puting in
the tadite-ind the watere. becuse
it mde a lile krusd and
it got they win it look like
dudol and in the ary wse
pute and that wite up to the
akmad and the ary was to
the dalone and mad the aye
for the dalow ckud grow.

In science class we did an experamit [experiment] with on iday [an idea] abot [about] what wold [would] happen when we placed the tablt [tablet] in the water. My berging [beginning] ida [idea] was that the tadlit [tablet] was in the water it woyld [would] evet [even] frme [from] puting [putting] in the tadite-ind [tablet in] the watere [water] becuse [because] it made a lile [little] krusd [crust] and it got they win it look like dudol [bubbles] and in the ary [air] wse [was] pute [put] and that wite up [went up] to the akmad and the ary [air] was to the dalone [balloon] and mad [made] the aye [air] for the dalow [balloon] ckud [could] grow.

Figure 30. Alexandra's writing sample where some issues about communication were found.

The writing sample above is one section of the two pages that she wrote in her reflection of the lesson of matter. As is indicated in the transcript on the right side, several issues of spelling through the whole sample are presented, bizarre word such as "akmad," and confusion of consonants such as b-d for the words balloon and bubbles. She also omitted vowels in the words was, form, idea, about, and because. Other issues analyzed in the sample include syntax, phonology, and semantics that might affect her writing production.

Alexandra was a vibrant student who expressed in one interview that she liked to write "because it's a good exercise for your little bones inside of your fingers" (Al.In.05012012.02:18). She always was very enthusiastic and tried hard in the class, but she was not completely satisfied about the responsibilities in the group regarding the experiment. She always was arguing with her partner about taking turns and reminding him to follow the teacher's direction of "pass the pen" when there were group activities. She expressed that her partner went to sleep, meaning that he was not interested in writing and she took the responsibility of writing. Alexandra said that the tasks that they needed to do should be fair and each of the members should take turns to write. She indicated that the best way to do the writing for the science activity was "Maybe he should write one paragraph and then I write one paragraph, and then he writes one paragraph" (Al.In.10092012.07:21). So in doing science in the classroom her least favorite part was writing in the group; she questioned the purpose of writing at all if she was able to remember the information. "I do not like writing it down because why can't we just like stand up? Well, if you don’t remember, you can just write it down on a piece of paper, but because I remember I’ll just say it” (Al.In.10092012.09:05).

In summary, there were several challenges that these Hispanics students experienced while participating in the argument-based inquiry approach as way of learning science in their classroom. The challenges were particular to each student and a great portion of them were related to external situations rather than the nature and elements of this approach. For example, Armando and his group had some difficulties during laboratory activities when they were discussing what counts as evidence and data in the lesson about magnets. This issue was overcome during the section of group debriefing and writing. By the time of the last lesson of the year these issues were not seen.

The remaining challenges were extrinsic to this argument-based inquiry but clearly impacting the student participation and the course of their science learning. These challenges were related to how the school operated and how the classroom setting was designed. These external situations constraint the effective implementation of this approach and the students’ learning development as is demonstrated in this study. Figure 31 shows a summary of the challenges that these students encounter.

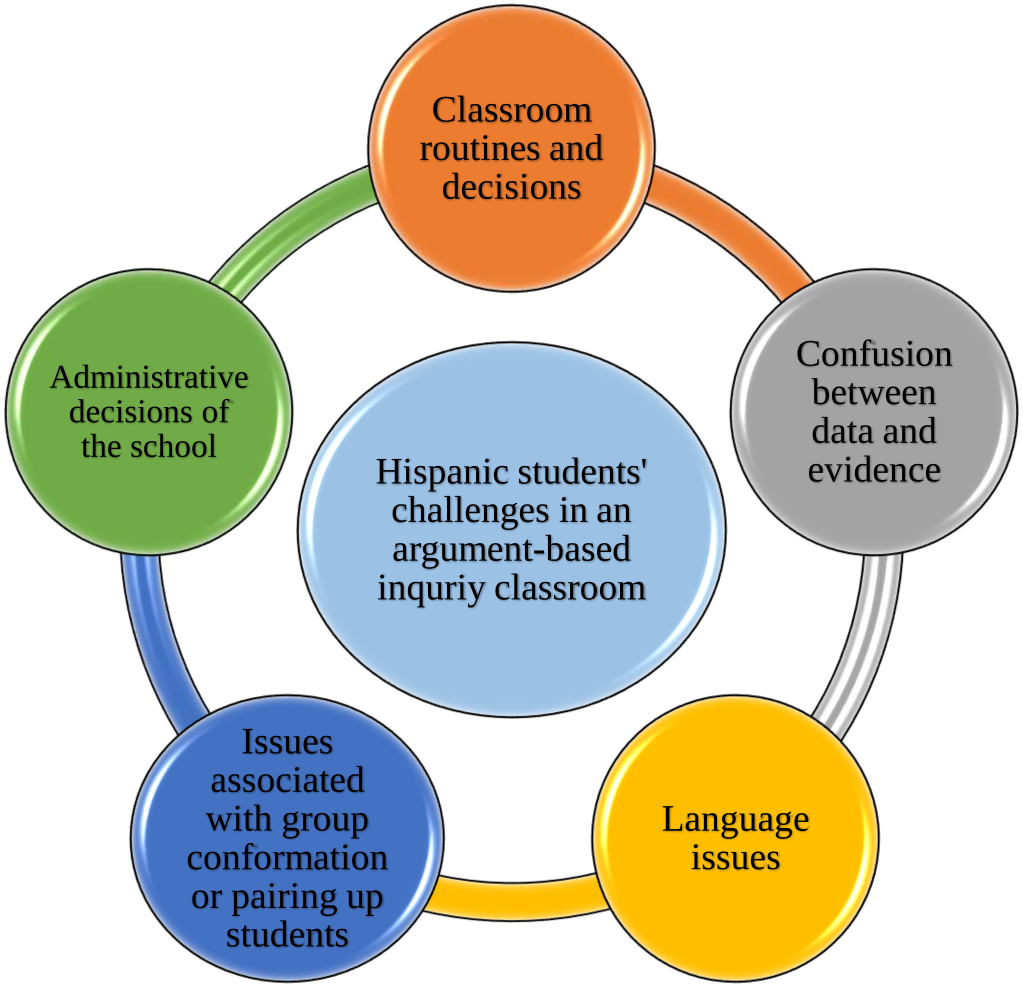


Figure 31. Summary of challenges that three Hispanic students encounter in an argument-based inquiry approach.

Summary

The purpose of this chapter was to develop a case study of three elementary Hispanic students to demonstrate how learning science in an argument-based inquiry context impacts their science learning in several areas such as understanding core concepts, argumentation, and science practices. Along with the analysis of students' science learning impact, challenges experienced by the students were revealed. Before building the case the backgrounds of the three students were presented and an analysis of two aspects of this argument-based inquiry approach were explored. Several themes emerged from an extensive analysis using different rubrics and constant comparative methods. Overall the findings indicate that although the students gained some learning in science by having a qualified teacher with experience regarding the SWH approach, there are other elements that work along those aspects. One is promoting students having meaningful dialogues where they can share, discuss, and challenge ideas about the topics under exploration. In addition, school administrations should consider giving science the importance required as part of the curriculum if the commitment is to promote as many students as possible to pursue careers in STEM areas.

In the next chapter I present the discussion of the findings based on the themes that answer the two research questions. The chapter will address how my findings support the literature and the contributions to fill the gap in the current literature in this area. Implications, contributions, limitations, and future research will also be presented.

CHAPTER FIVE

DISCUSSION AND IMPLICATIONS

In this study, two research questions were proposed: 1) In what ways do two aspects of an argument-based inquiry classroom (i.e., a) laboratory activities and b) the negotiation process) impact these Hispanic students' science learning in terms of a) conceptual understanding, b) understanding of the practice of science, and c) understanding of argumentative components? 2) What challenges do these Hispanic students encounter in an argument-based inquiry classroom? The analysis of the data helped obtain conceptual and practical understanding about these two questions, which will be discussed in the following sections. The first section will discuss the findings related with argument-based inquiry as an approach that promotes Hispanic student learning in three areas where they need to be proficient in the science classroom. The second section of the discussion will cover the challenges that students experience during their participation in this approach. Finally, implications will be discussed and further studies and applications will be suggested.

Discussion

In this section, I first discuss three salient features that emerged while investigating the first research question: 1) Importance of dialogue; 2) Importance of classroom setting regarding grouping and time allotment; and 3) Importance of various learning tools. Next, I discuss issues associated with the challenges that these students encountered while engaging in argument-based inquiry in the classroom.

Importance of Dialogue

The dialogical interaction that these Hispanic students experienced during laboratory activities and the negotiations process impacted their science learning. The practice of dialogue was present in all of the science learning dimensions investigated in this study. Dialogues promoting science learning occurred mostly during laboratory activities. Hispanic students still had dialogue in the negotiations in which group debriefings impacted their learning about argumentative components.

Based on the results of this study, the dialogical interaction of these three Hispanic students' classroom occurred mainly as student-student interaction and teacher-student in a minor portion. This argument-based inquiry approach was favorable for these Hispanic students to be involved in a collaborative scientific activity in which the main goal was to engage students in meaningful negotiations that required clarifying concepts and providing and elaborating explanations among their peers and teacher (Hand, 2008). Classrooms where these students participated were genuinely noisy due to students' involvement in scientific discussion. Every single student was participating in their group discussion having responsibilities and contributing as members. In the context of an argument-based inquiry, teachers highly encourage students to have these discussions. This can be a dilemma for some teachers since classroom management has been described as one of the challenges for inquiry-based classroom implementation (Davis et al., 2006). This situation was seen in Mrs. Thomas' science class teaching. This was also seen in Mr. Jones' class, who did not provide enough space for students to interact among themselves; in Alexandra's case, she did not have meaningful dialogue in her group. This situation might be one of the factors that contributed to Alexandra's limited learning in the areas under this study. Contrary to that situation, Mrs. Smith let the students talk from the beginning to the end of the science activities. Hispanic students need this kind of learning environment to overcome the "pedagogy of poverty" (Waxman, Padrón, & Knight, 1991), which is described as teacher promotion of low-level cognition in which they spend time in the explanation of concepts and students are not challenged with questions and group work, resulting in students' passive learning.

In this study, the dialogical interaction between teacher-student and student-student was critical to first access to students' knowledge they bring to the classroom (Moje, 2007) and promote negotiation of meaning regarding the core concepts of habitats, sound, and magnets. This study highlights that in order for teachers to promote active classroom dialogues, they should know how to foster learning in small groups with the understanding that minority ethnic students participate less frequently as they feel less comfortable when they do participate (Howe & Abedin, 2013). Such understanding includes how to ask productive open-ended questions, facilitate students' collaborative work by assigning individual students to right groups, hold high expectations for all of the students, manage misbehavior competently without affecting the progress of the lesson, less talk on the part of the teacher, and encourage dialogue among students in small groups. Those pedagogical approaches are a core factor in determining the extent of elaboration and development of dialogue that promotes learning (Webb, 2009).

Based on the findings of this study, the "dialogic teaching" among the teacher and students contributed to a substantial and significant discussion resulting in the development of students' thinking on particular ideas or themes (Mercer & Littleton, 2007). Mrs. Smith did not intend to give the right answer or discourage students because they said a wrong concept. What was mainly analyzed was the dynamic of involving students in those negotiations until they made sense of the concept under discussion on their own. All students had that opportunity and the environment that teacher provided was favorable for these Hispanic students to participate, especially for those with limitations in language or a shy personality who did not like to say something wrong in front of the public. In that way the dialogic interaction gave these students the access, power, voice, and authority in their classroom to generate and evaluate knowledge (Shoerning et al., 2015).

A second aspect gained through dialogical interaction is the level of socialization of the students which allows them to listen carefully, be supportive, and interact in a naturally reciprocal manner (Alexander, 2008). Amelia and Armando were involved in dialogic teaching and cooperative negotiation during laboratory activities with their group. The core ideas of the science disciplines were negotiated and scaffolded by the interaction of teacher-student and student-student accurately in laboratory activities and confirmed through cooperative negotiation. The experience of having meaningful dialogue in the science classroom for these Hispanic students allowed them to generate ideas that they could not have as individuals and those ideas should be recognized as developments of their own thinking (Game &Metcalfe, 2009).

Moreover, the dialogical interaction as meaningful dialogue observed in the classroom of these Hispanic students was a means to encourage them to become enculturated into the knowledge and the practice of science, which includes understanding inquiry or science practice and argumentation components and procedure. Dialogue among students in the teams in which these Hispanic students participated contributed in some way to students' learning of the practice of science. As Wells and Wells and Mejía Arauz (2006) explained, "in developing inquiring communities the focus is not the dialogue per se but rather on the activities that would be likely to generate dialogue." This suggests that meaningful dialogue is a vehicle to achieve the goal of the activities of learning the science practices that are promoted in this argument-based inquiry approach.

Based on the findings of this study, the aspect of laboratory activities made an impact on these Hispanic students' understanding of the science practice through meaningful dialogue. Learning science through this argument-based inquiry gave these Hispanic students the experience and increased engagement of having choices about how to conduct their investigation and how they would conduct their inquiries (Wells & Chang-Wells, 1992). The zone of proximal development (Vygotsky, 1978) can help to explain this scenario of collaboration and dialogue promoted in argument-based inquiry approaches. In the classroom, Mrs. Smith was responsible for exploring the actual knowledge level of the students through the KWL chart and discussion. After that, Mrs. Smith coached her students but left them to do their investigation and other procedures independently. This nature of inquiry involved a collaborative component that may foster learning in laboratory activities. Armando, Amelia, and Alexandra were engaged in a process of cognitive restructuring (O'Donnell, 1999). This process foster student giving explanations in the group and reorganizes ideas for clearer presentation (Bargh & Schul, 1980). Hispanic students conducting laboratory activities had the experience of doing science, being engaged in dialogic process of talking that led to the greater increment of their understanding (Ash, 2004).

Moreover, as the results reveal, dialogue also guided these Hispanic students' understanding of argumentative components. Argumentation is a significant part of the science practice and the central component of argument-based inquiry in which the Hispanic students in this study constructed knowledge through posting and answering questions, evaluating claims, analyzing evidence, and assessing alternative explanations (Driver, Newton, & Osborne, 2000). Hispanic students involved in the aspects of argument-based inquiry could develop initial science learning since they were engaged in formulating claims, using evidence through reasoning of data, and participation in public negotiation (Duschl et al., 2007). As they were involved in doing their laboratory activities, students exhibited an awareness of the importance of their question as a guide to pursue the answers for their scientific investigation. In their dialogue, students discussed among themselves and with the teacher the validity of their claim and the evidence. For example, the validity of the evidence was a challenge for Armando, who was not convinced that the evidence that supported their claim of magnets was because "we tried." This dissatisfaction that emerged from the dialogue allowed him to develop a better idea of what counts as evidence and what is data or observation. The dialogue at this stage of laboratory activities arose as a sociocognitive conflict theory explained from the Piagetian perspective (De Lisi & Golbeck, 1999). The sociocognitive conflicts made the students become aware of the strengths and weaknesses of their ideas as well as acquire techniques for communicating and negotiating on the knowledge they possessed (Skoumios, 2009).

Another form of dialogue that impacted these Hispanic students occurred through negotiation process. This form of dialogue was a group debriefing that supported students' reinforcement of argumentative components. Debriefing is a process of learning in which students have the opportunity to process and reflect on their experience. This event happened in a supportive environment that allowed students to lead discussion and draw conclusions from it (Knapp, 1992). Conducting the group debriefing section was an additional opportunity for the students to socially interact and reflect about their work of the lesson. This reflection section in the context of learning allowed these Hispanic students to analyze what went well and needed more work in their negotiations. The base of students' analysis was whether the audience agreed or disagreed with their statements. Students went over questions, claim, and evidence and learned that there was some information that was not coherent or meaningful as evidence. The group debriefing section took 20 minutes of the science lesson and offered them the chance to reach several ideas such as summarizing what was experienced, recognizing alternatives viewpoints, figuring out meaning from events, solving problems, and identifying fallacies and false conclusions (Resnick, 1987).

The two aspects of the argument-based inquiry classroom, laboratory activities and the negotiation process impacted these Hispanic students' learning of science by offering students opportunities to engage in dialogue. Involving students in meaningful dialogue allowed them to do intellectual work such as elaborating ideas, refining and restructuring concepts, and reflecting based on their experiences.

Importance of Classroom Setting: Grouping & Time Allotment

The elementary classroom setting was a second factor that impacted these Hispanic students' learning of science in an argument-based inquiry approach. Doing science as argument-based inquiry required students to engage in different activities of high cognitive demand (Cavagnetto, Hand, & Norton-Meir, 2010). Those high demands include proposing a testing plan, analyzing data, and creating claims and evidence. To allot students enough time to explore the process and gain conceptual understanding from the process of doing science, a considerable and intentional plan from the teacher was critical to support students gaining an understanding of the target big ideas. The time invested in their investigation helped to engage in meaningful conversation and collaborative learning. High-quality science education requires offering students to engage in three educational dimensions of learning (NRC, 2012). These dimensions look for involvement of students in a rich context of practice to understand how science is developed, context to explore how science fields are connected, and context to understand the content of science (NGSS). In preparing all of the students with enough core knowledge and quality in these practices and dimensions, management of time for students to set the materials, perform the investigation, and communicate their findings were indicated to be significant in the results of this study. The time that Mrs. Smith spent in each lesson impacted Amelia and Armando to gain the big ideas of information for the topic that they studied. Implementing a lesson in the classroom requires teachers to review students' activities, major concepts, objectives, teacher background, and organization for the timeline of the lesson (National Institute of Health [NIH], 2005).

Providing sufficient time to these Hispanic students to conduct their investigation showed a great impact in getting the disciplinary core ideas. In Robinson School they focused on a few core ideas to develop during the year. Mrs. Smith's science plan for the 2011-2012 year was to include two main units: life science in which she taught animal habitats and human-changed environment. For the second half of the year she introduced the unit related to physical science, including the lessons of magnetism and sound. In covering a limited number of science topics teachers and students make the commitment to achieve several goals such as exploring each topic deeply and achieving an understanding of the core discipline and reduction of details of the topic to give time to students to engage in scientific investigation and argumentation (NRC, 2012; NGSS, 2013).

There are not any rules that indicate how many days and hours should be in one lesson following inquiry guidelines. However the perspectives of *A Framework for K-12 Science Education* (NRC, 2012) and NGSS (2013) suggest developing lessons that are limited in details and extended in depth in order to allow more time for teachers and students to explore ideas in deeply manner. In Mrs. Smith's classroom, science activities followed a timeline of activities on consecutive days in which the first day was for exploring students' prior ideas through KWL and creating the guiding question. On the second day, students stated their beginning ideas, chose the materials, and designed their testing plan to conduct their investigation. In that step, Mrs. Smith revised students' testing plans and allowed them to continue with the data collection. In conducting data collection, students invested two or three days depending on the lesson's research question. Two more days were used for analyzing data, creating claims and evidence, and consulting experts. Finally, the negotiation process took one or two more days. In total, one week and a half was her timeline to move students forward in their science learning.

A second aspect of the classroom setting that impacted students' science learning was the organization of the group and pairing up students effectively. Amelia and Armando participated in groups of two or three students depending on the lesson and the teacher's decision. It is not clear how the teachers organized the different groups where these students were members. However, working in groups facilitated the learning environment for students and required balancing their risks and benefits (Lazar, 2014). For Armando and Amelia, the grouping and forming of pairs worked without any inconvenience; they had a voice and equal responsibilities among the group members. As the results of this study indicate, it is important to develop ways to assist students in developing their engagement in the specific science practices. For Alexandra, in doing group work, there were more challenges than benefits, which in some ways affected her progress in the practice of science. To address this problem of pairing and grouping up students effectively to participate in an inquiry learning approach such as science writing heuristic, Voreis et al. (2008) suggested introducing cognitive roles in the groups in which students have responsibilities of different types of thinking during cooperative investigation. The "thinking roles" included assigning one student to lead the group as the prediction manager, an evidence collector to help the group to analyze and compare claims, a researcher to ask the group to look for additional ideas, and a skeptic who encourages the group to think about different explanations and perspectives.

In learning science in the context of the SWH, students are expected to participate in a cycle of negotiations for clarifying meaning and explanation of ideas among peers and between student and teacher (Norton-Meier et al., 2008). Therefore, the cooperative learning and laboratory activities are critical for students to learn the culture of working in groups and become involved in meaningful discussion, formulating questions, and being skeptical of the procedures and results. One example of this was when Amelia was asking if she had enough information to support the claim or Armando asking his group why vibration was a word that emerged so many times from their data collection.

A third aspect of classroom setting that this study indicated to have impacted these Hispanic students was the teacher providing explicit explanation of instruction. For these Hispanic students, the explicit explanation played an important role in facilitating their science practice. For some of these students, learning of science as inquiry was a new experience and represented a new culture of which to be a part. In this study, one approach of teachers promoting the classroom culture of science practice was through the teacher's explicit explanation of the practice of science and the element of argumentation. Creating a classroom culture similar to the scientist is a complex endeavor in which science teachers are significant elements in supporting how students appropriate the cultural practice of science (Hogan & Corey, 2001). Therefore, the teacher's intervention of giving these Hispanic students an explicit instruction of what is a claim, what is evidence, and why students should agree or disagree with each other's statements is critical to the process of enculturation, in which students live the experience and the teacher makes the cultural tools and conventions available for students (Driver et al., 1994).

Based on the findings of this study, it is important that teachers clearly explain with examples to students the explicit inquiry-oriented instruction in order to foster this type of knowledge. This finding supports the research of Lorch et al. (2010) who found that combining explicit instruction with experimentation is more effective than experimentation alone. In addition it adds to the knowledge of research of effective teaching practice as cognitive guiding instruction (Waxman, Padrón, & Knight, 1991), which referred to the strategies of explicit instruction and modeling of cognitive learning strategies and giving students' opportunities to practice them.

Importance of Various Learning Tools

Several learning tools used as part of this argument-based inquiry approach showed to have potential to help students gain the different dimensions examined in this study. One of the learning tools that these Hispanic students used in all lessons was KWL. KWL is an instructional strategy in the form of a three column chart. It facilitates students' brainstorm of what they know about the topic in the first Know column, and promotes the elaboration of questions they would like to have answers in the second or Wonder column. After reading, they use the third or Learn column to answer their original questions and include other new information they have learned (Ogle, 1987). The structure and guidelines that promote KWL strategy allow all kinds of learners to write about learning and gain self-esteem since children know how to proceed (Glazer, 1999).

In addition, KWL is one strategy that has helped students with learning difficulties and supports success to English-learner students through graphic organizers (Carr & Bertrando, 2013).

The findings of this study suggest that the use of a KWL chart in the classroom can have an impact as a learning tool in these Hispanic students' learning of science practices. In the classroom where these Hispanic students participated, the purpose of the teacher in using a KWL chart was to create a safe learning environment where all students could participate and contribute ideas to the whole group. In doing that these students gained confidence to participate and be active in the class by raising hands and talking to their groups. One important aspect of using KWL attached to this argument-based inquiry activity for these Hispanic students was that it offered a form of explicit instruction that guided them to create questions, activate their curiosity, and introduce them to the subsequent scientific investigation. This is one important area to explore in educational fields of minority students. There is not a lot of research to support KWL as a learning tool for Hispanic students as a way of preparing them to embark in their scientific knowledge construction through metacognitive activities such as comprehension, elaboration of meaning, and reading and writing.

A second tool that impacted these Hispanic students' science practices was the use of representation. The use of representation has been found to enhance students' learning of science (Maruyama Tank et al., 2012; diSessa, 2004); therefore, it is essential that Hispanic students get involved more frequently in this valuable exercise that promotes scientific learning. One of the practices suggested by *A Framework for K-12*

(NRC, 2012) is to develop and use models. Students should be encouraged in the creation and use of models or representations to help develop explanations about natural phenomena. Lemke (1998) defines science as a way of knowing that is communicated not only through verbal concepts but also semiotic hybrids such as words, tables, figure captions, text graphs, and diagrams. Armando, Alexandra, and Amelia constructed representations for different learning goals such as: gaining an understanding of the concepts of ecosystem and food chain, the representation of the procedure of the matter experiment, and the encouragement of the student to use his or her creativity to better represent the phenomena. In getting involved in this practice these students were reflecting and doing what practicing scientists do in their work by relying on representations to interpret and materialize the understanding of a particular phenomenon.

Although this practice of constructing multimodal representation showed to impact these Hispanic students, it was not a frequent exercise in laboratory activities and negotiation process. Supporting student learning in how to build meaningful representation is not an easy task (Danish & Phelps, 2011). Therefore, teachers should look for strategies such as teacher-mediated negotiation as part of an ongoing open-ended process (Prain & Tytler, 2013). In addition, science teachers and instructors at different levels should emphasize the construction of representation in their classroom to support students' science learning, writing, and argumentation skills (Demirbag & Gunel, 2014). Hence, it is important for Hispanic students to be engaged in this type of language as a scenario in which they can adapt their linguistic resources as second language learner in order to participate and facilitate their understanding (Stevenson, 2013; Allen & Park, 2011).

A third learning tool that impacted these Hispanic students' science learning in an argument-based inquiry was writing. Students constructed their understanding in science through writing and social negotiation of meaning (Wallace et al., 2007). So it is important to create in the classroom the learning contexts in which Hispanic students can take advantage of "learning about the language as a process of using language" (Norton-Meier et al., 2008). For Amelia, Alexandra, and Armando, writing activities embedded in the context of science writing heuristic and reflection were encouraged in the classroom but not in a consistent manner (specifically, informal writing tasks such as letters, stories, etc.). For taking advantage of the benefit of writing to learn science it is critical that teachers recognize and support the activities of writing by helping students to understand the significance of the audience, the inclusion of representation, and the quality of the argumentative components (Chen et al., 2013).

The findings of this study showed how writing was beneficial for Armando and Amelia. The engagement in active writing gave Armando the awareness of elaborating the quality of his argumentative components and being mindful to communicate the ideas to a specific audience. They were able to reframe, transform, or constitute their knowledge to communicate the science ideas, which in Armando's case was to his dad, and the teacher in Amelia's case (Berieter & Scarmalia, 1987; Galbraith, 1999). Even for Alexandra, despite her language issues and being an English Language Learner, the writing reflection was a foundational point of showing an initial understanding of the science learning. Teaching planning, self-regulation, and revising strategies to students are remarkable for students' improvement in persuasive writing skills (Monroe & Troia, 2006).

A fourth activity that served as a learning tool for these Hispanic students participating in argument from evidence was the opportunity of consulting experts. Another form of language that impacted these Hispanic students was their engagement in reading different sources of information to compare their ideas. Checking with experts is a way of reading in which students gain new understanding, validate their ideas, and get a greater sense of confidence regarding their understanding (Hand et al., 2009). Amelia, Alexandra, and Armando had access to reading from texts such as science books and journals, and they also engaged with an expert in the field of Life Sciences. This phase was important for these students because this activity required them to read more attentively and think in a critical way in order to make connections with existing scientific knowledge and challenge their thinking (Chen & Steenhoek, 2014).

The result of this study indicated that checking with experts was significant for Amelia and Armando. First, from selecting books, students read and discussed with their partners. In doing so rich dialogue was generated specifically about what information was reliable from the books to support their claims. Second, having an expert from the field showing them concrete examples of what they were studying let them make strong connections with real world scenarios and science knowledge (Singletary, 2010). In addition, the information that students gained from their discussion with the expert strengthened and validated their arguments. Alexandra's participation in the stage of consulting experts was limited due to her tutoring sessions that were at the same time as her science class. In order to support Alexandra in her reading improvement, her science teacher and her reading tutor should integrate reading science as a way of learning to read. This dual approach has been shown to improve students' comprehension and is useful for English language learners (Brown & Campione, 1998; Morrow et al., 1997; Amaral et al., 2002).

The Science Writing Heuristic (SWH) approach is an inquiry-based learning approach that embeds an argument structure as central and is closely aligned to the purpose of NGSS (Hand, 2008; Choi et al., 2010). The findings of this study suggest that these three Hispanic students involved in an argument-based inquiry such as SWH had opportunities to engage in the practice of science, understanding of argumentative components, and understanding of science concepts and principles. As the results indicate, the nature of this approach supports students' learning in the three dimensions of science when they were involved in significant dialogue during laboratory activities and the negotiation process. The rich dialogue between them and the teacher or other students in the group provided scenarios to refine preexisting understanding, apply existing knowledge, reinforce knowledge connections, require cognitive demands to complete their investigation successfully, and recognize gaps in their knowledge that triggers their curiosity (Edelson et al., 1999). A second aspect that impacted these Hispanic students was the lesson setting and conditions of the classroom and teacher to maximize their abilities. A third factor was the inclusion of learning tools such as writing and use of representation that promoted an increase their metacognitive awareness which led them to have a sense of control of their learning and increase student level of confidence in their learning process (Hand, Norton-Meier, Staker, & Bintz, 2009). Figure 32 explains the learning trajectory of these three students while involved in the SWH approach.

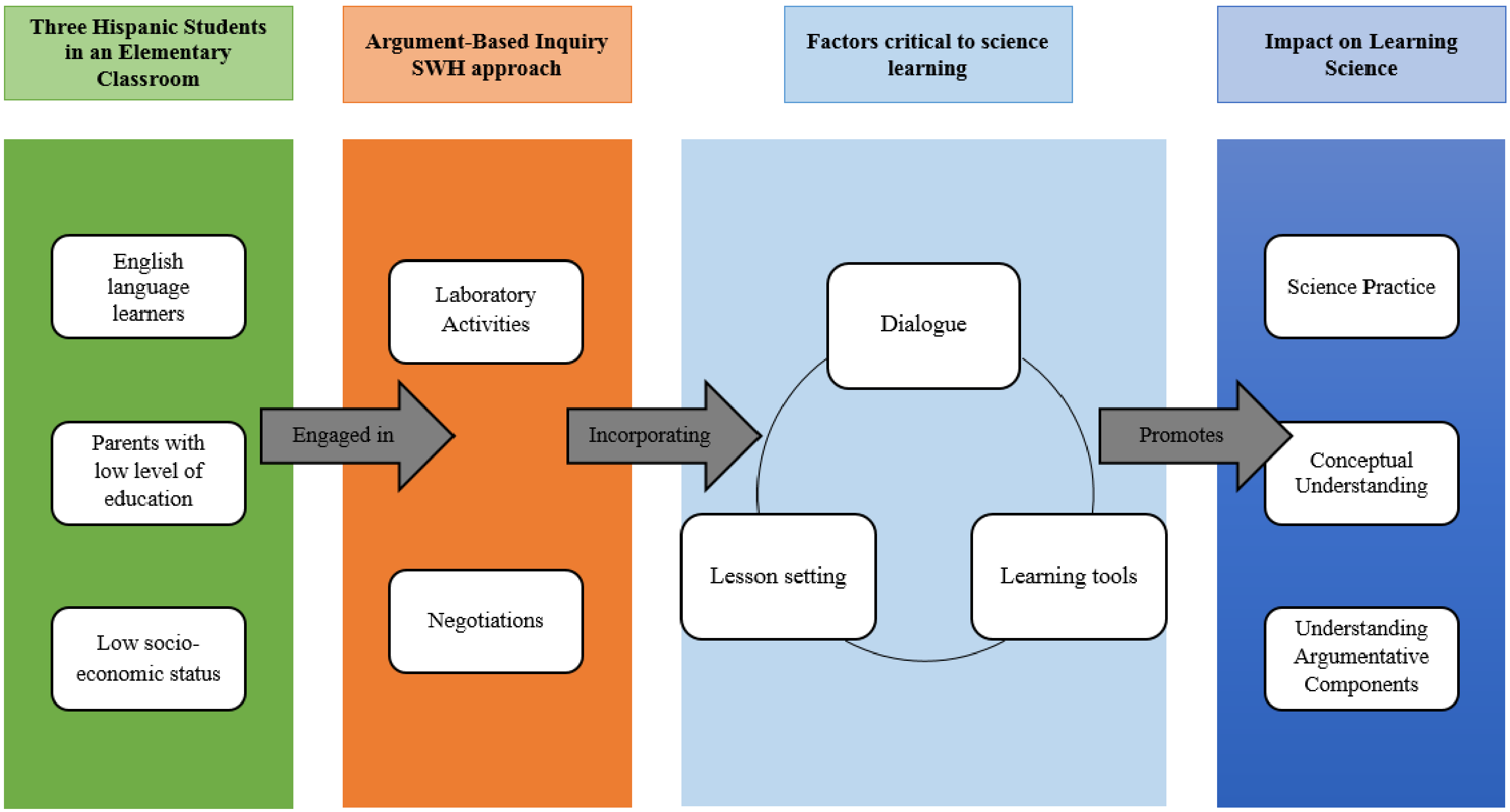


Figure 32. How Hispanic students learn science in an argument-based inquiry such as SWH.

What Challenges do Hispanic Students Encounter in the Argument-Based Inquiry Classroom?

Inquiry-based science instruction has been shown to help Hispanic students, minority students, students with learning disabilities, and English language learners mainly from a quantitative perspective measuring their achievement (Amaral et al., 2002; Akkus, 2008). While these studies have shown that there are effective strategies to promote science to minority students and foster the integration of science and English proficiency for ELL, it is also important to identify how the process of learning science happened as the findings of this study indicated. Additionally, beyond the contribution of this study a central part of it is to identify the challenges those students encounter in their experiences of learning science in this particular approach. Five main challenges appear to be critical to these Hispanic students' learning while in an argument-based inquiry context.

The first challenge that these students encountered was associated with making connections between data and evidence and differentiating its nature. As the results indicated, Amelia and Armando were able to formulate claims but had a lack of understanding in developing a connection between observable events and reasoning or interpretation from those observations during laboratory work discussion. Although these students collected data for the different science topics, students did not find it easy to tell what the data meant and make their reasoning behind their conclusions (Gomez-Zwiep, 2010). Students did not have any problems showing data; rather, the difficulty was in showing evidence, indicating that the structure of opportunities to show data and claim matters (Ryu & Sandoval, 2011). In this case the structure of showing the evidence to the whole class was through negotiations in which the teacher took the information from experts as being more relevant than the student's own interpretation. Students need help learning how to make the connection between evidence and data either during dialogues or writing (Fulton & Poeltler, 2013). Therefore, it might have been beneficial for all students to have Mrs. Smith give an explicit explanation regarding evidence to "tell the story of what happened" in their writing, and show the students how to link that construction with the ideas gained from the reading as a validation process of the concepts. If teachers become confused with the idea of considering only information from experts as evidence, students will have a "straight regurgitation" of facts that is not aligned with the process of this argument-based inquiry approach.

As this study indicates, it might also be beneficial for students and teachers to explore alternative strategies of refining evidence if telling the story is not sufficient. For example, for Armando and Amelia, being engaged in group debriefing and writing reflection was beneficial to refine their evidence. Promoting students to engage in reflective activities on evidence encourages their thinking on whether they had used evidence in their arguments after dialogue and review of their arguments in relation to using evidence to back up their claims (Iordanou & Constantinou, 2015). In addition, listening actively among peers and developing summaries of those dialogues can lead to that objective (Schoerning & Hand, 2013).

The challenge found in this study about developing effective evidence from data is an issue generally widely reported for students (Clark & Sampson, 2007; Eduran et al., 2004; Jimenez-Aleixandre et al., 2000). However, for Hispanic students the issue is echoing the critical and persistent achievement gap between races (NAEP, 2015). Taking in account the faster growth of Hispanic students in public elementary classrooms and their educational disadvantage, addressing this challenge in science classroom is a primary goal to overcome in science education.

The second and third challenges that the results reveal were associated with classroom routines and administrative school decisions. These challenges are not related with the functionality approach of science writing heuristic on the science learning experience of these students. However, it shows how accountable the school system is in fostering students in promising approaches in the students' interests.

Classroom management and routines are an important aspect of teachers' pedagogical knowledge, guidelines, and indicators for practice and programs on students' outcomes (Cook et al., 2014). As classroom diversity has increased in nature, classroom management is critical (Gottfried, 2014), especially because teachers need to be flexible and effective for promoting cooperative learning and aware of children inclusion in settings (Emmer & Stough, 2001). For Armando, constructing knowledge and experiences in this argument-based inquiry approach offered him the opportunity of engaging in the practices of science and learning the core of argumentation (Schoerning, 2015).

One of Armando's least favorite things to do was participate in negotiations of argument involving the whole group discussion. In order to strengthen those skills

Armando needed to be engaged in those kinds of environments to reinforce and overcome any issues related with negotiation of meaning and communication in front of the group. When a student is absent from school for reasonable motives such as illness, this is the time when classroom management could impact education. Jones (1996) states: "One of the comprehensive natures of classroom management emphasized is 'the use of instructional methods that facilitate optimal learning by responding to the academic needs of individual students and the classroom group'" (as cited in Emmer & Stough 2001, p. 104). Therefore, Mrs. Smith's classroom routine and decisions were not aligned with that feature. The fact that she did not accommodate him for those situations hindered his opportunities for learning. This situation may limit students' learning science process participation and appreciation.

The third challenge these students encountered was associated with administrative decisions. The role of the school administration or principal's decisions regarding teaching science class and students' participation in the science class was a factor that affected science learning opportunities for Amelia and Alexandra. Science education reform has declared to make efforts in the area of science in elementary school (Levy, Pasquale, & Marco, 2012). Therefore, in implementing methods, approaches in the area of science teaching and learning, professional development aligning with the curriculum, and assessment and instruction with national and state standards, administrative support is the key to the systemic science education reform (National Science Teachers Association [NSTA], 2003). Researchers have reported a number of factors that affect the sustainability of evidence-based practice in the school setting and one of the most prominent factors is administrative support (Strickland-Cohen et al., 2014). The role of the principal of Robinson School was crucial for the implementation of the science writing heuristic in fifth grade. It was crucial regarding how science was delivered to students, how to carry out the plan, and who would perform that approach to students and also change the initial plans. In addition, it was the school principal who decided the time when the special class took place for students with learning disabilities and English Language Leaners.

All of those decisions impacted these Hispanic students in their opportunities of being engaged in learning approaches that ensured their experience in high-quality science teaching. In Amelia's case, the decision made by the principal in changing the system of how science was taught affected her greatly because the administration did not take into account how it would affect the students whose teachers did not have the experience of teaching the approach or were not willing to follow. One of the roles of administrators is to help ensure the fidelity of implementation and student outcomes (Bambara et al., 2012). However, the principal's decisions were not accountable to ensure that all of the students were included in this argument-based inquiry approach. For Alexandra, the decision of the administration impacted her due to her tutoring in the special classes. There was not a balance between the benefits of being in the tutoring classes of math and reading, the detriments of missing one entire semester without science class, and being absent 20 minutes from every class due to ELL class. To address this dilemma, some research points out the possibility of cooperation between ELL teachers and content teachers in order to support students' relevant meaning of science and the language demand of ELL (Slater & Mohan, 2010).

On the other hand, these students experienced the emphasis of raising standards because of the No Child Left Behind (No Child Left Behind [NCLB], 2002) requirements. With the creation of the NCLB reform as an effort to increase standards, science at the elementary level has been impacted and left behind (Sandler, 2003). The teachers in Robinson School took 45 minutes from the science time slot for reading and math when the state test was approaching. Although the reading was about science topics, the approach that teachers used was reading and looking in the books for specific facts that answered some guiding question as was observed in Amelia and Alexandra's classrooms. In doing so, students obtained the facts of the topic but did not obtain the dimension of science practices and involvement in argumentation (NGSS Lead States, 2013).

A fourth challenge these students encountered was associated with group formation and pairing up of students. These three Hispanic students always worked in groups of two, three, or four students depending on the worked required for each lesson activity. For example the lesson of animal habitats was much simpler for the testing part since the task only required to open and explore two owl pellets, collect observations, and make some descriptions. For the lesson of environment, magnets, and sound, more members for the group were required because the testing part required more work to do. In addition the nature of science writing heuristic entails the implementation of group work because students need to negotiate meaning in different settings for succeeding in this learning environment (Norton-Meier et al., 2008). Moreover, in group work the idea is that students accomplish a common goal and develop an understanding of the core concepts (Parr, 2007). Therefore, forming groups required a better judgment by the teacher to select the students and organize them. As the results of this study reveal, the group formation operated in a good way for Armando and Amelia. However, for Alexandra, working in her group was not effective.

The teacher strategy to pair or organize groups was not clear in this study. However, in each lesson in which these students participated, the group had different members. All of the members of the group through conversation divided the responsibilities in their group and they followed the teacher's classroom rule of "pass the pen." In Alexandra's case there were many issues to make this group work. What was observed in Alexandra's group is explained by Baines et al. (2008) who describes that there are many reasons for which students do not get involved in the group work. For example, students in the group may be "free riding" which means leaving the work to others, being shy children, ignoring or excluding non-participants, and group split into smaller groupings. Therefore neither Alexandra nor her partner had a good experience since both of them were doing free riding. Cooperative learning is not easy to implement and the teacher and students should understand that all students must participate and realize that they are in the activity together (Schulte, 1999). Therefore it is also a task for teachers to look for strategies to encourage students to help each other (Mastropieri, 2001; Steward & Swango, 2004). Mrs. Smith did not take into account the characteristics of Alexandra and her partner. For forming a group in which one of the students always was late to start activities, the teacher could have considered making a group of three to balance the absence of Alexandra, her issues with language, and the lack of engagement of her partner. Therefore, the teacher should not assume that students know how to work together (Schulte, 1999) and should allow the students to learn that skill before they go to work in the groups.

The last challenge that students encounter in this argument-based inquiry approach was affecting Alexandra, who had particular issues with language. As the results revealed, Alexandra was the student who had more challenges and could not benefit as much from participating in this argument-based inquiry approach. In analyzing her challenges and struggles in this context, what made the situation worse is how the system operated around her issues. First, Alexandra's issues with reading and math took her from science class for a whole semester. She did not have the opportunity to get the learning for that time because the teacher could not make up for missing six months of science. School administrators and teachers have little training in meeting the needs of English Language Learners (Castaneda & Bautista, 2011). Therefore, it is important for administrators and teachers to adopt strategies of instruction to provide students with approaches in which they can develop content and language in science (Edmonds, 2009; Jimenez Silva & Gomez, 2010; Santau et al., 2010; Terrazas-Arellanes, 2013). These strategies indicate that the solution to this problem is not the separation of ELL from science or other subjects but to establish a synergistic relationship (Stoddart et al., 2002). Therefore, the teacher and school administration could have made a connection between

Alexandra's ELL teacher and Mrs. Smith by taking advantage of the rich language involved in using science writing heuristic approach in her class.

A second problem reveals Alexandra did not feel confident regarding writing in laboratory activities when she was working with her partner. However, when she was asked to write a reflection individually she let her ideas emerge easily. During thirty minutes she was able to write two full pages telling the story about what she did, what she observed, and what she learned. The analysis of her writing sample reveals that there was an effect of the enculturation of scientific writing when she wrote her reflection in the informal genre of a letter. Alexandra's involvement in the task of writing letters showed an understanding and development of scientific ideas such as observations, beginning ideas, questions and claims, and in general showing the development of technical language (Kamberelis, 1999). The findings indicated that the act of writing did not constitute a challenge. Alexandra's problem in math, reading, might be associate with other languages issues.

The analysis of the writing sample reveals that she had difficulties with phonological processing such as the manipulation of sound, spelling problems, transferring thoughts into writing form, and significant discrepancies between oral and writing performance (Giannouli & Pavlidis, 2014; National Institute for Literacy, 2006). Becoming aware of the warning signs of these signs is imperative to evaluate what children need to increase the chance of their success in school and life. Therefore, I believe that being involved in science classes, especially in an inquiry-based teaching approach such as SWH for more time could be an alternative to support her learning instead of removing her from science class. As Jarrett (1999) explains, an inquiry-based approach is the type of learning environment where students can develop their observation skills by being involved in hands-on activities, increasing the importance of the information learned while reducing language and literacy demand. For overcoming her language issues, Alexandra needed to learn language through language that was embedded in the practice with a clear purpose, not by ignoring the mechanic aspect of languages but by emphasizing those problems in the context of science inquiry (Norton-Meir, 2008).

This study indicated a range of challenges for these Hispanic students while participating in learning science through an argument-based inquiry approach. Many of these challenges are systemic in nature such as administrative school decisions, classroom management, pairing up and organizing the group work, and how the school administrators and teachers deal with students with learning disabilities and ELL. Another challenge was related to the nature of the approach to gather data and create evidence to support a claim, which supports the findings of Ryu and Sandoval (2011) in that students did not elaborate evidentiary justification or reasoning to create their evidence. Overall, the findings of this study suggest that Hispanic students must be involved in inquiry-based learning to meet their unique needs which are associated with language, assimilate the cultural way of knowing (Lee, 2002), and being active with their own language rather than continue in the pedagogy of poverty (Waxman, Padrón, & Arnold, 2001). In-depth analysis of those challenges that these three Hispanic students faced uncovered more of the challenges for teachers and administrative leadership in embracing these learning opportunities in their schools for students. Figure 33 shows a summary of these challenges and possible strategies:

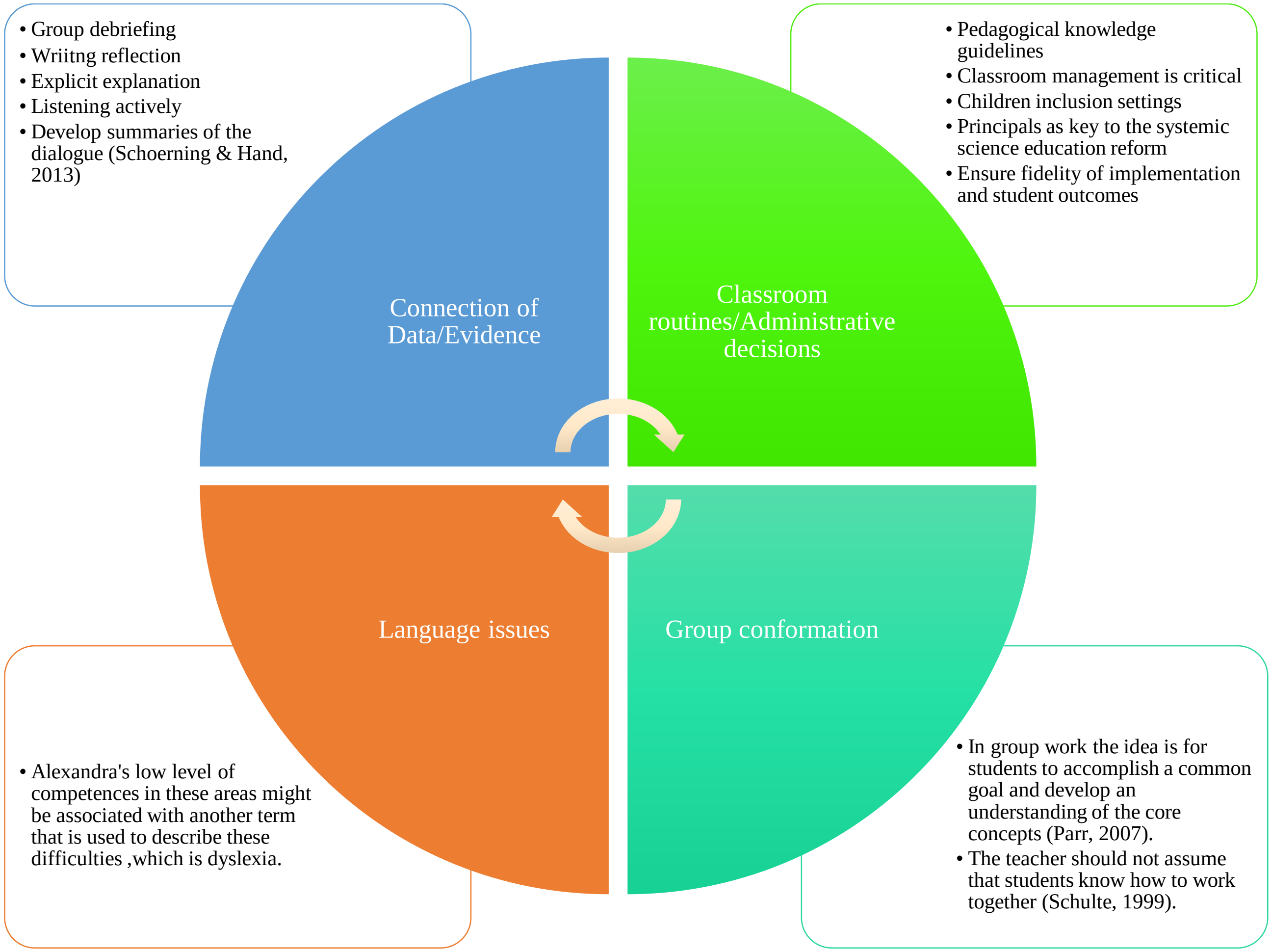


Figure 33. Three Hispanic students' challenges and strategies in argument-based inquiry.

Implications

The results of this study provide implications for science education policies, teaching practices, and future research.

Policy

The Hispanic population has increased in the last decade and that increase is also reflected in their enrollment in public school, the largest group of ELLs, and the highest dropout rate among other ethnic groups (National Center for Education Statistics, 2012). Regarding the academic aspect they are lagging dangerously far behind their non-Hispanic peers (Gandara, 2010). Numerous factors have been attributed to this crisis, which include inadequate social services, low socio-economic status and uneducated parents, schools that lack the resources to fill their basic needs, and educational quality and language barrier (Gandara, 2009). Although language is perceived as a common factor, what this study reveals are the educational inequalities as administrators and teachers are unprepared to identify Hispanic students' needs of being in a rich learning environment to diversify their learning in science and language. The importance of learning language through a science inquiry approach to help students with language issues was overlooked in the school. Engaging in inquiry-based learning for science has shown to be beneficial to students, especially for low achievers, when a curriculum is carefully developed and it is aligned with professional development and policies (Marx et al., 2004).

Even though an inquiry-based learning approach was implemented in the school and these three Hispanic students participated, the administration and teachers lack of providing them this rich environment was consistent throughout the year due to external reasons. For example, they changed their internal rules to teach science and not all of the teachers were trained to continue following the approach. Second, as one of the participants experienced, English language learners are commonly taken out from their regular classroom for their English classes and this practice worsens the situation by creating further inequalities because they miss important aspects of the regular classes (Gandara, Rumberger, Maxwell-Jolly, and Callahan, 2003). Third, the science classes and lessons were incomplete or interrupted to attend practices for the standardized test or to attend other activities different from the normal curriculum. Fourth, although the teachers from this school participated in the professional development of science writing heuristic by attending the meeting during two summers, not all of them implemented it in the classroom nor was there collaboration among the most experienced and the inexperienced ones.

Gandara et al. , (2003) suggests that the problem of inequalities are due to deficiency of resources to cover the high demands of ELL students in the classroom, but for these three students and for the rest of the students in fourth and fifth grade this might not completely be the case. Contrary to the context where Gandara et al., (2003) carried her investigation, in the state of Iowa the population of ELL is 4.5%. This is not comparable with the population of California that is 23.2% of the public school enrollment (National Center of Education Statistics, 2011-2012). Therefore, what this study reveals is first, the need of teachers and administrators of being consistent in the implementation of approaches that offer opportunities to have meaningful dialogue and effective learning tools based on language. In addition, school administration and policy makers should perceive that the inconsistency of implementation affects all students regardless of their ethnicity. Third, they also need to be ready for the demand of a diverse classroom since the Hispanic population is continuing to grow in the nation.

Practice

The results of this study indicate that Hispanic students' engagement in an argument based-inquiry was beneficial to promote their science learning regarding practices, conceptual understanding, and understanding of the argumentative components. The laboratory activities and cooperative negotiation were the scenarios to learn the culture and language of the science classroom (Hodson, 2014) that is the aim of national standards and science educators for all students in the nation. That is, teachers should consider that offering students opportunities for rich dialogue about concepts, questions, claim, evidence, and exploring the world by themselves will prepare them to appreciate and feel self-confident in their learning of science (Hohenshell, 2008) and advance to college as a scientist or as a literate citizen and therefore become part of the workforce of this country (Crisp et al., 2009).

Second, knowing that a student-centered approach (Driver, Newton, & Osborne, 2000) that includes the use of learning tools such as representation, reading, and writing impacted their learning, this practice should be stressed in their lessons regularly. Teachers should encourage the use of representation in the classroom as a way of motivating students to use another form of language if there is an impediment using English (Klentschy, 2008). In addition, teachers should understand the importance of representation and use them for different purposes and increase their complexity to promote students' thinking and getting a better grasp of science concepts (McDermott, 2010). The use of representation can give students the opportunity of connecting art and science as they appreciate using colors and forms, and they can learn another way to organize data, look for patterns, and make predictions (Justi, Gilbert, & Ferreira, 2009).

Another tool that this study reveals to contribute to Hispanic students' learning science was the use of writing. This study confirms that using reflection was significant to express their science knowledge construction and development of ideas. Teachers and administrators should support these types of activities as a way of increasing Hispanic students' awareness of how to communicate concepts in different manners to different audiences. Hence, students restructure their thinking to express the big idea in different ways (Hand et al., 2009).

Furthermore this study confirms that the engagement of students and subsequent learning of science practice, concepts, and argumentation was shaped when several conditions were combined in their involvement in argument-based inquiry, especially for laboratory activities. Teachers should consider lesson plans that allow students sufficient time to make extensive explorations that promote dialogue, listening skills, critique, respect of people's ideas, and agency (Shoerning, 2015). Since inquiry learning environments require students to work in groups, teachers should pay more attention to how to pair students in an effective way to make their experience more substantial to the science purpose.

Future Research

In order to fully explore and maximize the aspects that benefit Hispanic students' science learning in this argument-based approach, further research is needed. Some opportunities of future projects include exploring to what extent KWL strategies can initiate Hispanic students' engagement in the class by specifically addressing what is their prior knowledge compared with other students and what kind of experiences these students can reflect in their beginning thoughts. By exploring KWL I want to identify what triggers their curiosity and specifically get to know what they learn at the end of their inquiries.

Another tool that I want to examine is the use of representation and writing in classroom. As the results of this study indicate, students made some gains in their learning, although these tasks of creating representation and writing were not requested frequently. The first task that I want to do is to help teachers (in-service and pre-service) to use representation and writing in their lessons through professional development. My emphasis in that area with teachers would be to show them with evidence how science has advanced thanks to the use of representation to explain phenomena. Later I would examine how the use of representation impacts Hispanic students' science learning when it is implemented in the classroom in an efficient manner.

Third, I want to examine the increase of student science learning when the challenges described in this study are reduced. For example, I want to examine the effect of pulling students out the class in terms of limitations or benefits for their achievement. A second aspect regarding this challenge is to see what happens with students' science learning when the implementation of an inquiry-based science approach is applied in a consistent manner in the classroom.

Fourth, I want to explore teachers' perceptions of inclusion of minority students in the classroom, specifically exploring their sensitivity and responsiveness to help this group of students overcome challenges regarding being in school and in science classrooms. Exploring these issues can give information on their pedagogical preparation, content area preparation and beliefs on what the personal challenges implementing science learning approaches are specifically for Hispanic students. Finally, past research (Gandara at al.,

2003) demonstrated that language is not the determining factor that causes Hispanic students to lag behind in terms of achievement compared with other races. Even Alexandra with all of her limitations was able to participate using writing, speaking, and representation, which showed an initial understanding of specific core concepts. It may not be necessary to pull students out of science class to attend ELL classes in a separate area.

Limitations of the Study

While I believe that this study points out several important issues in minority students' educations, there were several limitations that could impact interpretations and applications of this study. Some limitations are associated with the logistics of the data collection procedures, including the inability to maintain an equal number of data sets for each of the participants and collect a complete data set of an entire lesson. Others are drawn from inherited limitations of the case study research design. The initial plan of data collection in this project was to capture an equal number of observations for each student. However, as the researcher, I could not control what happened in the context of a case study in which unexpected situations can happen. For example, I did not have the power to object to the principal's decisions of changing the way science was assigned to the teachers. Initially, Mrs. Smith was the teacher assigned to teach all fifth graders, but after one semester the school decided to change that approach. I missed more opportunities to see Amelia continuing to learn science in an argument-based inquiry when she stayed with her home room teacher who did not teach science using this approach. In addition, I had the same situation when I tried to observe Alexandra. Since she was pulled out of science class in fourth grade, I could not make any observations of her in science class for the entire semester. In my ideal plan I wanted to collect at least the experiences of these students in one semester for a complete lesson. This was not easy since some teachers complained about students being distracted by somebody videotaping in the classroom. Additionally, the research place where this study was conducted was one hour and thirty minutes away from the researcher's home and it was challenging to be there every day.

On the other hand, the research design of this study was a case study made up of three students. Due to the small sample size I cannot make generalizations regarding the result or establish to what extent the results of this study are similar or different, if applicable, to other students and schools settings. However, the results of this study point out assertions which readers can judge and recognize in the situations being described.

Finally, my personal involvement with students as having a Hispanic background may be seen as a limitation or advantage. Some can see it as a limitation since it creates bias regarding my belief and the personal significance of this topic. However, some people can see it as advantageous in terms of interaction with the students since I speak Spanish and some of them felt confident and open to talk to me. In addition, having a Hispanic background allowed me to gain access and their parents' trust in supporting me by giving me permission for their children to participate in this project.

Conclusion

Using a case study qualitative research design, the results of this research suggest that Hispanic students' learning can be positively impacted when they engage in an argument-based inquiry approach such as science writing heuristic. While these students were involved in laboratory activities and cooperative negotiation, several factors emerged to be significant for their learning of science. Based on the data analysis, these factors that promoted student science learning in this specific context included dialogical interaction, classroom setting, and using language-related tools. Furthermore, based on the exploration of how students learn in argument-based inquiry, challenges associated with the approach itself and with systemic issues emerged. The findings suggest that student confusion between evidence and data needs more attention from teachers. To this end, teachers should develop better understandings of argumentative components and the nature of argumentation to guide their students to be engaged in argumentative practices. The systemic challenges reflect how inconsistent the implementation of a teaching approach can be and how poorly teachers are prepared to deal with the demands of diverse learners and to address the needs of their students regardless of their ethnicity. Finally, this study suggests that Hispanic students need inquiry-based learning experience regardless of their proficiency in English. As this study indicates, students immersed in an argument-based inquiry approach that requires rich language use have the opportunity to learn language through science as a synergistic process.

APPENDIX A: STUDENT BACKGROUND SURVEY

STUDENT BACKGROUND SURVEY
Name
Grade
Age
Gender
○ Male
○ Female
Birthplace
○ USA
○ Latin America
First Language Spoken
○ English
○ Spanish
Language Spoken at Home
○ English
○ Spanish
○ Both
Number of Parents in the Home
○ Single Parent/Other Guardian
○ Household
○ Two Parent Household
Parent Education
○ Elementary
○ Middle school
○ High school
○ College
○ Graduate school

APPENDIX B: SAMPLE OF STUDENTS' INTERVIEW PROTOCOL

English	Español
1. Do you think it is important to learn science? Why?	¿Tú piensas que es importante aprender ciencia? ¿Por qué?
2. Do you think that the topics that you have been study are interesting?	¿Tú crees que los temas que has estudiado en tus clases de ciencias son interesantes?
3. What topics do you consider more interesting?	¿Qué temas tu consideras más interesantes?
4. When you really like a science topic do you spend more time reading about it after school?	¿Cuándo un tema de ciencia realmente te gusta te tomas el tiempo para leer más acerca del después dela escuela?
5. Do you enjoy your science class? What things do you enjoy?	¿Disfrutas tus clases de ciencia? ¿Qué cosas disfrutas de esta?
6. What TV shows that talk about science do you watch?	¿Qué programas de televisión que hablen de ciencia tú ves?
7. What makes you pay attention in your science class?	¿Que hace que prestes atención en tus clases de ciencia?
8. How do you pay attention in your science class?	¿Cómo tú presta atención en tus clases de ciencias?
9. When do you not pay attention in science class?	¿Cuándo no prestas atención en tu clase de ciencia?
10. Do you think it is more interesting to learn science looking for the answer yourself or getting the answer from the teacher?	¿Cómo te parece es más interesante aprender ciencia: buscar la respuesta a tu pregunta por ti mismo o que tu maestro te diga la respuesta?
11. Which way is more fun?	¿Cuál de estas maneras es más divertida?
12. What things would you like to learn about science?	¿Qué cosas te gustaría aprender acerca de la ciencia?
13. What science class was awesome last semester? Why?	¿Qué clase de ciencia te pareció sorprendente el semestre pasado? ¿Por qué?
14. What did you learn in that class?	¿Qué aprendiste de esa clase en especial?
15. How do you think what you learn in your science class relates to your everyday life?	¿Cómo piensas que lo que tú aprendes en tus clases de ciencia está relacionado con tu vida diaria?
16. How do you feel working with your classmates?	¿Cómo te sientes trabajando con tus compañeros de clases?
17. Do you like working in groups in your science classes?	¿Te gusta trabajar en grupo en tus clases de ciencia?
18. When you want to know something about science do you look for information by yourself?	¿Cuándo quieres saber algo acerca de la ciencia buscas información por ti mismo?
19. What kind of sources do you use to look for that science information?	¿Qué fuentes usas para buscar la información acerca de la ciencia?
20. Have your parents ever helped you on your science assignments?	¿Alguna vez tus padres te han ayudado en tus tareas de ciencia?

21. How do your parents help you on your science assignments?	¿Cómo tus padres te ayudan con tus tareas de ciencia?
22. Do you like to do experiments? Why?	¿Te gusta hacer experimentos? ¿Por qué?
23. Are you excited when you share your science ideas in the classroom?	¿Te emociona compartir tus ideas acerca de la ciencia en tu salón de clase?
24. What do you understand about a claim? Can you give me an example?	¿Qué tu entiendes por la palabra “claim”? ¿Puedes darme un ejemplo?
25. How did you support that claim?	¿Cómo demuestras tu claim?
26. When you work in small groups do you have disagreements?	¿Cuando trabajas en pequeños grupos ustedes están de acuerdo en sus ideas o no?
27. How much effort do you put in your science class?	¿Cuánto esfuerzo tú pones en tus clases de ciencia?
28. Do you spend enough time writing your reflection?	¿Dedicas suficiente tiempo escribiendo tu reflexión?
29. What do you write about in your reflection?	¿Que escribes en tu reflexión?
30. Do you spend enough time working in your small group?	¿Dedicas suficiente tiempo trabajando con tu grupo?
31. What do you talk about in the small groups?	¿De qué hablan cuando trabajan en grupo?
32. Do you participate in those discussions? How?	¿Tú participas en esas conversaciones? ¿Cómo?
33. Do you want to be the best in your science class?	¿Tú quieres ser el mejor en tu clase de ciencia?
34. What would be a reason for not being interested in your science class?	¿Cuál sería una razón para no estar interesado en tu clase de ciencia?

APPENDIX C: RUBRIC TO EXPLORE CONCEPTUAL UNDERSTANDING ABOUT SOUND

Conceptual Understanding about Sound Iowa Core Curriculum: Understand and apply knowledge of sound, light, electricity, magnetism, and heat	
<u>Understanding the concept of energy as sound</u> Energy can be changed into sound energy. Sound energy is the energy of vibration. Sound energy travels in waves that move only through matter. The uses of sound include communication, navigation, entertainment, and medical diagnosis.	1. Does the student describe the sound concept using the technical vocabulary? 2. Does the student relates sound as a property of a way of energy? 3. Does the student recognize the sound property in their experiments?
<u>Understanding the concept of the nature of sound</u> Sounds are produced by vibration of matter. These vibrations can move through air; they cause the air particles or molecules to press together in places. Sound energy travels in waves. The number of waves passing a point in one second is called the frequency.	1. Does the student describe vibrations? 2. Does the student understand how sound energy travel? 3. Does the students relate sound and uses to everyday life?
<u>Understanding about how transmission of sound occurs through a medium</u> Sounds are produced by the vibrations of matter. These vibratios can move through matter that is in solid, liquid, or gaseous form, but they cannot travel through empty space where there is not matter.	1. Does the student understand how sound travel through matter? 2. Does the student offer an example? 3. Does the student relate sound and vibration?

APPENDIX D: RUBRIC TO EXPLORE CONCEPTUAL UNDERSTANDING ABOUT MAGNETS

Conceptual Understanding about Magnets Iowa Core Curriculum: Understand and apply knowledge of sound, light, electricity, magnetism, and heat	
<u>Understanding the concept of magnetism as a property of matter</u> Magnetism is a property of matter in which there is a force of attraction or repulsion between like or unlike poles. The magnetic forces are strongest near the ends, or magnetic poles, of the magnets.	1. Does the student describe the magnetism concept using the technical vocabulary? 2. Does the student relate magnetism as property of matter? 3. Does the student recognize the magnetism property in their experiments?
<u>Understanding characteristics of magnets</u> Opposite poles of magnets attract; like poles repel. The magnetic field is the region around the magnet where the magnet forces act. Only a few materials show strong magnetics properties. Permanent magnets are made from materials such as iron, cobalt, and nickel, which retain their magnetic properties from long time. Being near or rubbing against a magnet can cause paper clips and nails to become temporary magnets, but they lose their magnetic properties soon after they are separated from the other magnet.	1. Does the student describe magnetic interactions? 2. Does the student understand the materials from which magnets are made? 3. Does the students relate magnetism and uses to everyday life?
<u>Understanding about how magnets interact with each other</u> When you bring the north ends of two magnets close together, they repel each other. However the north and south ends will interact. Like magnetic poles repel and opposite magnetic poles attract. These forces decrease as the distance between the magnets increases.	1. Does the student understand how magnets work? 2. Does the student offer an example? 3. Does the student relate electricity and magnetism?

APPENDIX E: RUBRIC TO EXPLORE CONCEPTUAL UNDERSTANDING ABOUT ANIMALS' HABITATS

Conceptual Understanding about Life Science: Habitats	
Understanding about ecosystem An ecosystem encompasses all of the living (biotic) and nonliving (abiotic) things in a particular area. Biotic factors include plants, animals, fungi, bacteria, and other living things. Abiotic factors include soil, sunlight, temperature, nutrients, and water.	1. Does the student understand what an ecosystem is? 2. Does the student identify that plants and animals are related by the food chain? 3. Does the student provide an example of ecosystem?
Understanding the concept of animal habitats An organism's habitat is the physical place where it lives. An organism's habitat is usually a small part of the ecosystem.	1. Does the student describe the habitat concept using the technical vocabulary? 2. Does the student understand the difference between ecosystem and habitats? 3. Does the student provide an example of habitat? 4. Does the student understand the concept of food web and food chain?
Understanding niche concept A niche is an organism's role within ecosystem. The niche includes an organism's uses of the biotic and abiotic resources in an ecosystem. Owls swallow their prey whole, or nearly whole when possible. While soft tissues are digested, fur, feathers, and bones are not. About 12 hours after feeding, the owl regurgitates a compact pellet containing the undigested material.	1. Does the student infer the owl role in the ecosystem? 2. Does the student understand the owls' feeding habits? 3. Does the student infer owls' diet?

APPENDIX F: RUBRIC TO EXPLORE CONCEPTUAL UNDERSTANDING OF HUMAN-CHANGED ENVIROMENTS

<table>
<tr><th colspan="2">Conceptual understanding about how organisms cause changes in the environment in which they live.
Iowa Core Curriculum: Analyze how all organisms, including humans, cause changes in their ecosystems and how these changes can be beneficial, neutral or detrimental.</th></tr>
<tr><td><u>Positive Impacts to the Environment</u>
Cleaning Waterways:
Waterways get clogged up with the accumulation of natural debris and excessive plant growth, and also by waste dumping. Periodical clearing prevents flooding of the banks and protects many ecosystems.
Reforestation Efforts:
Large areas that underwent deforestation for cultivation, grazing, and for human settlements are reforested with native plant species to restore ecological balance.
Protecting Native Species:
Animals and others are afforded protection by declaring certain areas of their native habitat as protected reserves. This may help increase their numbers.</td><td>1. Does the student understand their own impact on the environment?
2. Does the student mention how humans can help to protect the environment?
3. Does the student understand that humans can affect environments positively?</td></tr>
<tr><td><u>Negative Impacts to the Environment</u>
Soil pollution: Pesticides, herbicides, large landfills, waste from food processing industries, and nuclear waste generated from nuclear reactors and weapons deplete our soil of its nutrients and make it virtually lifeless.
Air pollution: Burning of fossil fuels and toxic gases produced in factories cause pollution. Air pollution infects the environment and threatens the health of all who inhabit the earth.
Global warming and ozone layer depletion:
Carbon footprint is the measure of direct or indirect CO2. Greenhouse gases like CO2 and methane are believed to lead to global warming. Chlorofluorocarbons (CFCs), used in refrigeration, and aerosols destroy the ozone layer that shields the earth from UV rays.</td><td>1. Does the student describe how soil can be contaminated?
2. Does the student describe air pollution?
3. Does the students understand the concept of global warming?</td></tr>
</table>

APPENDIX G: RUBRIC TO EXPLORE CONCEPTUAL UNDERSTANDING OF MATTER

<table>
<tr><th colspan="2">Conceptual Understanding about States of Matter</th></tr>
<tr><td><u>Understanding the concept of matter</u>

Matter is anything that has mass and takes up space. Materials can exist in different states – solid, liquid and gas.

Properties of matter: mass, weight, volume, density, color, odor, shape, texture and hardness</td><td>1. Does the student describe the matter concept using the technical vocabulary?
2. Does the student understand that matter is usually found in three states: liquid, solid, and gas?
3. Does the student identify the properties of solid, liquid and gas?</td></tr>
<tr><td><u>Understanding the properties of matter</u>

Some common materials can be changed from one state to another by heating or cooling.

1. Physically, a change in the size shape or state of matter (e.g., the melting of an ice cube, tearing of paper).
2. Chemically, where matter can change into another kind of matter (e.g. burning of wood, rusting of iron).</td><td>1. Does the student understand concepts such as melting point, boiling point and freezing point?
2. Does the student understand the concept of evaporation, condensation and sublimation?
3. Does the students understand that matter can change physically and chemically?</td></tr>
</table>

APPENDIX H: RUBRIC TO EXPLORE SCIENCE PRACTICES

Engaging in the practice of science Engaging in the practice of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world.	
Asking questions (science) and defining problems (for engineering) Scientific questions arise in a variety of ways. They can be driven by curiosity about the world, inspired by the predictions of a model, theory, or findings from previous investigations, or they can be stimulated by the need to solve a problem. Scientific questions are distinguished from other types of questions in that the answers lie in explanations supported by empirical evidence, including evidence gathered by others or through investigation	1. Does the student identify scientific testable and non-scientific non-testable questions? 2. Does the student use prior knowledge to generate the question? 3. Is the question that is generated feasible to carry out in the classroom?
Developing and using models Models include diagrams, physical replicas, mathematical representations, analogies, and computer simulations. Although models do not correspond exactly to the real world, they bring certain features into focus while obscuring others. All models contain approximations and assumptions that limit the range of validity and predictive power, so it is important for students to recognize their limitations	1. Does the student build a model to represent and explain a scientific phenomenon? 2. Does the student develop a model in a collaborative way? 3. Does the student identify the limitation of the model?

Planning and carrying out investigations Scientific investigations may be undertaken to describe a phenomenon, or to test a theory or model for how the world works. Whether students are doing science or engineering, it is always important for them to state the goal of an investigation, predict outcomes, and plan a course of action that will provide the best evidence to support their conclusions. Students should design investigations that generate data to provide evidence to support claims they make about phenomena. Data aren't evidence until used in the process of supporting a claim. Students should use reasoning and scientific ideas, principles, and theories to show why data can be considered evidence.	1. Does the student plan and conduct an investigation in a collaborative way? 2. Does the students evaluate their testing plan? 3. Does the students make observations and/or measurements to produce data?
Analyzing and interpreting data Once collected, data must be presented in a form that can reveal any patterns and relationships and that allows results to be communicated to others. Because raw data as such have little meaning, a major practice of scientists is to organize and interpret data through tabulating, graphing, or statistical analysis. Such analysis can bring out the meaning of data—and their relevance—so that they may be used as evidence.	1. Does the student represent data in tables or multimodal representation to reveal patters that indicate relationship? 2. Does the student record information? Observation though ideas? 3. Does the student use logical reasoning to make sense of a phenomena? 4. Does the student compare and contrast data based on prior experiences?

Using mathematics and computational thinking Students are expected to use mathematics to represent physical variables and their relationships, and to make quantitative predictions. Other applications of mathematics in science and engineering include logic, geometry, and at the highest levels, calculus. Computers and digital tools can enhance the power of mathematics by automating calculations, approximating solutions to problems that cannot be calculated precisely, and analyzing large data sets available to identify meaningful patterns. Students are expected to use laboratory tools connected to computers for observing, measuring, recording, and processing data. Students are also expected to engage in computational thinking, which involves strategies for organizing and searching data, creating sequences of steps called algorithms, and using and developing new simulations of natural and designed systems.	1. Does the students organize simple data to reveal patterns that suggest relationships? 2. Does the student recognize when to use qualitative vs. quantitative measurements? 3. Does the student describe measurement estimates and/or graphs to address scientific problems?
Constructing explanations (for science) and designing solutions (for engineering) The goal of science is to construct explanations for the causes of phenomena. Students are expected to construct their own explanations, as well as apply standard explanations they learn about from their teachers or reading. An explanation includes a claim that relates how a variable or variables relate to another variable or a set of variables. A claim is often made in response to a question and in the process of answering the question, scientists often design investigations to generate data.	1. Does the student provide a claim? 2. Does the claim answer the research question? 3. Does the student construct an explanation based on observations?
Engaging in argument from evidence	1. Does the student refine their reasoning based on research

Argumentation is a process for reaching **agreements** about **explanations** and **design solutions**. In science**, reasoning** and **argument based on evidence** are essential in identifying the **best explanation** for a natural phenomenon. In engineering, reasoning and argument are needed to identify the best solution to a design problem. Student engagement in scientific argumentation is critical if students are to understand the culture in which scientists live, and how to apply science and engineering for the benefit of society. As such, argument is a process based on evidence and reasoning that leads to explanations acceptable by the scientific community and design solutions acceptable by the engineering community.	findings? 2. Does the student respectfully provide and received critiques from the audience? 3. Does the student construct an argument based on evidence (data reasoning) or model?
Obtaining, evaluating, and communicating information Communicating information, evidence, and ideas can be done in multiple ways: using tables, diagrams, graphs, models, interactive displays, and equations as well as orally, in writing, and through extended discussions**.**	1. Does the student obtain and combine information from book or other resources to obtain scientific information? 2. Does the student communicate scientific information orally or in writing formats? 3. Does the student read appropriate text resources to obtain scientific information and describe how are they supported by evidence?

APPENDIX I: RUBRIC TO EXPLORE UNDERSTANDING OF ARGUMENTATIVE COMPONENTS

Understanding Argumentative Components	
Three core elements of argument Three core elements of arguments (questions, claim, and evidence) are explicitly and clearly described.	1. Is/are the question(s) posed by the author testable? 2. Is/are the author's claim(s) valid? 3. Is the evidence reliable?
Connections among elements of argument The author creates causal coherent connections among elements of arguments through his/her argument.	1. Does the author's claim plausibly answer the question? 2. Is the author's claim plausibly supported by evidence? 3. Does the author plausibly create evidence from data?
Level of scientific-explanatory argument Student-authors' explanatory argument should make sense to readers to scientifically understand natural phenomena.	1. Does the author's explanation present how something happened? 2. Does the author's explanation present why something happened? 3. Is the explanation connected to observable events or phenomenon and unobservable and theoretical components by using powerful science ideas and models?
Level of rhetoric reference of reasoning The author explicitly provides his/her reasoning to present how data in his/her investigation is used to support the claim.	1. Is his/her reasoning presented inclusively? (At the simplest level students merely include data in their explanation without any exposition as to its purpose, i.e. DNA sequencing results). 2. Is his/her reasoning presented descriptively? Summaries of what graphs show or occasionally the meaning of the graph. 3. Is his/her reasoning presented interpretively? Students interpret the significance of their data for their explanation.

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