Using Inquiry and Tenets of Multicultural Education to Engage Latino English-Language Learning Students in Learning About Geology and the Nature of Science

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ABSTRACT

Traditional school science instruction has been largely unsuccessful in reaching diverse student groups and students from, in particular, underrepresented backgrounds. This paper presents a case study of an urban, dual-language middle school classroom in which the teacher used an alternative instructional approach, involving her students in an authentic geological investigation with fossils. In this instructional setting, the teacher successfully engaged her English-language learning students from Latino backgrounds in science learning through inquiry, instructionally congruent science teaching strategies, and explicit instruction in nature of science. Students participating in the geological investigation interacted with practicing scientists. This instructional approach modeled the activities of science and better connected diverse students to the scientific community of practice. The practices used in this classroom provide a compelling example of how science instruction can be carried out in a way that makes science accessible despite linguistic differences and engages students in the activities of science, who otherwise might not be. © *2012 National Association of Geoscience Teachers*. [DOI: 10.5408/10-213.1]

Key words: inquiry, underrepresented, multicultural, instructional congruency, nature of science

INTRODUCTION

Few countries boast the diversity and educational opportunities of the United States. However, educational researchers, practitioners, and policy makers in the United States are still in the nascent stages of learning how to engage all students, including students from diverse and underrepresented backgrounds, in science learning (Organization for Economic Cooperation and Development, 2010). Traditional instructional approaches in science have largely been unsuccessful in reaching English-language learning (ELL), Latino, Native American, and African-American student groups, who remain underrepresented in the field of science (National Academy of Sciences, 2010). These groups constitute a large and growing proportion of students in urban school environments, which oftentimes do not provide authentic learning experiences (Settlage and Meadows, 2002) or have the resources (Rivera Malucci, 2010) to engage students in science learning in meaningful ways.

This paper presents a case study of an urban, ELL middle school classroom that is engaged in an authentic scientific investigation as a context for both science and ELL. In this classroom, the teacher, Monica, makes a significant point of departure from traditional science instruction by involving her students in inquiry-based instruction. As such, these students participate in asking scientifically oriented questions, making observations and inferences, and conducting data collection and analysis. She does so with instructionally congruent practice (ICP), in which she draws on students' everyday understandings and increases the accessibility of the science content matter through linguistic scaffolding. Further, Monica explains how the activities students are involved in relate to actual scientific practice, combined with the pedagogy of explicit instruction in nature of science (NOS). We hypothesize that these combined instructional approaches, inquiry, ICP, and NOS could help increase the accessibility and demystify science for diverse groups of students. In particular, we have evidence that the instructional approach used by this teacher will have significant bearing on students from underrepresented groups when applied more broadly by other teachers.

This paper describes the theoretical underpinnings of the Fossil Finders project, a curriculum developed to engage students in authentic scientific investigations in collaboration with scientists and to provide explicit instruction in NOS. It further describes how Monica strived to integrate aspects of ICP into inquiry-based science teaching in her dual-language classroom. We share vignettes to demonstrate how Monica combined inquiry with a linguistically accessible and culturally relevant instructional approach. We further illustrate how students, in turn, engaged in thinking about and learning science.

THEORETICAL BACKGROUND

In many science classrooms, teachers use traditional science instruction. This instruction involves a didactic approach, in which educators introduce science to students through lectures, worksheets, and laboratory investigations that reinforce science principles presented in teacher-directed lessons. Inquiry-based authentic investigation, as an alternative instructional approach, offers active learning opportunities for students in the practice of science

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(Crawford, 2000). These learning opportunities are significant in that science content-matter learning becomes contextualized in actual scientific inquiry. In an inquiry-based science classroom, a learner (1) engages in scientifically oriented questions, (2) gives priority to evidence in responding to questions, (3) formulates explanations from evidence, (4) connects explanations to scientific knowledge, and (5) communicates and justifies findings (National Research Council [NRC], 2000, p. 29). These essential five features of inquiry align with other reform efforts in science education, in which science learning includes engaging students in "knowing," "doing," and "talking" science (American Association for the Advancement of Science, 1989).

Though several studies have found inquiry-based instruction successful with certain ELL student groups (Amaral et al., 2002; Lee et al., 2006), inquiry-based instruction might continue to challenge students from underrepresented backgrounds. This is because inquiry, based on the tenets of Western modern science, might not be culturally congruent with all students' backgrounds and the instructional settings to which they have become accustomed (Lee and Fradd, 1998). Without greater attention to the cultural backgrounds of students, inquiry-based learning might not serve to engage all students in science learning. Accordingly, we propose using an instructional approach that couples inquiry with ICP. Aligned with other research on science learning for diverse and ELL students (cf. Warren and Conant, 1992; Aikenhead, 1996; Rosebery et al., 2002), Luykx and Lee (2007) have shown that ICP are those that take students' linguistic and cultural backgrounds into account, while engaging them in content-matter learning. Strategies toward ICP in science include (1) a sharing of scientific authority with students, (2) integrating a diversity of cultural experiences and materials into science instruction, (3) using students' home languages in the classroom, and (4) using linguistic scaffolding to enhance meaning. The sharing of scientific authority with students repositions students as active participants in scientific knowledge construction. Instructional practices promoting student authorship have demonstrated greater student engagement in learning and transfer (Engle and Conant, 2002). Further, instructional practices that draw on students' diverse cultural and linguistic backgrounds by drawing on cultural examples and the use of native language provide students with opportunities to focus on learning scientific content first—with scientific and English-language learning a result (Valdes, 2001; Lipka, 2008). These features of ICP along with inquiry-based instruction could help increase the accessibility of science and reposition students as active participants in their construction of scientific understandings.

This instructional approach provides promise for effective engagement of students in the activities of science and connection of science learning to students' everyday and cultural lives. Nonetheless, through this instructional approach, little is done to support students in further understanding *scientific* culture, which oftentimes remains obscure even to student who engage in inquiry (Schwartz et al., 2004). We thus propose using explicit instruction in NOS (Lederman, 1992; Schwartz and Crawford, 2004) as an instructional approach to bolster ICP (Meyer and Crawford, 2011). Understandings about NOS, or the framework behind scientific knowledge, include that science is

> *...tentative (subject to change); empirically based (based on and/or derived at least partially from observations of the natural world); subjective (theory laden, involves individual or group interpretation); necessarily involves human inference, imagination, and creativity (involves the invention of explanations); and is socially and culturally embedded (influenced by the society/culture in which science is practiced).* (Lederman 2004, p. 304)

Introducing students to science within its framework of knowledge construction provides opportunities for demystifying how scientific knowledge is created and how it changes over time. Such knowledge could provide students with tools for the exploration of science on its own terms, and provide avenues for expanding not only the definitions of science, but also for recognizing its limitations (Southerland, 2000). Though each of these instructional strategies—inquiry, ICP, and explicit instruction in NOS—could serve to strengthen science education in its own right, it is the unique combination of the three that could serve to engage underrepresented students in science learning, increase the accessibility of science, and help demystify science as a field—all of which could contribute lasting effects to student experiences in science learning. We refer to this approach as "multicultural inquiry" because it takes both the culture of science and the background cultures of students into account as a part of science instruction.

These theories guided the development of the Fossil Finders project, a curriculum that engaged students in an authentic investigation of fossils from the Devonian Period and explicit instruction in NOS (will be made available at www.fossilfinders.org). The curriculum was jointly developed by educational researchers and practicing scientists, bridging the gap between school-based science and the authentic activities of scientists. Sustained collaboration with scientists throughout the implementation of the project in classrooms provided students with opportunities to interact with scientists. One teacher's implementation of the curriculum with her ELL students established the grounds for this research. This teacher, Monica, regularly practiced aspects of ICP in her teaching prior to participation in the project. Thus, we were able to observe how Monica used the context of an authentic investigation to integrate inquiry-based instruction and explicit teaching about NOS with ICP. As we later explain, these practices reinforced one another to make science content accessible to students. They also provided learning opportunities for students to engage in inquiry and interact with scientists. In these ways, students were provided with opportunities to learn about and participate in scientific culture.

DESIGN AND METHODS OF ANALYSIS

This study used a case study design and a participatory observation approach (Merriam, 1988) in collaboration with the teacher, to address how student science learning was supported in an instructional setting that merged three distinct approaches: (1) authentic investigation and inquiry, (2) ICP, and (3) explicit instruction in NOS. To this end, the first author observed the enactment of the Fossil Finders

curriculum in one teacher's dual-language, urban fifth-grade classroom, serving 21 Latino students (14 girls and 7 boys) from predominantly low-socioeconomic-status backgrounds (84% of the students received free or reduced lunches).

Students in the class were either first- or second-generation immigrants and spoke Spanish in their homes. As such, students were grouped into high-, intermediate-, and low-levels of English proficiency, as assessed by the school. While the class formally received liberal arts instruction in Spanish, and science and math instruction in English, students informally used Spanish in their groups on a regular basis, and Monica made use of Spanish when clarifying student questions. Thus, students' home languages were integrated into and welcomed in the class.

Monica further aimed to engage her students in learning about science, bringing inquiry into her science instruction. It is important to note this was Monica's first attempt at implementing an inquiry-based curriculum with her students. As evidenced by classroom observations, Monica, in fact, did implement a guided-form of inquiry and engaged her students in most of the scientific aspects of inquiry as defined above. Monica also practiced culturally relevant strategies in her teaching to reach her ELL student population by integrating language and cultural examples.

Monica implemented the Fossil Finders curriculum over 13 instructional days, in block periods between 30 and 90 min. During this time, Monica introduced the background Fossil Finders instructional materials focused on NOS and geology, extended these materials into literacy-building activities, and initiated the fossil investigation. Moreover, a scientist's visit to the classroom established a setting in which students were able to interview and interact with the scientist, providing students greater access to the scientific community.

Data collection in this classroom setting consisted of videorecording instructional days, gathering student work samples, pre- and posttesting students on geological content-matter learning, and interviewing students about their views on science. For the purposes of this paper, video of the instructional days provided the primary source of data (Jordan and Henderson, 1995) to describe the teacher's instructional approach and student engagement in learning. Video recordings were content logged and coded for the instantiation of instructional practice with respect to features of inquiry, ICP, or NOS. Instructional episodes indicative of the teacher incorporating features of inquiry, ICP, or NOS, were then transcribed and analyzed. This paper makes use of representative vignettes of these data to demonstrate how the instructional approach was implemented.

RESULTS AND DISCUSSION

Description of the Fossil Finders Curricular Implementation in Monica's Classroom

The implementation of the Fossil Finders unit consisted of 13 instructional days over the course of 3 mo. During this time, there were three distinct chapters to the implementation of the curriculum: (1) background lessons, (2) literacy extension activities, and (3) the actual investigation (Table I).

Monica began the Fossil Finders unit with background lessons about NOS and fossil identification. During instructional days 1 and 2, Monica initiated the Fossil Finders lesson about NOS called "Tricky Tracks." This lesson was modified from the National Academy of Science's (1998) "Proposing Explanations for Fossil Footprints" activity. The purpose of this lesson was to engage students in beginning to think about aspects of NOS and in particular, to help them learn to differentiate between making inferences and observations. Though this lesson does not offer students an opportunity to work with authentic data, it models the activities of scientists and how scientific knowledge is tentative, and how it could change based on the availability of new information. Thus, students have an opportunity to learn about the empirical nature of scientific work through the context of this activity.

On day 3, Monica introduced the actual fossil samples to the Fossil Finders leaders, a group of eight students with higher levels of English-language proficiency (ELP). Because of their higher levels of ELP, the Fossil Finder leaders remained in class, while the rest of the students received specialized language instruction, working in small groups in the hallway. The Fossil Finders leaders were given a collection of fossils that Monica had gathered over the summer. These were not the research samples of the actual Fossil Finders investigation, but rather a set of fossils handpicked by the teacher for use in helping students practice identifying different types of fossils. As students studied these fossils, they made inferences. Many students thought they were seeing bones, fingers, fish, and so on. Monica allowed the students to retain their initial inferences without correcting them. By later dispersing the student leaders across groups, Monica was able to provide students with a collaborative learning space and address the learning needs of students at various levels of ELP.

By day 4, Monica made adaptations to the Fossil Finders curriculum by adding a story-writing component to the Tricky Tracks activity. She revisited the important concept that scientists might form different interpretations from the same data, and she used this as a vehicle for students to practice literacy skills. Monica asked students to write stories about their own interpretations of what might have occurred in the Tricky Tracks scenario. Over the next several days, students focused on hypothesizing about the environmental conditions in which the fossilized tracks of the Tricky Tracks scenario might have been set. Students used their thinking to create the background and setting aspects of the stories they were writing about the tracks. At the same time, Monica introduced students to the process of identifying fossils by using identification charts. Prior to this, students observed the fossils and made inferences about them. Students thus learned the names of different fossilized organisms and how to differentiate between them based on their sizes and shapes. Students also practiced measuring these fossils and filling out data sheets, with information about the types of fossils they were observing, and the size, color, and condition of each. Throughout the next few days of instruction, Monica repeatedly asked students to make inferences about the environment in which these organisms had once lived. This mirrored what Monica had asked her students to do for their Tricky Tracks stories. Monica continued to fashion the conversations related to the Tricky Tracks writing activity and to make inferences about the environment in which the fossilized organisms once lived. Through this scaffolding, students began to infer that the temperate land environment in upstate New York where Monica collected the fossils had once been covered by a

Table I: Curriculum implementation and focus across instructional days.

Instructional Day	*Chapter*	*Activity*
1–2	Background lessons	Tricky Tracks: Learning about NOS
3	Background lessons	Unguided "discovery" with fossils: What are they? Students form their own ideas
4-12	Literacy activities	Writing stories about Tricky Tracks: Modeling the subjectivity of science
5–9	Background lessons	Students learn to identify and measure fossils. Students then learn to gather more detailed data about fossil samples into a data sheet.
10–11	Investigation	Scientist visits classroom; students conduct investigation.
12–13	Investigation & Literacy activities	Monica confirms student data and measurements by working with individual groups; other students continue working on their Tricky Tracks stories.

tropical ocean. These activities continued for the next several instructional days.

Students then began to prepare for a geologist's visit to their classroom. Monica asked students to draft questions in their journals that they would ask a scientist. On day 10, the geologist, Trina, came to visit the classroom. Trina assisted with the implementation of the fossil investigation and answered student questions. Trina established a friendly rapport with students through her enthusiasm about fossils, storytelling, and joking about being a "geeky" scientist. At the same time, the scientist held students accountable for content-matter learning. With Trina in the classroom, students worked in small groups to identify, measure, and record data related to the fossil samples from sedimentary deposits in upstate New York. These research samples had been collected by Monica with other teachers and collaborating scientists. The samples were labeled, washed, weighed, and shipped to their classroom by the scientists. For the most part, students were able to correctly identify the types of fossil they were seeing, such as differentiating between brachiopods and clams. Student groups continued working to identify, measure, and record information related to fossils in the sample sets through day 11 of the unit.

On days 12 and 13, students worked independently on completing the Tricky Tracks stories at their desks. As they worked, Monica met with individual groups in the back of the classroom to review the samples they had recorded on their data sheets, and to verify information such as the type of fossil and its measurements. At times, Monica found errors in measurements. However, at other times students defended why their data was correct. Through this process, students experienced how scientists might disagree about their observations, and that some scientific data could have uncertainty associated with them.

Over the course of the instructional unit, Monica also appeared to make a shift in her instructional approach, which entailed moving from a teacher-directed approach to a more student-centered approach. Monica reflected on her instructional approach, and commented, "I think sometimes, after you've been in education for so long, that you forget that you do not want to just point out and say 'this is a trilobite.' Instead, we want to say, 'What does this look like to you?&apos" In this statement, Monica demonstrated that she was cognizant about wanting to use a more student-centered questioning approach in inquiry. Further, she engaged students in aspects of inquiry after engaging students in learning about NOS. She was thus able to help students to make a connection with how their work with the fossils aligned with the work of actual scientists. In addition, a classroom visit from an actual scientist reinforced Monica's teaching about NOS and inquiry. Students demonstrated learning and taking ownership of their data toward the end of the unit, as illustrated in the vignettes below.

Monica's Unique Instructional Approach

Monica's instructional approach, embedded into the context of an authentic investigation, provided her with opportunities to (1) practice and engage students in aspects of inquiry, (2) integrate inquiry with her regularly practiced ICP approach, and (3) situate NOS as a cornerstone to explain scientific culture and practice, as well as to frame students as practicing members of the scientific community. How she addressed each is further described below in more detail.

Inquiry as a way of doing science

Transcriptions provide evidence of Monica directly emphasizing essential features of inquiry, such as use of evidence to justify explanations and tying explanations to scientific knowledge. This can be seen in the following transcription of Monica's statements on day 1 of instruction:

> *I like the way that everyone is saying that one dinosaur went home because we don't like to think that one dinosaur ate the other dinosaur. You don't like to have that happen. But, actually that's the food chain. It does happen for survival. One animal, we knew that one footprint is smaller than the other. And we saw the larger one. So, we knew that one...the larger animal most likely is going to be able to eat the smaller animal and defeat it. And that he will be the predator and he's going to eat it, right? And that's how he's going to survive, right? So, we like to say he went back home, but if you look at the footprints, we didn't see the footprint going back home. Okay? So, we really can't infer that a footprint went back home, though it's a nice thought, we don't like to think that one animal ate the other, but we know that that happens in nature. One animal eats the other, we know that?*

Here, she addressed the anthropomorphic explanations that students gave for what had occurred across the Tricky Tracks scenario and the need to use evidence when constructing explanations (a feature of inquiry). In her statement "We don't like to think that one dinosaur ate the other dinosaur. . .but, actually that's the food chain," Monica

gives an example of connecting explanations to age-level-appropriate scientific knowledge (NRC, 2000, p. 27) Moreover, she demonstrates the need to use evidence in constructing explanations with her comment on the direction of the footprints. "If you look at the footprints, we didn't see the footprint going back home." These comments were reiterated later during instruction.

Students communicated their understandings and data-based interpretations through oral presentations to the rest of the class members. These presentations consisted of a volunteer student (oftentimes one with a higher level of ELP, as further described below) standing in front of the class and reading his or her work aloud. Though student presentations were a regular part of classroom instruction prior to the Fossil Finders unit, Monica modified these student presentations to embrace features of inquiry, e.g., communicating and justifying their findings. Further, both Monica and the students' peers provided feedback to the presenting student, focused on good use of vocabulary, scientific knowledge, descriptions, etc. Monica thus used this time to comment on the importance of the use of evidence when formulating explanations. For example, when Isabel and Bianca shared their stories about dinosaurs without making reference to the evidence, Monica commented,

> *What I have a comment about for both of you and for anybody else is that the Tricky Tracks was a great story starter for you, but we're not connecting back to our Tricky Tracks. So, for Isabel, I would want you to add in there: How did the Tricky Tracks lead you to the escaped T. rex? And, I want you, Bianca, to tell me, How did the Tricky Tracks lead you to the dinosaur egg? Okay? So, we have to incorporate the Tricky Tracks in our stories. If you don't have that in there, I will come up with a question for you and then you'll be able to incorporate. Okay?*

Here, Monica again referred to the need to use evidence in constructing explanations. In this passage, she also indicated she would be providing students with instructional scaffolding to meet this goal by formulating guiding questions for these students. Together, these passages typify Monica's attempt to implement an inquiry-based instructional approach in her classroom and to facilitate student engagement in the various features of inquiry.

These findings mostly fall in line with the anticipated outcomes of a teacher's use of inquiry in a normal classroom setting. For example, it is not usual for a teacher to utilize all features of inquiry in a single lesson; rather, the use of inquiry is dependent on lesson objectives. However, Monica's integration of inquiry with other instructional practices such as ICP and explicit instruction of NOS, as further described below, provides compelling examples of the culturally relevant learning opportunities created by involving students in authentic investigation.

ICP: Making science more accessible

The ICP observed in Monica's classroom simultaneously reflected aspects of inquiry. For instance, Monica provided time for students to explore fossil samples and to make sense of what they were seeing, based on their prior knowledge as an introductory part of the curriculum. One of the students, Raul, enthusiastically began sorting through the fossil collection, making inferences about what he was seeing. However, he demonstrated little subject-matter knowledge about the fossils he was observing. Raul described what he was seeing to the first author on the second day of making fossil observations:

> *Raul: I think I found a fish.*
>
> *Xenia: A fish? Why do you think it's a fish?*
>
> *Raul: 'Cause it has the fin right there and it looks like it has the eye.*
>
> *Xenia: Oh, it looks like a fish. The rock itself. Okay.*

In this segment, Raul interpreted the entire rock as a fish fossil. He provided rationale for his thinking by pointing to striation formed on the rock, which he thought was a fin. Moreover, what he thought was an eye was actually an indentation in the rock. Though Raul was clearly making a mistake, Monica provided him with the instructional opportunity of making observations and drawing from his own inferences. In other words, Raul was given opportunity for him to make sense of his observations himself. This opportunity is rare in many science classrooms. In this case, Monica repositioned herself as a facilitator of instruction, not the ultimate source of knowledge, and allowed students to make sense of what they were seeing on their own terms. During this time, Monica also deferred scientific authority to students in terms of what they were seeing and did not correct their evident mistakes. In this way, she allowed them to bring their own understandings into the science-learning process. She also recognized the contributions of students, or their authorship, and provided them with opportunities to share scientific authority. In a later class, she attributed content-matter–knowledge connections to particular students. For example, during a classroom reading session, Monica embedded a comment to relate it to what Raul had said in class the day before:

> *Monica: There are specific fossils found in different parts of the U.S.…[we are] looking for signs of the sea that was once here…And, that was a discovery that Raul made yesterday, that New York State was…?*
>
> *Raul: [Enthusiastically interjects] Underwater!*
>
> *Monica: One time, underwater…*

Here, Raul had scientific authority validated by his teacher. Monica also probed students to consider that there were multiple plausible answers to their questions. In this way, she constructed a classroom environment in which she was no longer the single source of knowledge, but rather, she took on the role of a learning facilitator.

Monica further regularly embedded linguistic scaffolding into her instruction, and she invited the use of everyday language into the classroom. These are both features of ICP. Many literacy-building activities were already embedded in her instructional approach, and Monica further adapted science-learning activities into writing activities. The Tricky Tracks story-writing activity described above is an example of this. In this activity, Monica emphasized the creative features of science and some of the possible inferences that

scientists might make, given the same data set. Students consistently made use of their everyday and native languages in the classroom, though generally, formal instruction occurred in English. Video records demonstrate Monica addressing particular students in Spanish. In the following transcription, Monica is explaining classroom instructions to an ELL student:

Nosotros estamos haciendo una historia de los dinosaurios. ¿Estábamos [inaudible]…verdad? Ahora, estamos haciendo una historia…de si fue un dinosaurio entra…okay. ¿Ahora entiende? (We are making a story from the dinosaurs. We were…right? Now, we are making a story…about if one dinosaur entered…okay? Do you understand now?)

Though parts of the above dialogue are missing, it nonetheless illustrates the form of instructional support Monica provided by using the students' native languages. Through language support, Monica was able to ensure that all students were accessing classroom directions and clarify questions. Transcriptions of video records also indicate Monica inviting students to take notes in Spanish should they choose to, and episodes in which students used Spanish while working in their groups.

Features of ICP brought together with inquiry were salient in Monica's practice of drawing from students' diverse cultural experiences. An example of Monica drawing from student experiences during instruction can be seen during the visiting scientist's discussion of climate and locations where fossils can be found. In the following transcription, Monica connected a portion of the scientist's discussion with her students' experiences:

Scientist: What's the equator like?

Students: [In chorus] Hot!

Scientist: Hot, humid, right? Rainforesty, right? So, just above the equator, say Florida, Mexico, Caribbean Islands…what is that climate like? [Hot] But, like a beach. You all lay out and tan.

Monica: Everybody here is familiar with the Caribbean Islands 'cause most of you have been there. Where, where do you go?

Brendan: Puerto Rico… right?

Monica: Puerto Rico.

In this example, Monica connected the instruction to her students' backgrounds, given that most of the students in her classroom either immigrated to the United States from Puerto Rico or had families there that they visited.

Nature of science: Explaining scientific culture

Inquiry-based instructional strategies that theoretically reflect scientific practice and instructionally congruent teaching can practically increase the accessibility of science instruction for ELL students were reinforced by Monica's instruction in NOS. This included utilizing the context of the Fossil Finders investigation to position students as practicing scientists and explaining how scientists go about gathering empirical evidence. The following transcript provides evidence for Monica's positioning of the students as practicing scientists and justifying tasks based on what scientists do:

It's important as scientists to always keep accurate records and to date all of your [journal] entries. Okay? We date everything we do in our class anyway, right? Reading, writing, everything that we do, but specifically as scientists, you need to keep accurate notes and put your date all the time, whenever you do entries.

By positioning her students as researchers that are helping scientists, Monica engaged her students in the practices of scientists. This positioning allowed her to consistently compare what students were doing with the work of professional scientists and justify the tasks she was asking students to do. When Monica framed her students as scientists and justified the activities of scientific practice when it came to careful observation, measurement, and working with data, she also addressed the empirically based characteristics of science, a feature of NOS. Monica further addressed additional features of NOS by using the Tricky Tracks activity. For example, she made the case that "[different] scientists have the same evidence but different conclusions." In this way, Monica addressed the subjective and interpretive features of science in the following transcription:

So, that's what I wanted you to see…different perspectives, different ways that you can view the Tricky Tracks, okay? And I want you to think back, do you remember...there was question [we had] that said, 'If scientists all have the same facts, how come they have different theories on what may have happened to dinosaurs?'...If they all have the same facts, why do they have different theories? Remember we said it was different stories? This is the perfect example of how we can have the Tricky Tracks, the same facts, the same observation, but yet we are making different inferences, right? Different takes on what could have been. Does that make sense to you?

Monica also addressed the creativity feature of science and emphasized the difference between making observations and inferences. She modeled these differences in the Tricky Tracks activity and continued to apply the terms "observation" and "inference" throughout the rest of the instructional unit. Students demonstrated evidence of transferring these concepts to understandings about New York State geology by making the inference that their local environment in upstate New York was once covered by ocean water. However, though Monica implicitly addressed the socially influenced features of NOS, transcripts do not provide evidence that Monica explicitly referred to science as a socially constructed body of knowledge that is influenced by the culture(s) in which it is practiced. This feature of NOS could have been particularly relevant in making this concept explicit to underrepresented students.

Access to a scientist, who explained how she went about "doing science" and the steps she took to become a scientist, further helped demystify scientific culture. Together, the positioning of students as practicing scientists and access to a practicing member of the scientific community provided students with the opportunity to not only learn about

scientific culture, but to also be participants of a scientific classroom culture.

CONCLUSION

The analyses of classroom observations in Monica's classroom reveal how one teacher employed a unique instructional approach that combined features of inquiry, ICP, and explicit instruction in NOS through the context of an authentic investigation. We refer to this combined instructional approach, which has potential for reaching diverse students in science as "multicultural inquiry." In other words, this instructional approach uses a culturally congruent practice when involving students in inquiry and the context of authentic scientific activity to demystify NOS, or the deeper-set cultural notions about science.

The Fossil Finders curriculum provided Monica with opportunities to implement a multicultural inquiry approach by involving her students in authentic data collection and discussions related to NOS, all the while addressing differing linguistic abilities and the cultural backgrounds of her students. Though the instructional approach used by Monica was embedded in a curriculum, it is plausible to consider that the same instructional approach could be used more broadly with other inquiry-based science-curriculum materials.

When it comes to inquiry, episodes from lessons across the Fossil Finders unit demonstrate that Monica addressed particular features of inquiry to different degrees. Together, these features formed a foundation for introducing scientific activity and culture to the classroom. Monica provided her students with questions to pursue and opportunities to grapple with fossil samples and data. Data also indicate that Monica regularly implemented features of ICP in her classroom, though many of these practices were already established prior to the Fossil Finders unit. For instance, Monica did not need to clarify that students could use their native and everyday languages in the classroom. This was a classroom norm. The context of authentic investigation, however, provided Monica with a natural space within which to infuse concepts of NOS (Schwartz et al., 2004) into her teaching. Moreover, it provided opportunities to demystify the activities that students were involved in by explaining how they were related to the activities of actual scientists. Additionally, Monica was able to position what students were doing as the work of scientists, using NOS as a source of rationale. This positioning could be a key component to enhancing student views about science and identity development as future scientists (Holland et al., 1998).

The implementation of the Fossil Finders curriculum, in particular in an ELL context, provided a basis on which to analyze the feasibility of implementing a multicultural inquiry instructional model. Monica's classroom served to demonstrate what might be possible, in terms of innovative approaches to science teaching and learning, to engage diverse students at different levels of ELP in science. By involving her students in an authentic scientific investigation, Monica allowed her students to build language skills as they engaged in content-matter learning, and made a significant point of departure from traditional instruction in science. Moreover, through her attempts to reposition herself as a learning facilitator rather than the ultimate source of knowledge, she engaged students in co-constructing understandings about science. Monica also made various features of NOS explicit through instruction, a significant step toward demystifying science by framing science content within an authentic scientific context. As a teacher working in a bilingual classroom setting and making use of many strategies for ICP, she also demonstrated how these separate constructs of the multicultural inquiry approach conceptualized in this study could be merged. Monica's teaching provides an excellent example of what is possible in an upper–elementary school classroom of ELL students, and where, perhaps, teacher support is needed for science instruction, framing science as a cultural way of learning. However, the multicultural inquiry approach need not be limited to ELL classrooms. With the consideration of science as a language and culture (Lemke, 2001), all students effectively become science-language learners who could benefit from instructional strategies, making the language and culture of science clear.

More broadly, findings from Monica's classroom suggest that, in fact, upper–elementary school educators can integrate rigorous and culturally accessible science instruction into their practices, given appropriate and sustained support. Further research is needed to consider the added supports educators might need to implement innovative curricula with their students. Additional research is also needed to consider student learning in such instructional contexts. Students, as in the case of Raul described above, demonstrated learning about scientific inquiry and geology content matter through the context of an authentic investigation (Meyer, 2010). In other words, the learning opportunities that were constructed for them were accessible, and engaged students in learning science. Though these scenarios provide positive support for the instructional approached used in Monica's classroom, they form only initial understandings about how to support diverse students in science-content learning. More research is needed to learn about whether science learning in an authentic setting can be coupled with identity formation for students as potential practicing scientists (Holland et al., 1998). Further, more research is needed to determine whether authentic science-learning opportunities could have a long-term impact on student performance and interest in science for underrepresented groups, in particular.

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