Scientific Discourse in Three Upper Elementary Classrooms: The Role of the Teacher in Engaging Elementary Students in Argumentation

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There is broad acknowledgment in the research community that literacy practices such as reading, writing, and oral discourse play a significant role in learning and practicing science (Cervetti & Pearson, 2012; Krajcik & Sutherland, 2010). *A Framework for K-12 Science Education* (National Research Council [NRC] 2011) highlights this relationship, noting that “reading, interpreting, and producing text are fundamental practices of science, and they constitute at least half of engineers’ and scientists’ total working time” (pp.3-19). Various scholars (e.g., Lee & Spratley, 2010; Moje, 2008; Pearson, Moje, & Greenleaf, 2010) have argued that without explicit attention to the unique reading and writing practices within subjects such as science, students will leave school with an inadequate understanding of what it means to use literacy as a tool for constructing and evaluating knowledge within the various disciplines.

Two literacy practices essential to producing new knowledge in science are argument and critique (Krajcik & Sutherland, 2010; Osborne, 2010). Argumentation has not only been identified as a core practice of science, but is also the keystone of a democratic society (Allen, Montalbano, & Duke, 2018). Research suggests that student participation in argument helps to (a) develop students’ communication skills, (b) enables metacognitive awareness, (3) promotes critical thinking, (4) supports students’ understanding of the culture and practice of science, and (5) fosters scientific literacy (Jimenez-Aleixandre & Erduran, 2007). These abilities are consistent with those characterized as twenty-first century skills necessary for a variety of professions (Zembal-Saul, McNeil, & Hershberger, 2013).

An emphasis on evidence and argumentation is evident within the framework for K-12 science education (NRC, 2011), and national standards and reform documents in education (American Association for the Advancement of Science [AAAS], 2009; National Governors Association Center for Best Practices & Council of Chief State School Officers [NGA &
Both the Common Core State Standards (CCSS; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) and Next Generation Science Standards (NGSS Lead States, 2013). The NGSS positions argumentation as a critical approach for promoting students’ knowledge building and cognitive thinking in science. The focus on argumentation is also deeply rooted within each strand of the college and career anchor standards. Students are expected to demonstrate that they can utilize specific textual evidence to support both oral and written claims (NGA & CCSSO, 2010). The Benchmarks for Science Literacy (AAAS, 2009) also include a similar focus on justifying claims with evidence.

Previous studies on argumentation in science education have focused mainly on students in the middle and high school grades (e.g., Kawalkar & Vijapurkar 2013; McNeill & Pimentel 2010; Sampson, Enderle, Grooms, & Witte, 2013). Although major reports, such as the 2007 National Research Council (NRC) report titled, Taking Science to School, have highlighted the importance of engaging elementary students in scientific practices, discourses, and reasoning, little research currently exists to assist elementary teachers in this effort. For this reason, I wish to design a study to explore how teachers can scaffold elementary students’ engagement in argumentative discourse within the science classroom.

This study will aim to answer the following research questions:

a. What are the patterns in classroom discourse in three fifth-grade elementary science classrooms?

b. What is the role of the teacher in promoting scientific argumentation in terms of both the argument structure and dialogic interactions in classroom discourse?
Literature Review

Despite the emphasis and the increased attention on argumentation over the last few decades, argument is nearly absent from science education (Osborne, 2010). Previous reviews of literature related to argument in science education (e.g., Cavagnetto, 2010; Driver, Newton, & Osborne, 2000; Sadler, 2004) have found that current classroom practices provide few opportunities for students to develop their ability to construct arguments. While social interaction plays a prominent role in the lives of professional scientists, students in science classrooms often work independently with little opportunity to share ideas, findings, or interpretations (Cavagnetto, 2010). Furthermore, while studies reviewed did provide evidence that students’ argumentation skills can be enhanced through involvement in discursive activities, few teachers have the necessary skills to effectively facilitate argument-based discussions. As a result, the majority of science lessons are dominated by teacher talk. The importance of argumentation for people’s lives, combined with the well-documented lack of argumentation in science classrooms, makes it imperative to identify effective educational methods that support the development of scientific argumentation.

Earlier reviews on this topic (Cavagnetto, 2010; Driver, Newton, & Osborne, 2000; Sadler, 2004) have focused on studies carried out in secondary science classrooms. As a result, little information currently exists on the practice of scientific argumentation at the elementary level even though research suggests that early elementary science practices are fundamental for developing proficiency in science (NRC, 2007). Additionally, opportunities for elementary students to participate in scientific argumentation are rare due to the false assumption that they lack the cognitive capacity to engage in reasoning practices that are inherent to scientific
thinking. Although not exhaustive, this literature review provides insight into how teachers can scaffold elementary students’ engagement in argumentative discourse in science classrooms.

Teacher Roles in Supporting Argumentation and Dialogic Interactions

Research suggests that a critical component in promoting argument is the need for more student-student dialogical interaction (Driver et al., 2000; Martin & Hand, 2009). For young children who are new to constructing scientific arguments, dialogic discussion can serve as an important scaffold. Stemming from sociocultural theories of development (e.g., Vygotsky, 1978), dialogic discussions provide a social environment in which key discourse skills (e.g., asking questions, providing reasons and evidence) can be acquired through apprenticeship by a more knowledgeable other. As students observe and interact with more knowledgeable others, they are able to engage in cognitive processes beyond their current ability level. Students and teachers can both act as a more knowledgeable other through modeling and scaffolding. Through what Croninger, Li, Cameron, and Murphy (2017) refer to as a discourse apprenticeship, students gradually internalize higher cognitive functions, such as critical and analytic ways of thinking and reasoning.

Research has suggested that teacher questioning is a major contributing factor shaping the role of teachers for promoting dialogic interaction in argumentative practice (Chen, Hand, & Norton-Meier, 2017; Chin, 2007, Martin & Hand, 2009). Findings from Chin’s (2007) analysis of teacher-student interactions across six seventh-grade classrooms suggest that different roles of questioning serve different functions for scaffolding student thinking and construction of scientific knowledge. While many previous studies on classroom discourse have simply categorized the types of questions through the dichotomy of closed and open-ended questions (e.g., Martin & Hand, 2009), Chen, Hand, and Norton-Meir (2017) examined the multi-function
and relationship between teacher questions and student cognitive responses. Chen and colleagues conceptualized four critical roles of teacher questions: dispenser, moderator, coach, and participant. Results from this multiple-case study revealed that as teachers shifted from relying solely on the dispenser role to using multiple roles, higher levels of student cognitive responses were promoted. Similar to Chin’s (2007) findings, Chen and colleagues conclude that teachers must adopt various roles of questioning when establishing dialogic interaction in argumentation.

In order to provide opportunities for students to participate productively in scientific discourse, teachers must transition from their traditional role as sole authoritative voice in the classroom to a new role in which they encourage and support students to have a more active voice in discussion. For many teachers, engaging students in dialogic discussion for the purpose of constructing scientific arguments is a significant departure from the way they typically teach science (Zembal-Saul, McNeil, & Hershberger, 2013). Research suggests it can take more than a year before significant shifts in classroom discourse patterns are observed. For example, in a longitudinal study that examined the discourse patterns of a fifth-grade teacher, Martin and Hand (2009) found that it took an 18-month period to transition from a teacher-centered, didactic teaching style to an argumentative orientation in which students played a more active role in classroom discussion. As Chen, Hand, and Norton-Mier (2017) warn, shifting classroom discourse patterns is not a simple matter of developing a new skill, but instead requires an in-depth understanding of current classroom discourse norms and utilizing instructional strategies that can be used to establish new rules for classroom discourse.

Together, these studies show that teacher questions have the potential to increase student talk and expand classroom discourse beyond the traditional lecture format (McNeil & Pimental, 2009) and that increasing the amount of student-student dialogical interaction within the
elementary science classroom is central to promoting argumentation. Thus, the role of teacher questions in science talk offers a promising area for future investigation in the search for a better understanding of how to teachers can scaffold elementary students’ engagement in argumentative discourse.

**Methods**

**Instructional Context**

This study will take place during a multi-day lesson on water ecology and the effect of humans on the environment. The purpose of this lesson is for students to identify the causes of water pollution and what humans can do to combat the problem. Students will be asked to craft a reasoned, evidence-based argument to persuade others. On day 1, teachers will focus on building background knowledge and eliciting interest in the topic. Students will brainstorm how water becomes polluted and view a short *BrainPop* video clip on water pollution. After observing the video clip, students will have the opportunity to revisit the notes from their brainstorming session to make changes based on what they learned from the video. On day 2, students will read an article on water pollution in the city of Springfield that will provide the basis for discussion. On day 3, the teacher will pose the following question to students: Should the city of Springfield ban phosphorous-based lawn fertilizers? Each teacher will conduct a 15-30 minute whole classroom discussion in which students will be asked to take a position on the issue and provide supporting reasons and evidence for their opinions.

**Participants**

Participants will include three fifth-grade teachers and their students from three different elementary schools in a large central Florida public school district. All three teachers will teach the same water ecology lesson in the spring of 2019. Participants will be selected using
purposeful sampling methods. Selection will be based on teacher compliance, grade level, similar education backgrounds, and a minimum of five years teaching experience. The goal will be to select one teacher who teaches in a school where the student population is distinctly different compared to the other two teachers. This teacher will serve as the contrasting case to see whether there are obvious differences between the atypical case and the other two cases. When using purposive sampling of cases, the atypical case often provides the researcher a greater opportunity to examine the phenomenon of interest (Stake, 2000).

**Researcher’s Role**

In regard to my positionality, I am a former elementary classroom teacher with a specific interest in the complementary relationship between literacy and science. Since the annual testing requirements of No Child Left Behind were enacted, elementary schools across the nation have reduced time spent on subjects other than reading and mathematics. During the years I was teaching, I became increasingly concerned with the limited amount of instructional time being devoted to science at the elementary level. Furthermore, the little science instruction that was taking place in the district rarely engaged students in practices that promote deep knowledge building in science. My experiences as a teacher being forced to eliminate science instruction from my day to make room for more standardized test preparation ultimately led to my interest in conducting research in science-literacy integration. During this study, I intend to take the role of an outsider, or an objective observer.

**Data Sources and Data Analyses**

All three teachers will conduct a 15-30 minute whole classroom discussions in which students will have the opportunity to state different claims and their justifications for those claims with their classmates. Due to my research interest in classroom discourse, the analysis
will focus mainly on the whole classroom discussion in an attempt to characterize discourse practices of the students and the potential role of the teacher in promoting argumentation.

All three teachers’ classroom discussions will be transcribed, and each transcription will be broken into utterances, in which an utterance represents a unique idea or contribution to the discussion. First, utterances will be counted, and patterns will be identified for the interactions between students and teacher to determine whether the discussion was dominated by teacher talk or student talk. Secondly, each utterance will be coded using a protocol adapted from a previously published study of scientific discourse (McNeil & Pimentel, 2010). The three coding schemes include: argument structure, dialogic interactions, and the type of teacher questions.

**Argument structure.** The coding scheme for argument structure is based on Toulmin’s model of argumentation (1958). Table 1 provides a description of the argument structure coding scheme.

Table 1. Coding Scheme for Argument Structure

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>Claim</td>
<td>Conclusion made about the topic.</td>
</tr>
<tr>
<td>Evidence</td>
<td>Data either in support or against the topic.</td>
</tr>
<tr>
<td>Reasoning</td>
<td>Justification for why the evidence supports the claim.</td>
</tr>
<tr>
<td>Question</td>
<td>Question about the discussion.</td>
</tr>
<tr>
<td>Other</td>
<td>All other utterances not included in the four previous codes for argument structure and questions.</td>
</tr>
</tbody>
</table>

Each utterance will be coded as one of the five-argument structure codes to determine the percentage of the discussion focused on argument and whether some components are more ubiquitous than others.

**Dialogic interactions.** In addition to the structural aspect of argument, data analysis will also focus on the interactions between members of the classroom. Table 2 presents the coding scheme that will be used to capture the dialogic interactions during the discussions.

Table 2. Coding Scheme for Dialogic Interactions

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tr>
<td><strong>Independent</strong></td>
<td>Not linked to a previous idea offered in discussion. It is still considered independent if the utterance is in response to a question, as long as that question is not linked to any previous idea.</td>
</tr>
<tr>
<td><strong>Connected</strong></td>
<td>Dialogic interactions that support, refute, restate, or ask a clarifying question about a previous idea.</td>
</tr>
<tr>
<td><strong>Dismissal</strong></td>
<td>Explicitly or implicitly suggests that a previous contribution is not important or relevant for the discussion.</td>
</tr>
<tr>
<td><strong>Acknowledgement</strong></td>
<td>Recognize a statement, but not to the extent of supporting, refuting, restating, or clarifying.</td>
</tr>
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**Teachers’ use of questioning.** The final coding scheme will focus on the types of questions asked by the teachers, since research has demonstrated the potential role of questions in impacting the direction of classroom discourse. The teachers’ questions coding scheme (Table 3) will be used to classify each teacher question into four different types of questions based on Blosser’s (1973) classification scheme. I am interested in examining whether or not there is a relationship between the types of questions teachers pose and the discourse patterns in their
classrooms. Therefore, analysis will focus on classifying teacher questions and not the student-generated questions.

Table 3. Coding Scheme for Teachers’ Questions

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>Open</td>
<td>A content question with many possible answers where the teacher is not looking for a specific response.</td>
</tr>
<tr>
<td>Closed</td>
<td>A content question with limited correct answer(s).</td>
</tr>
<tr>
<td>Rhetorical</td>
<td>A question in which an answer is not solicited identified by continuous talk by the teacher.</td>
</tr>
<tr>
<td>Managerial</td>
<td>A noncontent question that is used to organize or manage the class.</td>
</tr>
</tbody>
</table>


Validity

Each transcript will be coded independently by two raters. Interrater reliability will be calculated by percentage agreement for each of the three coding schemes. All disagreements will be resolved via discussion.
References


Sampson, V. Enderle, P., Grooms, J. & Witte, S. (2013). Writing to learn by learning to write during the school science laboratory: Helping middle and high school students develop argumentive writing skills as they learn core ideas. *Science Education, 97*(5), 643-670.


