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Framing for Scientific Argumentation

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Abstract: In recent years, research on students' scientific argumentation has progressed to a recognition of nascent resources: Students can and do argue when they experience the need and possibility of persuading others who may hold competing views. Our purpose in this article is to contribute to this progress by applying the perspective of framing to the question of when and how a class forms and maintains a sense of their activity as argumentative. In particular, we examine three snippets from a sixth-grade class with respect to how the students—and the teacher—experience, or *frame*, what is taking place. We argue that they show dynamics of framing for individuals and for the class as a whole that affect and are affected by students' engagement in argumentation. We close the article with implications of this perspective for research, teaching, and instructional design. © 2011 Wiley Periodicals, Inc. J Res Sci Teach 49: 68–94, 2012

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Research on learning in science presents argumentation as a fundamental aspect of the discipline (Duschl, Schweingruber, & Shouse, 2007; Kuhn, 1993; National Research Council, 2011). Within science, argumentation serves to expose and address inconsistencies among ideas and evidence; it is a central means by which the community assesses the promise of conjectures and the validity of claims. As synthesized by Berland and Reiser (2009), individuals engaging in argumentation are making sense of phenomena, articulating those understandings and persuading others of their ideas. Meeting these goals requires that individuals construct and support claims using evidence and reasoning; and that they question, challenge and revise their own and other's claims, evidence and reasoning. Students, however, seldom do these things. A number of studies have documented challenges associated with argumentation, in both classroom and clinical contexts (e.g., Berland & Reiser, 2009; Erduran, Simon, & Osborne, 2004; Felton & Kuhn, 2001; Kuhn, 1991; Larson & Britt, 2009).

Over the past 20 years there has been progress in how researchers understand these challenges. In early work, D. Kuhn (1991, 1997, 1999; Kuhn, Black, Keselman, & Kaplan, 2000) used laboratory studies to identify developmental levels for coordinating theories and evidence, arguing that student reasoning needed to undergo ''strong restructuring'' in the sense Carey (1988) had described for conceptual understanding. D. Kuhn's work demonstrated that higher levels of argumentation abilities were rarely seen in adults and children alike

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and resulted in a deficiency view of individuals' reasoning abilities. This view has had a strong influence on the science education community, including inspiring instruction that treated argumentation as a set of skills that could be developed through explicit directions and scaffolds regarding the strategies of argumentation. A variety of design studies have shown gains in argumentation as a result of this explicit instruction (Chin & Osborne, 2010; McNeill, Lizotte, Krajcik, & Marx, 2006; Sampson, Grooms, & Walker, 2011; Schworm & Renkle, 2007; Simon, Erduran, & Osborne, 2006; Voss & Means, 1991). For example, Nussbaum, Sinatra, and Poliquin (2008) found that explicit instruction helped students attend to alternative explanations and engage in thought experiments.

Other studies of argumentation have considered it from a socio-cultural perspective (see review in Ryu & Sandoval, in press), specifically to focus on the social context in which students are asked to engage in argumentation. For example, Kelly, Druker, and Chen (1998) concluded that high school students are more likely to warrant their claims when they expenence a lack of shared understanding or agreement across the partners. More recently, McNeill and Pimentel (2010) compared three classes in which the students received similar instruction regarding argumentation. These authors found that, in the class in which the teacher asked open-ended questions, the students' arguments were more thorough and they engaged with one another's ideas in a more substantive manner, than did students in the other classes. These findings lend support to a growing body of evidence that students are more skilled arguers than traditionally expected, when the context, or more specifically, how students experience the context, calls for it (Berland & Reiser, 2009; Bricker & Bell, 2007; Engle & Conant, 2002; Louca, Hammer, & Bell, 2002; May, Hammer, & Pea, 2006; Naylor, Keogh, & Downing, 2007; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001).

Research on students' scientific argumentation has thus shifted in focus from identifying and teaching decontextualized skills of argument that students ''lack,'' to exploring the contexts in which students do and do not engage in argumentation. This shift is emphasized in D. Kuhn's recent work (2010; Kuhn & Udell, 2007) in which she investigated the ''cognitive challenges'' facing students when they participate in argumentative discourse in a context designed to elicit their nascent argumentation abilities, rather than in decontextualized laboratory studies. For example, Kuhn and Udell (2007) found that high school students were able to rebut potential counter-arguments when prompted but rarely did so spontaneously—this lead the authors to claim that the students knew how to include rebuttals but not that rebuttals were expected.

Views of the importance of context have raised new considerations for instruction and research. For instruction, they suggest that the first step in fostering student argumentation may be to create learning environments in which the students' sense of what they are trying to accomplish—or their understanding of the purpose of the discussion—aligns with scientific argumentation. The first author and colleagues (L. Kuhn, Kenyon, & Reiser, 2006), for example, showed that middle school students argue when they disagree and feel a need to reach consensus. D. Kuhn and Pease (2006) similarly emphasize that ''achieving and maintaining an awareness of the objective of inquiry activity'' (p. 547) is a key challenge for supporting students' engagement in inquiry practices—such as argumentation.

For research, this shift points to the importance of understanding how students form and maintain that sense and awareness, which a number of studies suggest occurs within rich, multilayered dynamics. Leander and Brown's (1999) analysis of students' and teachers' various interpretations of, and goals for, their discussion demonstrates the complexity associated with individuals building a shared understanding of the activity objective. In this case of a

high school physics class, there were apparent conflicts among participants' experiences of what was taking place. The authors argued that the interactions reflected a complex interplay among participants' stable understandings and the ''highly unstable negotiations of meaning.'' Similarly, Tabak and Baumgartner (2004), applying Cazden and Beck's (2003) notion of ''participant structures,'' presented evidence that students' understandings of those structures—including roles and expectations for how individuals participate—can shift within a discussion as a result of things as subtle as a shift in the pronouns the teacher uses. Lidar, Lundqvist, and Ostman (2006) gave evidence of how a teacher's ''attentional cues'' gradually helped the students stabilize around a new understanding of which aspects of their observations were important, that is of what information was valuable in the current setting. Studies such as these demonstrate that the classroom community forms its sense of the purpose of a discussion dynamically through subtle cues and explicit messages among participants.

In this article, we contribute to this work with a case study of learning and teaching in a sixth grade science class. The empirical case we present shows multiple stabilities in the students' and teacher's understandings of what is taking place during argumentative and more traditional class discussions, with dynamics at the levels both of individuals and of the class as a whole. The theoretical case we present is that these phenomena of student, teacher, and class dynamics connects to prior research on *frames* and *framing* (Bateson, 1972; Goffman, 1974; Minsky, 1975; Tannen, 1993).

We begin in the following section with a review of the perspective of framing and an argument that it is relevant to research on argumentation in the science classroom. In the Methods Section, we explain how we have applied this perspective to analyze data from the target class. We then present the data and our analysis of two snippets from the class that show two different stabilities of expectations and interactions, with evidence that the stabilities at levels both of the class as a whole and of individuals within it. We then turn to a third snippet that is striking for its *instability*, in conflicting dynamics evident again at levels of the class and of individuals. We close the article with implications for instruction and for further research.

Research on Framing

In Berland and Hammer (in press), we make the case that attention to students' understanding of the purpose of their discussion brings research on argumentation into contact with research on frames and framing (Bateson, 1972; Goffman, 1974; Minsky, 1975; Tannen, 1993), which is concerned with the structure of individual's expectations for what is taking place. Simply put, a frame is an individual's sense of ''what is it that's going on here?'' (Goffman, 1974, p. 8). For example, students in a particular moment of science class might frame what is going on as performing a required task or as discussing a collegial disagreement, and the difference would affect how they participate. In the former, the students might focus mainly on the requirements and whether they are meeting them to the teacher's satisfaction. In the latter, they might focus more on the disagreement itself, which would make them more likely to feel a need to be persuasive.

There is an extensive and varied literature on framing, across disciplines including anthropology (Bateson, 1972), sociology (Goffman, 1974), linguistics (Tannen, 1993), and artificial intelligence (Minsky, 1975). Tannen (1993) and MacLachlan and Reid (1994) provide helpful reviews. Our use of the idea here is guided primarily by Goffman (1974) and Tannen (1993), within the original framing literature, as well as by accounts of *epistemological framing* (Hammer, Elby, Scherr, & Redish, 2005; Redish, 2004). There are several features of framing that will be important to our analysis.

First, a frame is an individual's sense of ''what is it that's going on here,'' a sense that affects and involves what the individual ''can be alive to at the particular moment'' (Goffman, 1974, p. 8). Individuals form this sense based on their past experiences, organized in ''active developing patterns'' or ''schemas'' (Bartlett, 1932). One classic example is *dining at a restaurant* (Schank & Abelson, 1977), a schema people have formed that structures their expectations for what will happen, including goals, others' behaviors, the types of knowledge that will be valued, etc.—in this way, for example, they know to expect a waiter to bring them a menu.

A schema has flexibility, such that the particular situation does not have to match any previous one precisely to be active in the moment. Thus the restaurant schema can accommodate restaurants in which patrons pay at the front and those in which they pay the waiter. As well, members of communities have shared sets of schemas, such that they often frame situations in corresponding or compatible ways. That is, within a community there are kinds of activities that become familiar, from games to lessons to rituals, and so on. These familiar schema—''basic frameworks of understanding available in our society'' (Goffman, 1974, p. 10)—are resources for interpreting what is taking place.

Second, individuals use tone of voice, word choice, and body language in ''meta-communicative messages'' (Bateson, 1972) to signal how they are framing the situation to other participants. Bateson analyzed how monkeys play-fighting signaled to each other that ''this is just play,'' such that an ''attack'' was not interpreted as an attack. Tannen and Wallat (1993) analyzed a pediatrician's meta-communicative messages, including three distinct vocal registers, that signaled which of three kinds of activity were happening in her speech: whether she was speaking to the child who was the patient, speaking to the parent, or recording technical observations. A central point here is that people are adept at interpreting these signals: the child, the mother, and the researchers all evidently followed the doctor's shifting framings.

To return to the school-based example above, students working in an activity designed to promote argumentation might frame it as a required task. They would be framing ''what is it that's going on here'' based on a structure of expectations they formed from past experiences of required tasks and meta-communicative messages from their teacher and classmates. In contrast, students may frame what they are doing as trying to resolve a collegial disagreement. This framing would elicit a different structure of expectations that they had formed from a (largely) different set of past experiences of disagreements and, perhaps, playful competitions; in this way, participants may have a mutual understanding that each side is trying to persuade the other. In both cases, the students' framing would be influenced by each other's and their teacher's signals—including explicit instructions and as well as subtle meta-communication, such as tone of voice or body language.

The Dynamics of Framing

By all accounts, framing is a dynamic, ongoing process. Individuals constantly frame and reframe how they understand what is taking place, in small adjustments of the schema (think of a waiter bringing complimentary food without waiting for an order) or in larger adjustments (think of discovering that what you thought was a restaurant is actually an elaborate surprise party). Moreover, because people signal to each other their framing of what is taking place, the dynamics of this process are typically social.

Accounts of framing in a classroom, including ours below, give evidence of dynamics both at the level of individual participants and of the class as a whole. For example, in a study of a college level physics class, Hutchison and Hammer (2010) suggested that Hutchison, as the teacher, ''likely contributed to the shift'' in how students, as a group, framed the activity,

in part by presenting an idea to the students at the blackboard, and in part by a change in his ''tone of voice ... from a soft, facilitating tone to a sharp, directing one, the familiar 'teacher voice' '' (p. 519). These meta-communicative messages may have told the students that what had been an open conversation and exploration was shifting into a lecture—although that was not the teacher's intent.

Scherr (2009) and Scherr and Hammer (2009) studied how groups of students formed an understanding of their activity. The data showed clusters of behavior among groups of students collaborating in introductory physics. In one cluster, for example, the students spoke quietly, eyes mostly focused on their worksheets, and made only small, personal gestures; in another, they spoke in full voices, looked at each other, and made larger, more demonstrative gestures. There was evidence that the group worked together to stabilize on these behaviors. For example, a student's ''bid'' (Lemke, 1990) for a change of activity could be taken up or rejected by the rest of the group.

These studies presented and analyzed local dynamics of framing. In this way, they speak to the questions posed within research of argumentation: When and how does students' awareness of the objective form, and what makes it stable?

Framing and Argumentation

In their study of argumentation, comparable to Pope's (2003) ''doing school'' or Lemke's (1990) ''playing the classroom game,'' Jimenez-Aleixandre, Rodríguez, and Duschl (2000) contrasted ''doing science'' with ''doing the lesson.'' Of course, there are many versions of ''doing the lesson,'' just as there are many kinds of restaurants, but the broad picture is of teacher-controlled activity. Thus when students and teacher frame an activity in this way, they generally expect the teacher to set the topic, direct the flow of conversation, evaluate ideas, and so on: The teacher has both social and epistemic authority.

This depiction of ''doing the lesson'' is similarly depicted in communication studies. Consider, for example, a classroom activity of writing a letter to the editor. Paretti (2009) discusses how students might engage in this activity as an assignment, with the purpose of performing for the teacher, as opposed to actually writing a letter to an editor. The former has been called ''pseudotransactional'' writing (Petraglia, 1995; Spinuzzi, 1996). Students might similarly engage in pseudoinvestigations or pseudoargumentation, with attention more on following the instructions and satisfying the teacher than on the substance of the ideas.

Two aspects of these accounts are of central importance for what follows. First, they are all concerned with how students frame what is taking place specifically with respect to knowledge (Hammer et al., 2005; Redish, 2004). Within the classroom game, the teacher or textbook has final authority on what is ''correct.'' In contrast, when ''doing science,'' students would assess an idea as ''true'' by whether it makes sense, fits with available evidence, and can predict new outcomes (Coffey, 2003). Students engaged in pseudotransactional writing may assess their work by the criteria they expect the teacher will apply, rather than, for example by whether they believe it will convince a newspaper readership.

Second, these accounts are all explicitly or implicitly concerned with how students frame what is taking place *socially*, including participants' roles in the discussion and the types of utterances that are expected. In one framing, the students and teacher expect the teacher to be in charge not only of what ideas are correct but also, for example, of who is entitled to speak and when. In another framing, they might have quite different expectations regarding what is appropriate behavior.

Important, and as we argue evident in what follows, the social and epistemological aspects seem to be tightly connected in the participants' forming and maintaining a sense of

what is taking place. Expectations of the teacher's social authority, for example, apparently support and are supported by expectations of the teacher's epistemic authority.

Below we apply the theoretical construct of framing to analyze argumentation in a sixth grade science class. This next section provides background information about the class and the study, and it explains our approach to selecting and analyzing data.

Methods

In this article, we examine the dynamics of how a classroom community achieved—or did not—a stable framing of what they were doing. To do so, we examine what participants were saying and how they were interacting with one another. In this, we pay particular attention to indications of their epistemological and social expectations.

Study Context

Mr. S's was a self-contained 6th grade class, in a charter school within an urban school district in the Midwestern United States. Ninety-four percent of the students in this school were African-American and 89% participated in the free or reduced lunch program. The 16 students in Mr. S's class were known as the ''stars'' of the school: the principal reported that Mr. S's class contained students who were excelling. In addition, the students were aware of this status and eager to demonstrate their academic prowess. In fact, during his pre-interview, Mr. S reported that his students would discuss a single question for an entire lesson and express frustration if they did not have the opportunity to demonstrate their own understanding. Thus, Mr. S said that his role was to rein in his students, controlling when and how they participated.

The lessons discussed below were part of the class's enactment of a unit developed by educators and researchers (Finn, L. Kuhn, Whitcomb, Bruozas, & Reiser, 2006) on the IQWST project, from a learning-goals-driven design approach (Krajcik, McNeill, & Reiser, 2008). The unit was designed to facilitate student learning about the characteristics of living things and relationships between organisms (e.g., predator/prey) while simultaneously learning how to engage in scientific argumentation. The strategies for supporting argumentation throughout the unit are described in Berland and Reiser (2009).

Our initial motivation to study this class centered on the emergence of argumentation in one class discussion. This argumentation was not the result of a systematic effort to foster student participation in scientific argumentation, and it did not come from the students' history of classroom-base discussions. In fact, Berland (in press) demonstrates that the argumentation observed in the second snippet we analyze below was significantly different from other discussions in the class's enactment of the unit. Instead of argumentation, most lessons involved students (working as individuals or in groups) observing a scientific phenomenon (e.g., they dissected a sea lamprey and observed cells under a microscope) and then using those observations to address the ''driving question'' (Krajcik, Czerniak, & Berger, 2007) in a whole-class, teacher-guided discussion.

We use three snippets of classroom interactions to examine the dynamic ways in which this class converged around a stable (or not) understanding of what was taking place. In the first snippet, the class engaged in what we call an ''idea-sharing'' discussion, which occurred on the first day of the unit. Our analysis reveals a stable framing, in which the students were apparently working toward the goal of displaying meritorious thinking, with the expectations that the teacher would validate their ideas and manage the discussion, while the teacher was facilitating turn taking, acting and understood as the social and epistemic authority. The pattern in this discussion corresponds to accounts in the literature of prototypical interactions,

such as Mortimer's and Scott's (2003) ''chains of interactions.'' We expect it will be familiar to readers, and evidence within the discussion suggests it was familiar to the students and the teacher.

The second snippet is from the ''argumentative'' discussion that occurred on the final day of the unit. Here we build on previous analyses (Berland, in press; Berland & Reiser, 2011), to reveal a distinct but also stable framing, in which the students were trying to persuade each other to accept their claims—to ''win'' a playful intellectual competition. In contrast to idea-sharing, the students substantively engaged with each others' ideas. Again, the evidence suggests that the students and teacher were engaged in something familiar, although not, evidently, from what they had experienced in prior science classes.

Finally, the third snippet occurred immediately after the argument, when the teacher moved to resume his role as epistemic and social authority. It shows ''(in)stabilities'' similar to those discussed by Leander and Brown (1999). This is the *discordant* discussion, and it motivated our collaboration to continue studying the class past Berland's (in press; Berland & Reiser, 2011) prior work. What, we wanted to understand, accounted for this discord? In this article, we work to account for it in a manner that coheres with our understanding of the stabilities in the earlier discussions.

Thus we use these three snippets as data to build a theoretical account of how the class framed what was taking place and how different framings supported or inhibited student engagement in argumentation.

Data Selection and Analysis

This study grew out of our shared interest in the contrasting dynamics between the argumentative discussion and the subsequent discord: How could we account for the stability of the former and instability of the latter?

With this interest in mind, we watched the video of the discordant discussion and independently constructed conjectures to understand what was taking place and why, working from the theoretical construct of framing. We then compared our explanations, gradually coming to consensus regarding the dynamics of the various participants' framings. With an initial understanding of the discordant discussion, we reexamined the argumentative discussion, in order to understand how the participants had stabilized around a framing of that discussion, and expectations within that framing. This analysis was strongly influenced by the first author's prior work (Berland, in press; Berland & Reiser, 2011). Engaging in a process in which we progressively refined our hypotheses (Engle, Conant, & Greeno, 2000), we used our understanding of the argumentative discussion to refine our hypotheses regarding the class's unstable framing of the discordant discussion, and vice-versa.

We realized, in that work, that we were looking at two idiosyncratic episodes from this class: Although the students and teacher gave the sense they knew what they were doing in it, the argumentative discussion was unlike anything else the first author had observed in this class (Berland, in press), and the discordant episode was unusual in its discord. To get a sense of how things went ''normally,'' we examined earlier class discussions and picked two seemingly typical sessions to study through the theoretical lens of framing.

Once again, we interpreted these independently and compared and revised our hypotheses in order to form a consensus explanation of the framings found in these earlier discussions. Through this, we worked to connect those interpretations to our understandings of the argumentative and discordant discussions, revising our explanations of those, as necessary. In what follows, we present our ''final'' analyses of the different dynamics. To save space, we have picked one of the two earlier discussions to present. Because our arguments rest on

evidence available within each of the snippets, it is reasonable to consider these three episodes as the full data corpus of this work.

Idea-Sharing, Argumentation, and Discord

In this section we analyze the three snippets described above: the idea-sharing and argumentative discussion and the discordant discussion.

Idea-Sharing Discussion

This discussion occurred on the first day of the class's enactment of the curriculum. Mr. S presented several pictures (e.g., of a single celled organism, a fish, a computer) and asked students to discuss why they believed each object was living or not. Students first worked individually, recording their reasoning, and then Mr. S led them in a discussion to compare their answers. His expectation was that this discussion would result in a list of the students' implicit ''criteria'' for differentiating between living and non-living things and that these criteria would become the basis for their preliminary characteristics of living things list.

Similar to Mortimer's and Scott's (2003) ''chains of interaction,'' the discussion consisted of a series of exchanges that Mr. S Initiated by asking a question, to which a student Responded. Mr. S would then provide Feedback, generally revoicing (O'Connor & Michaels, 1993) the student's contribution rather than evaluating it. Mr. S and the students would repeat the Response-Feedback pattern, enabling students to elaborate upon their contributions and giving other students opportunities to answer the question. In this way, multiple students answered—or shared their ideas about—each teacher question, and teacher evaluation was minimized. We therefore call this an ''idea-sharing'' discussion. Table 1 exemplifies this interaction pattern.

Table 1
Example of the students and Mr. S engaging in idea-sharing

Line	Speaker	Quote
3	Mr. S	Matthew, why do you think [picture] #1 is living? [Picture #1 is of a sea gull swooping down to the water]
4	Matthew	Birds fly to eat
5	Mr. S	Birds fly and eat so you need to be alive in order to fly and eat
6	Mr. S	Ok. Adam?
7	Adam	Inaudible
8	Student 2	[On my worksheet,] I said it was living, because it look like it just flew down to get a fish, maybe. That is what I was thinking.
9	Mr. S	That is why it was alive, you say?
10	Student 2	Yeah, if it was going to fly it had to be alive to get whatever it needed or even to just get to the water.
11	Mr. S	So it had to be alive to fly, is what you're saying?
12	Student 2	Yes
13	Mr. S	Ok. Joseph?
14	Joseph	because it is moving
15	Mr. S	because it is moving? Because it is moving
16	Mr. S	Ok. Jonathan
17	Jonathan	because it can breath and uh see and eat
18	Mr. S	Because it can breathe?
19	Jonathan	and see and eat
20	Mr. S	See and eat
21	Student 3	[off camera mumbles] How do you know it breaths?
22	Mr. S	[points to Student 4 to silently identify him as the next speaker] And then Katherine after that

The chains of interaction pattern is evident throughout the idea-sharing discussion: Mr. S collected answers from the multiple students who raised their hands, here Matthew, Adam, Joseph, Jonathan, and Colby. That multiple students were raising their hands (or calling out as Student 2 did) suggests that they were eager to display their thinking, even when doing so was repetitive. For example, in line 8, Student 2 repeated Matthew's warrant that a bird that flies is alive. Moreover, students generally spoke directly to Mr. S, rather than to one another, which suggests they were mainly hoping to display their thinking to him.

Throughout the discussion, Mr. S's feedback focused on recognizing and reiterating the students' ideas (lines 5, 9, 15). In some cases he clarified the students' contribution (see line 11). If he did not reiterate or clarify the student contribution, he would acknowledge it with a simple "ok" (see lines 6 and 13). This move seemed to signal his understanding.

In fact, Mr. S. rarely evaluated the student contributions for correctness. The lack of a focus on accuracy was largely by design: His explicit purpose was to elicit students' ideas, not to drive them towards the canonical understanding. Still, the students' ideas were generally moving in that direction, so for the most part there was little tension between the objectives of eliciting student reasoning and making progress toward target concepts. (E.g., the idea that flying implies living is consistent with, and could be part of constructing, the textbook understanding that living things move.)

Occasionally Mr. S emphasized the ideas that aligned more closely with the curricular objectives. For example, shortly after the excerpt shown in Table 1, Colby explained that "you can be dead but you could still be moving" so something is living "because it is moving by its own free will." This is a kernel of a scientific idea that most of the student comments were missing, and Mr. S highlighted it:

> All right, lets talk about something he just said. He just said that you can be dead and still moving and his key thing was that it was moving by its own will or on its own accord, by itself (line 40).

This validation of particular ideas brings Mr. S's comments closer to an authoritative interaction (Scott, Mortimer, & Aguiar, 2006), and suggests that he may have had the curricular objectives in mind. For the most part, however, Mr. S focused on eliciting and clarifying student ideas, and he provided little validation.

The general pattern held for about 30 minutes, and in this sense we describe it as stable. Features of the pattern suggest several social and epistemological expectations:

- The students' repetition of ideas suggests that one of the students' goals was to "get credit" for the contribution. This introduces a sense of competition for opportunities to display understanding.
- Within this competition, Mr. S's "chaining" discussion style made it possible for multiple students to "win" by having multiple ideas validated and multiple students answer each question.
- The teacher validated student ideas by recognizing them, and rarely evaluating them.
- The chaining and focus on validation also made it possible for students to construct and display their own ideas, suggesting that this was a goal for Mr. S. Student participation in the discussion, such as Student 2 explaining that he had written an idea on his worksheet, suggests that they were also framing their role as knowledge construction and display.
- Within that student construction of ideas, Mr. S emphasized validation of particular ideas, suggesting he had an additional goal that students learn the canon.

- Mr. S and the students understood that it was his role to choose the discussion topic by asking the questions and managing student contributions, including giving them permission to speak.

Although these patterns appeared throughout the discussion, not all of the participants' actions align with them. For example, in line 21, an unidentified student mumbled ''how do you know it breaths'' in an apparent challenge to Jonathan's claim. This was divergent from the class's framing of the discussion in several ways: It was a student speaking to a student, without being recognized by the teacher; it was a challenge to a claim; and it requested that the student justify his thinking. Perhaps this unidentified student was questioning Jonathan's authority or perhaps he was looking for evidence. In either case, we see a hint of another way the class might have framed a conversation: individuals could have challenged one another and supported their claims.

However, the data suggest both individual and distributed mechanisms of framing and stability. That the student mumbled suggests he was aware he was of diverging from the current framing; his shift of register signaled that he was doing something different (Tannen, 1993). That others, the students and the teacher, ignored his contribution—although it was clearly audible—suggests they too saw it as a divergence, and this helped maintain the framing. Had Jonathan, other students, or the teacher acknowledged the challenge, the framing might have shifted. To say this another way, the student's mumble was a kind of fluctuation that the class could either amplify or suppress. Here the class effectively suppressed it.

There were other moments of divergence and correction, or fluctuation and suppression. Mr. S's emphasizing a particular point—to focus on the remark that something can be dead and still moving—is an example, a momentary divergence from the pattern that did not continue. Another instance in which there was a corrected divergence occurred when students expressed opposing ideas over whether plants are living things. Mr. S responded to this disagreement by asking students to explain how plants appeared to be both living and not living, eliciting non-factual responses such as ''Because they need sunlight water and soil to grow but they don't move'' (Jackie, line 150). After four students had given such answers, Mr. S moved the discussion on to the next picture—without resolving the plant's status. This move helped restore and maintain the framing in which student ideas were not compared and students shared their ideas without evaluation. Thus, in both cases, the students and teacher moved quickly back into the patterns of idea-sharing after the divergence.

These divergences and corrections show individual and class-level dynamics of stability. That this interaction pattern is common to school discussions (Mortimer & Scott, 2003) suggests that this was a familiar participant structure for the students and teacher—that is, they seemed to know what they were doing. At the same time, individuals could ''forget'' or choose to deviate; they could make ''bids'' (Scherr & Hammer, 2009) for something different, and in these moments others could act to restore and maintain the expectations.

Idea-sharing is largely inconsistent with scientific argumentation. The students' expectations that the teacher would direct the flow of conversation and decide when to ''OK'' a contribution, as well as the students' apparent goal of ''getting credit'' for contributing an idea would conflict with scientific argumentation in which the participants manage and validate the ideas discussed. In addition, that Mr. S refrained from explicitly evaluating ideas—other than for clarity—meant that students had no need to compare across the disparate ideas. That is, within this framing, students had no real reason to consider whether they agreed with their classmates. In fact, we could see this tension in the discussion itself: The student (line 21) who wanted to challenge an idea limited his remark to a mutter that other

students ignored; and the teacher acted to limit debate between opposing positions about whether plants are living things.

At the same time, idea-sharing involved at least one expectation that aligns with scientific argumentation: the students were constructing knowledge by connecting their observations of the items in the pictures with their prior knowledge and experiences. Moreover, Mr. S encouraged this by focusing on the clarity rather than correctness of student ideas. Thus, while the stability with which this class framed the idea-sharing discussion is largely inconsistent with argumentation, we see one expectation emerging as a resource upon which the students could build when engaging in scientific argumentation: students experienced knowledge construction as being an important part of their class discussions.

We turn now to a conversation with very different patterns of interaction.

Argumentative Discussion

The Setting. The argumentative and discordant discussions took place on the final day of the unit. They focused on a computational NetLogo model (Wilensky, 1999) of a simple ecosystem that was comprised of foxes, rabbits, grass and an unknown organism called an ''invasive species.'' The students were told that foxes eat rabbits and rabbits eat grass, and they worked with the model to explore graphs of the population fluctuations. The challenge for the students was to use the graphs of the populations to determine the invader's food source. Figure 1 shows an example of these graphs showing the population fluctuations before and after the invader entered the ecosystem.

Students worked with this model for three class periods. In the first, they worked in pairs to construct initial answers regarding the invaders' food source. In the second, they worked in groups of four and attempted to converge on an answer to the question. On the third day, our focus here, the teacher tasked the whole class with converging on an answer to the question.

As we noted above, while the curriculum is designed to facilitate student argumentation, this was the only lesson in which the students were supported in, or observed to be, engaging in argumentation. Mr. S introduced this discussion by saying ''Alright, now what we have to do you guys, what we have to do is come to consensus. But, before we do that, we need to hear why you people believe what it is that you believe, ok?'' The class then entered into a brief discussion in which Mr. S reminded them that, in science, their beliefs should be backed up with evidence. Thus, Mr. S introduced the possibility that the students might argue by highlighting two aspects of argumentation: (1) a need for consensus, which requires comparing their disparate understandings and (2) a need to support ideas with evidence.

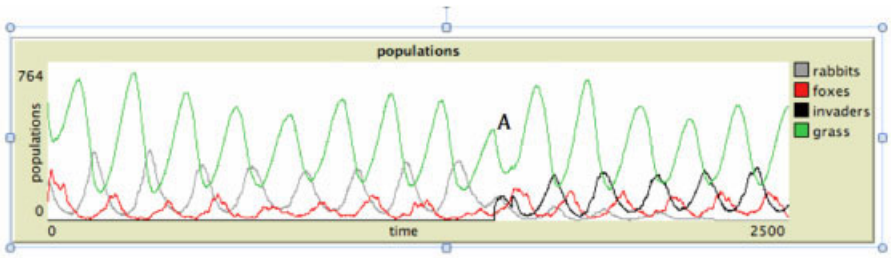

Figure 1. Example graph of population fluctuations in the NetLogo simulation (point A marks the beginning of the invasion).

After this brief introduction, the students began an argumentative discussion that lasted for approximately 35 minutes. They never achieved the hoped-for consensus, and with time running short, Mr. S moved to end the debate and ''wrap-up'' the inquiry. Our analysis explores these two discussions. We begin with the argumentation, which we discuss as an alternative stable framing to idea-sharing, and then turn to explore the discordant ''wrap-up.''

The Argument. As discussed above, the first author has engaged in detailed analyses of the interactions in this discussion, in prior work (Berland, in press; Berland & Reiser, 2011). In this article, we apply the theoretical lens of ''framing'' to those analyses in order to understand how the classroom community stabilized around the expectations that are suggested by their interactions. Those prior analyses show that Mr. S and his students converged upon a stable set of interaction patterns that suggest a stable framing. Table 2 illustrates these interactions patterns.

Table 2 began roughly 8 minutes into the argument when Isaac asked Tyler, the presenting student, to explain a feature of the data that was inconsistent with Tyler's claim that the invasive species ate rabbits. Tyler was standing in front of a graph similar to the one depicted in Figure 1. Issac's question (line 205) challenged Tyler's earlier claim that the invader ate rabbits, noting that the population of the invasive species was increasing after the rabbit population, their supposed food, had gone to zero. Another student suggested that the invader ate grass (line 211), but Tyler disagreed, claiming that the invader ate foxes and rabbits (line 213). He used evidence of the grass population remaining constant while the population of the invader increased to defend his claim that the invader did not eat grass (line 217).

The interactions in this discussion suggest that the students had framed this discussion and the idea-sharing discussion quite differently. Here, students frequently addressed one another directly and responded to each other's arguments, suggesting that they expected to challenge and be challenged by their peers. For example, had Tyler expected critiques to

Table 2
Excerpt from the argumentation discussion (Berland & Reiser, 2011)

Line	Speaker	Quote
205	Isaac	Well, at the end of the graph, when the rabbits are dead, how do they [the invasive species] keep going up?
206	Tyler	What you mean? What you mean? Hold on, hold on, you mean right here, when they dead, how they keep going up?
207	Isaac	How the invader going up?
208	Tyler	Because it already ate the rabbits!
209	Isaac	You said if it eats rabbits, it would die out if it have nothing to eat
210	Mr. S	Tyler what he said is that if it eats the rabbits, if the rabbits are at 0 then how is the invader still surviving?
211	Student	maybe it ate off grass
212	Students	[Calling out]
213	Tyler	It don't eat grass
214	Mr. S	Shh
215	Student	Ahh Tyler, you ain't got NUTHIN
216	Tyler	It probably might eat foxes but grass
217	Tyler	see look all the way straight across, you see how it keep going like that, right. See when it [invader] come up, Still the same [the grass]. . . Still the same . . . still the same. . .
218	Students	Indecipherable calling out

come only from Mr. S, he would not have found it necessary to respond to Isaac. Moreover, Mr. S seemed to encourage these social expectations in the way he set up the room: He sat behind his students allowing them to focus on another as they stood and presented their group's argument. And, he provided a yardstick for the presenter to hold; this served both as identification for the student with the floor and as a pointer to indicate places on the projected graph.

However, there is evidence that Mr. S was not independently stable in framing the conversation as managed by the students. In fact, after the first student had finished his presentation, Mr. S started to move the conversation onto the next presenter and the students complained. One asked, ''Can we say something?'' And Joshua, the presenter, asked, ''Can I take questions?'' Mr. S acquiesced to their requests, and the students' and teacher's expectations seemed to stabilize around students responding to one another directly.

The exchange in Table 2 occurred about 5 minutes after that explicit negotiation regarding students questioning one another, and it reveals the students consistently interacting with one another directly. Mr. S had shifted to a role of facilitator in that interaction, so in line 210 he intervened to help Tyler understand Isaac's reasoning. This had a clear effect on the substance of the conversation, as several students responded to that reasoning. In line 214, on the other hand, Mr. S tried to control the conversation in another way, saying ''shh,'' but that had no discernible effect; the students continued to call out challenges and questions to one another (see lines 215 and 216). Much as the students ignored the challenge, in Table 1 (line 21), here they ignored—if they noticed—Mr. S's request for quiet. Mr. S did not demand compliance, but allowed the students to continue. As in the idea-sharing discussion, the stability here involved a dynamic among the participants who, as a group, seemed to know what they were doing.

Although Mr. S had less of a role in the argumentative discussion, the students' framing seemed stable and included some epistemological expectations that align with argumentation. For example, exchanges such as the one shown in Table 2 reveal the students constructing the ideas themselves and to using evidence when doing so: Isaac used evidence to challenge Tyler (line 205) and Tyler responded with evidence of his own (line 217). Thus the students had at least a nascent understanding of evidence, and, in this context, they expected to use evidence when constructing and evaluating one another's arguments.

Moreover, as Berland and Reiser (2011) argued, the students were engaging in what Walton (1998) called a ''persuasive dialogue'' with the goal of winning the debate by persuading others that they had the right idea—more than, it seemed, with the goal of arriving at the correct answer. Thus Tyler, having claimed that the invasive species ate rabbits, would press to ''win'' with that idea, regardless of the strength of the counter-arguments. Like lawyers at a trial, perhaps, the students worked to discredit competing ideas and promote their own interpretations. It was, in essence, a competition of persuasion (c.f., Langer-Osuna & Engle, 2010).

In sum, Mr. S and his students interacted in ways that suggest a relatively stable set of expectations.

- As with the idea-sharing discussion, there was a sense of competition, but of a different sort. Here, students were competing to persuade others of the accuracy of their ideas. Unlike the idea-sharing discussion, because their ideas were in opposition, only one side could win.
- Students worked to support their ideas by comparing them against the available evidence, addressing each other in the process rather than the teacher. This suggests that they expected to assess ideas as worthy by their fit with evidence and reasoning.

- Mr. S's stated goal for this discussion was that students would reach consensus and construct their own ideas. Students clearly engaged in the knowledge construction, but there was little evidence they were trying to achieve consensus.
- Unlike the idea-sharing discussion, students were selecting the discussion topic by determining which ideas to discuss further; they responded directly to each other, and they controlled turn-taking among themselves. Mr. S, too, mostly acted in accordance with these expectations

Like the idea-sharing discussion, the stability of the class's framing involved the class responding to deviations with tacit or explicit corrections, such as in ignoring Mr. S's ''ssh.'' Another example is in how students worked to prevent Tyler's holding his position, and the floor, in the face of compelling counter-evidence (''Tyler, you ain't got NUTHIN!'').

The framings of the two discussions shared at least one common feature: students were constructing and sharing knowledge. However, they differed in a number of respects that are relevant for argumentation: The idea-sharing discussion fit within familiar patterns of interaction in school, with the teacher acting as social and epistemic authority, in tension, as we discussed, with argumentation. This argumentative discussion, which did not fit within any pattern typical to school (e.g., Weiss, Pasley, Smith, Banilower, & Heck, 2003), involved students playing a significant role in controlling the topic and flow and in assessing each others' claims, evidence, and reasoning. Also unlike idea-sharing, competition here was between ideas, or between students in defending their ideas, rather than simply for opportunities to display their reasoning. In this competition, there was little room for compromise.

This discussion provides ample evidence of students' abilities for argumentation: Students who had very little instruction in how to argue were using evidence to defend their claims (i.e., line 217); identifying counter-evidence to challenge others' claims (i.e., lines 205, 209); and evaluating counter-arguments (i.e., lines 213, 215). (See Berland and Reiser, 2011 for more discussion of this interaction.) Moreover, the fluency—their pace, ease, and rhetorical flourishes (e.g., ''you ain't got nuthin'')—of their participation, suggests they were doing something that was in some way familiar to them.

Some educators may object to the characterization of this discussion as nascent scientific argumentation, in that the students seemed to be trying to ''win'' by persuading others of their views, rather than trying to construct the best answer. However as argued by Mercier and Sperber (2011), individuals employ their reasoning abilities in the service of winning arguments. In this class, the goal of winning is clearly motivating scientific behaviors of supporting claims with evidence and reasoning as well as identifying counter-evidence to challenge others. In addition, accounts of professional science (Latour, 1988; Solomon, 2001) often depict scientists as competing. Solomon (2001), for example, argues that while the scientific community is rational in the normative sense of truth-seeking, individuals themselves remain biased and motivated to confirm their own ideas.

To this point, we have analyzed two snippets showing patterns of interaction among participants that were stable over 30 minutes or more. In each, there was evidence of individual expectations as well as of group level dynamics; in each the stability evidently involved the group's correcting individual divergences, or fluctuations, away from the pattern. That is, one reason these discussions could take place as they did is that the individuals participating had a generally compatible sense of what was taking place; another reason is that the group as a whole held each other accountable to that sense, in moments of fluctuation.

We have also shown that the two framings were quite different from each other. The latter aligned more closely with, and gave greater evidence of, the beginnings of scientific

argumentation. In this way, the data here contributes to the body of evidence we cited in the introduction that students come to class with nascent resources for argumentation, which they may use or not depending on how they frame what is taking place.

In the following section, we examine an episode that contrasts with both the idea-sharing and argumentative discussions in that it is difficult to characterize what the class, as a whole, is doing. We argue that in this episode, the classroom community did not converge on a stable framing.

The Discordant Discussion

About 35 minutes into the argumentative discussion, Mr. S moved to the front of the room, telling the students it was time to ''move on.'' This was a bid—from his perspective an *instruction*—that that they would shift to a more typical participant structure with the teacher as the social and epistemic authority. As we show, the class did not uniformly accept the change of framing, which led to ''(in)stabilities'' (Leander & Brown, 1999) in the students' and teacher's framings of the discussion. We begin by describing Mr. S's first moves to re-frame the discussion, and we then turn to explore the dynamics of what followed.

Mr. S's Move to Wrap-Up the Debate. Table 3 shows the beginning of the wrap-up discussion.

In the moment depicted by Table 3, Mr. S's words and behavior both initiated a shift in the class's framing. The words ''we need to move on'' marked the transition explicitly. In addition, the progression of pronouns from ''you'' to ''we'' to ''I'' marked the shift implicitly (Tabak & Baumgartner, 2004). His behavior did so as well, as he moved from sitting at the back of the room to standing at the front. In all these ways, he signaled and enacted a shift in his role from facilitator to leader.

At least one student shifted in his framing of the discussion in response: Joshua asked Mr. S to ''tell us [the answer],'' evidence that he expected the answer could come from the teacher. Mr. S embraced this request playfully, by joking that the invader ''eats birds'' (there were no birds in the model).

During the exchange shown in Table 3, Mr. S removed the projection of the computer model and put up a transparency with space for individuals to record written evidence for and against each possible claim. He then began reading aloud from the teacher guide (see Supplemental Materials A, Online), which provided an argument as to why each possible erroneous claim was necessarily false. For example, the first time Mr. S referred to the teacher guide, he worked to refute the possibility that the invader ate rabbits. This is shown in Table 4.

At the beginning of this exchange, Mr. S (using the teacher guide) introduced the first claim to disprove: maybe the invader ate rabbits. In line 484, Mr. S read the teacher guide's

Table 3
Introduction to the wrap-up discussion

Line	Speaker	Quote
479	Mr. S	Ok, you guys, so basically, it's hard for you guys to come to a consensus, we're trying to but we need to move on a little bit, but I do need to know...
480	Joshua	Tell us
481	Mr. S	You want me to tell you?
482	Joshua	Yea
483	Mr. S	Ok ok, it eats birds

Table 4
Exemplifies Mr. S's use of the teacher guide

Line	Speaker	Quote
484	Mr. S	Ok, something I wanna go through first before we even go through this sheet, a little bit of thinking, things for you to think about. Let's think about this ... where did it [Teacher guide] go, I just had it, here it is ... Ok, lets say that it eats, well no one mentioned that so I won't talk about it. But lets say it eats rabbits, if the invader eats rabbits, the grass would increase because its not being eaten. Instead the grass population has been decreasing
485	Student	So it eats grass and rabbits
486	Mr. S	So if the invader, think about this now, you people who say that it eats rabbits
487	Mr. S	If you say
488	Darnell	inaudible
489	Mr. S	Darnell, shut your mouth when I am talking
490	Mr. S	If you say the invader eats rabbits, then you have to take into account that the grass would all of a sudden increase, but the grass has been decreasing, not going down to zero but its been decreasing. So you have to come up with some way to explain why the grass has been decreasing. Something to think about
491	Student	See Darnell, I told you

challenge to this possible claim: the grass population would have increased if the invader ate rabbits (because nothing was eating the grass), but it decreased. In this, Mr. S made no mention of the graph the students had been using as evidence during their argument—it was no longer on display. That he removed the graph, which had been so clearly the focus of their attention, indicates an epistemological shift on his part: Mr. S expected students to accept the authoritative account rather than to consult their own evidence. The exchange shown in Table 4 also gives dramatic evidence of a shift in Mr. S's social expectations. In particular, his sharp reprimand to Darnell for speaking out of turn (line 489) communicated that Mr. S now expected to identify who would speak, when.

In sum, Mr. S's introduction of the wrap-up discussion reveals that he attempted to shift the framing away from a dialogical interaction to an authoritative one (Scott et al., 2006)—to one in which he had both social and epistemic authority. Moreover, some of the students followed him in that shift.

Not all students did so, however. Darnell and other students were still calling out, in line with the argumentative discussion, not with the framing Mr. S was trying to establish. As the discussion proceeded, there were similar instances of some students taking up Mr. S's new framing and others apparently trying to continue what they had been doing. There was also evidence that Mr. S fluctuated in his own expectations for the discussion.

Students and Teacher Show Fluctuating Expectations. In the following analysis, we move through the wrap-up discussion chronologically, focusing on Mr. S's response to students disagreeing with him and the expectations suggested by those interactions.

After presenting the evidence to disprove the possible claim that the invader ate rabbits (shown in Table 4), Mr. S argued that it did not eat foxes either. This is shown in Table 5.

Some students celebrated that Mr. S disputed the claim that the invader ate foxes (line 493), which suggests that they accepted his authority to validate the right answer. When other students disagreed (line 496), Mr. S responded, ''Let's agree.'' (line 497). This statement could be seen as a bid to work towards agreement or a demand that the students accept his authority. The fact that neither Mr. S nor his students continued to discuss the foxes suggests they understood it as the latter.

Table 5
Exemplifies Mr. S's response to student disagreement

Line	Speaker	Quote
492	Mr. S	Alright. The next one, if the invader eats foxes, eating foxes does not explain the rabbit or grass population is decreasing. Because if foxes eat rabbits and rabbits eat grass, then if the invader eats the foxes then the foxes can't eat the rabbits and the rabbits will still eat the grass. So how do you explain those two?
493	Student	Yay!
494	Mr. S	So it doesn't eat the foxes, you can say
495	Mr. S	Do you agree on that?
496	Students	No
497	Mr. S	Let's agree
498	Mr. S	Tyler you with me so far?
499	Tyler	I think the invader eats itself
500	Mr. S	That's a good one, he said the invader probably eats itself

Throughout this wrap-up, Mr. S dismissed students' disagreements and reasoning. For another example, recall line 486 of Table 4, in which he ignored a student's claim that the invader could eat grass and rabbits. These dismissals suggest that one of Mr. S's goals was for the students to reach closure by agreeing with the curriculum's answer, and that he had the epistemological expectation that the students would accept his (or the teacher guide's) authority. The dismissals also suggest the social expectation that the teacher would control when and how long a claim would be discussed. Thus, Mr. S was not only communicating the arguments from the teacher's guide; he was also sending meta-communicative (Bateson, 1972) signals of his framing. In this case, he was conveying that the students should accept his answers and reasons as correct.

However, Mr. S was not consistent in this dismissal of student thinking. For example, in line 500 he validated Tyler's suggestion as a "good one," and allowed it to dictate the next claim discussed. In addition, after quickly dismissing this possibility, he moved to summarize the arguments against each erroneous claim so the class could "reach consensus." Table 6 shows a segment of the conversation that ensued.

Mr. S's words in Table 6 communicate the importance of students' constructing their own ideas—he did this by repeatedly using the "we" pronoun, as in "we agree on that, right?" (line 507) and "we ruled that out" (line 509). Tyler (line 512) then challenged Mr. S, saying "No," he did not agree. Rather than asserting his authority and demanding that Tyler accept his answer, Mr. S then pressed him to respond to the argument that the grass population did not increase, and gave him the floor to do so. At the same time, Mr. S. evidently missed that Tyler was claiming that the invader ate both rabbits and grass (line 515). When Tyler repeated "grass and rabbits" (line 516), Mr. S quieted him and reiterated the evidence that challenged the possibility that the invader ate just rabbits.

In this way, Mr. S sent mixed signals about Tyler's role. On the one hand, he wanted Tyler to rule out rabbits by virtue of the reasoning and evidence rather than by authority; on the other hand, he insisted that Tyler follow his reasoning on his topic—ruling out just rabbits—rather than considering Tyler's suggestion of two food sources. Tyler seemed to pick up on these signals: in line 519 he implied that he did not have to accept the teacher's authority, that he could "think about it." At the same time, he gave up on pursuing his own idea that the invader ate both grass and rabbits. To be sure, all of this involved tone and body language we are not presenting here but that were part of the participants' experience. In particular, the

Table 6
More examples of Mr. S's responding to student disagreement

Line	Speaker	Quote
507	Mr. S	So we ruled out itself, all together we did that, right? We agree on that, right?
508	Students	Yes
509	Mr. S	We ruled out that it eats just rabbits, we agree on that now?
510	Tyler	No
511	Mr. S	No?
512	Tyler	No
513	Mr. S	No?
514	Tyler	I think it eats grass and rabbits
515	Mr. S	So, Tyler explain to me if the invader eats the rabbits, the grass would increase
516	Tyler	Grass and rabbits
517	Mr. S	Shh, listen
518	Mr. S	Rule out that it eats rabbits, yes or no? Say no, you can't rule it out yet?
519	Tyler	I'm thinking about it
520	Mr. S	Well, explain this then ok. If the invader eats the rabbits the grass would increase because it is not being eaten, instead the grass pop has been decreasing. So basically if this invader eats the rabbits then there would be no rabbits to eat the grass and the grass population did not shoot up
521	Tyler	Yea, you can rule that out

intensity of Mr. S's speech would send meta-communicative signals to Tyler, and this may have contributed to Tyler's accepting Mr. S's bids for what to discuss and how to engage.

Evidence of the participants' mixed expectations continued through the end of the wrap-up discussion when Mr. S announced the correct answer—the invasive species ate grass. Different students responded to this by questioning and accepting that claim. Table 7 reveals

Table 7
The conclusion of the wrap-up discussion

Line	Speaker	Quote
564	Mr. S	Darnell, tell them what it eats
565	Darnell	It eats grass and foxes
566	Mr. S	Have a seat
567	Mr. S	Isaac tell them what it eats
568	Isaac	Grass?
569	Mr. S	GRASS!!!
570	Students	Cheering and jumping around
571	Mr. S	<Trying to get students to calm down>
572	Mr. S	So, it eats grass. Mark aske. . . [cut off by students]
573	Student	<Inaudible>
574	Mr. S	How are you going to tell me no? Yea it does
575	Student 1	That doesn't explain why it can't eat all of them . . . This doesn't explain the foxes and the invader
576	Student 2	The foxes eat the rabbits
577	Student 3	The only reason the foxes going down because if the rabbits dead its not enough food for the foxes to eat
578	Student 1	How come it shot up when the rabbits died
579	Student 3	That's why I kept saying
580	Students	[yelling, not clear]
581	Student	Be quiet, ya'll taking his time
582	Mr. S	You can do 60 [minutes of recess]

this mixed response, in which Mr. S seemed to have a stable framing of the discussion: the goal was to identify the correct answer using an external authority and the students' role was to accept that answer. He stated the answer, dismissing Darnell's alternative and then accepting Isaac's venture, "grass?" (line 568). He cut off further debate by saying "how are you going to tell me no?" (line 574). In the end, he moved to discipline students who continued to challenge his argument (line 582). These dismissals and reprimands indicated that the ideas the students constructed were less valuable than the ideas the teacher was attempting to communicate. Thus, these moves reinforced Mr. S's goal that the students agree with the ideas of the authority and the epistemological expectation that this authority came from the teacher materials rather than the students' understandings of the data.

Some students accepted Mr. S's answer, cheering as if they were at a sports event on his announcing it. This cheering may have occurred because they could use his answer to accomplish their own goal: They wanted to win, and he declared they had. In this way, these students may have accepted Mr. S's epistemological expectation (i.e., his authority could prove them right) but not his goal (i.e., their goal was to be proven right, rather than to learn the teacher's claim).

Other students, however, continued with their alternative claims and questions. These students' challenges and their attempts to reference data that was no longer visible (i.e., lines 575 and 578) suggests that they did not think the answer to the question was something the teacher could tell them without accounting for the evidence and reasoning behind other claims. Thus, it appears that some of the students had different epistemological expectations than Mr. S's: they were attempting to interpret the data themselves, much as they had done during the 35 minutes of argumentation that preceded this wrap-up discussion. Here, however, their work interpreting the data went against Mr. S's social expectations; Mr. S apparently experienced it as disrespectful, and gave them the punishment of losing an hour of recess time (line 582).

This wrap-up discussion concluded shortly after the exchange shown in Table 7 when Mr. S directed the students to complete a worksheet about the invader's food. Thus, the wrap-up discussion concluded without a resolution regarding the social and epistemological expectations. Instead, over the course of the discordant wrap-up discussion, there was evidence of:

- Competing goals: Students learning the correct answer vs. students persuading others that their understanding is correct.
- Competing expectations regarding who would identify the topic of discussion: teacher versus student.
- Competing expectations regarding the source of the ideas: teacher versus students.
- Competing expectations regarding how ideas would be validated: an authority figure versus evidence.

In general, we suggest, the split is between a framing that is more like what they were doing in the idea-sharing discussion and one that is more like what they were doing in the argumentative discussion. For example, the expectation that the teacher will identify the topic of discussion aligns with the idea-sharing discussion while the expectation that the students will do so aligns with the interactions observed in the argumentative discussion. Moreover, as discussed throughout the analysis, the social and epistemological expectations of the argumentative and idea-sharing discussions were inconsistent with one another. Thus, we suggest that the tension that emerged in the discordant discussion resulted from the combination of more traditional school framings and those that align with scientific argumentation. In

particular, at times during the discordant discussion, participants exhibited traditional expectations of the teacher holding social and epistemic authority, and, at others, individual contributions suggested that they perceived the authority to be distributed among the students. That is, they were fluctuating between a dialogical and an authoritative dialogue (Scott et al., 2006).

It is important to note that, while Mr. S may have entered into the discordant discussion with expectations that aligned with the more traditional, authoritative, image of school, the above analysis demonstrates that he fluctuated in his expectations. Moreover, the students also moved between the more school-centric and argumentation-centric framings of this discordant discussion. Thus, this analysis reveals a discussion framing that never became stable.

Discussion

There is a consensus forming in science education research that students have nascent abilities for argumentation, which come into evidence when they experience the setting as one in which argumentation is sensible (i.e., L. Kuhn et al., 2006). With it, the focus of research on argumentation has shifted from the development of skills to ''the importance of students' achieving and maintaining awareness of the objective of inquiry'' and ''the continuing challenge that this awareness poses'' (D. Kuhn & Pease, 2006, p. 547). Research on framing, we have suggested here, provides theoretical purchase on how students achieve and maintain that awareness.

The argumentative discussion above is a case in point: The students were making claims, supporting claims with evidence and reasoning, attending to and challenging each other's claims and evidence although they had had essentially no formal preparation in the skills of argumentation (Berland, in press; Berland & Reiser, 2011). We characterized that episode in terms of framing: The students and teacher appeared to have framed what was taking place as a playful intellectual competition among students over which of them could better explain the data in the graphs. Moreover, they were robust in that framing, maintaining it for more than half an hour, with minimal teacher intervention. Indeed, we argue, the discord that followed reflected the persistence of that framing against the teacher's move to shift the class into a more customary framing, with the teacher as the social and epistemic authority, as they had done in the earlier idea-sharing conversation. This was a competition of a very different kind, between two (or more) ways of framing what it was they were doing, and it was interesting to see that it took place not only between participants but also within individual participants, including Mr. S himself.

Frames as Schemas Organizing Past Experiences

Research on framing concerns how people form and maintain a sense of ''what is it that's going on'' (Goffman, 1974). It builds on schema theory; a frame is a kind of schema that ''organizes past experience'' (Bartlett, 1932), past experience that works essentially by being recognized or activated in the moment (Tannen, 1993). People recognize new situations as being similar to previous, familiar, situations, and this recognition shapes their expectations, what they notice, what they consider, and what they intend. It is essential to recognize, as Bartlett (1932) emphasized, that these organizations of past experience are ''active, developing patterns,'' not rigid structures. Framing a new situation involves tapping into previous patterns and interacting with them; the patterns themselves shift to accommodate the new situation. For example, we know what it means to be in a restaurant, but our sense of that is ever evolving, as new restaurants differ in small ways from our previous experiences.

From this perspective, we can look to the students' past experiences for insight into how it was that they framed what they were doing in these different ways. What social and epistemological resources do students have for understanding what it is that's going on? In this respect, it is fairly straightforward to understand the idea-sharing discussion as a familiar school activity, a version of something the students and teacher have experienced, consistent with accounts in the literature of teacher-led activity (e.g., Mortimer & Scott, 2003).

That the students and teacher settled on a stable framing of the argumentative discussion suggests a familiarity with those interactions, as well. However, given that students rarely engage in scientific argumentation in school in general (e.g., Weiss et al., 2003), and that the argumentation was atypical for this class in particular (Berland, in press), we expect the familiarity has more to do with experiences outside of school. This argument aligns with Lee's (2001, 2006) Cultural Modeling framework in which she provides evidence of students' everyday experiences and language supporting their knowledge construction and engagement in canonical academic work. Calabrese Barton and Tan (2009) similarly argued for the relevance of "cultural funds of knowledge," specifically with respect to forms of discourse, and how they may contribute to "hybrid spaces"—an account again consonant with research on framing.

While we do not have data regarding the conjecture that these students were drawing on their everyday experiences to engage in the argument, research examining children's discourse out of school reveals that they engage in argumentative interactions that can be seen as aligning with scientific argumentation (Bricker & Bell, 2007; Moje et al., 2004; Seiler, Tobin, & Sokolic, 2001). For example, Moje et al. (2004), interviewed and observed 30 Latino youth ages 12–15. Among their findings was that "the activities youth engage in when 'messing around' often have some direct relevance to scientific and other content area literacy learning ... such as making claims and providing warrant for choices of music, media, and clothing" (p. 58).

Community-Level Dynamics of Stability. The dynamics of framing we observed in this discussion occurred at the level of individuals and the classroom community. Individuals in the idea-sharing and argumentative discussions occasionally behaved in ways that were inconsistent with the pattern of what was taking place. For example, we discuss around Table 1 how a student questioning the contribution of a classmate went against the social expectation that the students were answering teacher questions, not asking questions of one another. Similarly, in Table 2 the teacher tried to shush students—going against the expectation that students were controlling the interactions. In contrast, the classroom did not converge upon a single stable framing in the wrap-up discussion; it was replete with conflicting signals over framing, with students and teacher often at odds in how they understood what was or should be taking place and some individuals fluctuating within themselves.

There were several ways the community worked to achieve and maintain a shared framing. One was to address expectations explicitly. For example: the students asked Mr. S if they could take questions rather than having him manage the discussion, during the argumentative discussion; Mr. S asked students to listen to one another, during idea-sharing; and, Mr. S punished them for speaking out of turn during the wrap-up. In other instances, the community implicitly communicated whether a contribution aligned with their otherwise stable social expectation, by ignoring out-of-frame moves such as the student's mumbled challenge during idea-sharing and the teacher's shush during the argumentation.

Unlike the social expectations, there were few instances in which the students and teacher explicitly address epistemological expectations. Instead, participants expressed frustration

with one another's behavior when it aligned with divergent epistemological expectations. For example, during the wrap-up discussion, Mr. S responded to student challenges by asking: ''How are you going to tell me no?'' (Table 6). In this instance, he was explicitly responding to the student behavior while implicitly communicating epistemological expectations: the students should not challenge him. Similarly, the students' equally exasperated questions and references to the data that was no longer on display indicated their epistemological expectation that claims should be accountable to evidence.

This analysis suggests that the students' and teacher's social expectations interacted closely with their epistemological expectations, to the point that they used the former, in part, as tacit proxies for the latter. This relationship between epistemological and social expectations builds on prior theoretical work that posits that the students' epistemological understandings of their class discussions influences how they interact in those discussions (Duschl & Osborne, 2002; Hammer, 1997; Lidar, Lundqvist, & Ostman, 2006; Sandoval, 2005). In this case, we are seeing that student and teacher expectations for behavior were directly tied to their individual expectations for how answers would be constructed and validated.

This relationship raises a number of questions. In particular, we wonder how teachers can (or whether they should) manage the topic of discussion and select speakers while simultaneously creating a space in which the students are enabled to use their commonsense and the available data to construct and validate the ideas being discussed. It is clear that Mr. S struggled with this balance during the wrap-up discussion, as his efforts to take social control of the class also had him minimizing students' epistemic privileges to challenge claims. We explore the instructional implications of this finding in the following section.

Instructional Implications

We have provided evidence that the students in Mr. S's class had productive resources for scientific argumentation, not only in nascent skills within argumentation—such as for constructing claims, coordinating claims and evidence, rebutting counter-arguments—but also for recognizing moments in which those skills were relevant. Based on similar findings in the literature (Berland & Reiser, 2011; Bricker & Bell, 2007; Engle & Conant, 2002; Louca et al., 2002; May et al., 2006; Naylor et al., 2007; Radinsky, 2008; Warren et al., 2001; Zohar & Nemet, 2002), this is likely to be the case in general. This suggests that the emphasis in instruction should therefore begin with tapping into those resources (Hammer & Elby, 2003). Moreover, the strategies for that will likely differ substantially from strategies designed to promote students' *construction* or *development* of those abilities and understandings (Kuhn, 1991; Zohar & Nemet, 2002).

Using framing as an organizing construct offers insight into how instruction can be designed to tap into those resources: In particular, this perspective suggests that instruction should design or build on situations that students recognize as argumentative. As important, it must take care to avoid students' framing what is taking place in ways that could inhibit argumentation. In this class, it seemed that supportive framing connected to student experiences of differences of opinion or intellectual competition; inhibitory framing connected to their experiences of traditional, teacher-controlled lessons.

This aligns with the ''immersion'' approach to fostering argumentation that Cavagnetto (2010) identified in his review of studies designed to foster argumentation. In immersion settings, the argumentative interaction is a core part of their classroom activities. As he synthesized, engaging in scientific inquiry (and argumentation) is like learning a new language: ''science uses specialized vocabulary and includes cultural norms that influence the discourse and the community's knowledge construction'' (p. 351). As such, one might expect

immersion into inquiry to enable students to develop a usable understanding of the science and the cultural practices of science. In this work, Cavagnetto states that explicit scaffolds and prompts might be part of immersion environments.

However, incorporating the perspective of framing to understand when and why students engage in argumentative practices raises questions about how to include direct instruction regarding the components of arguments in these immersive settings: explicit instruction may inadvertently cue students to frame what they are doing such that they are working to meet teacher expectations, rather than working to meet a knowledge construction goal, ''doing the lesson'' rather than ''doing science'' (Jimenez-Aleixandre et al., 2000). That is, it may promote pseudoargumentation rather than argumentation (Berland and Hammer, in press).

Ford (2006, 2008) similarly concluded that explicit instruction could negatively impact students' understandings of their knowledge construction processes. He compared student reasoning that came out of two instructional conditions. One focused tightly on the control of variables strategy, analogous to instruction focused explicitly on the steps or components of argumentation. The other condition focused on students achieving a meaningful result, rather than on a particular method, analogous to an argumentation activity focused on motivating the discourse rather than the structure of the interactions. He found that students who focused on achieving a meaningful result gave evidence of having attained what he called a ''grasp of the practice'' of scientific investigation, while still doing fairly well with the control of variables strategy in post-tests. In contrast, students who received the explicit instruction in controlling variables showed greater gains in that particular skill, but they were significantly behind in their ''grasp of the practice.'' We interpret Ford's findings as phenomena of framing: Students in the one group framed what they were doing specifically as controlling variables in the ways they were taught; students in the other were trying to identify and understand physical phenomena.

This analysis helps explain Kuhn and Pease's (2006) conclusion that ''a great many students engage in inquiry activities in science classes without understanding that the activity presents an opportunity to find out something'' (p. 515). That is, if the initial emphasis is on the form and structure of the ''inquiry activity'' as an element of curriculum, then students may well frame the activity as being an opportunity to demonstrate understanding of the form and structure, to do what they are ''supposed to be doing.'' To promote students' framing what they are doing as *finding out something*, we suggest making *that* the beginning of the activity, and proceeding from there. That is, classroom activities should focus, at least at the outset, on the questions that argumentation could answer rather then on the structure of the students' discourse.

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