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Leema K. Berland

Victor R. Lee
Utah State University

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In pursuit of consensus: Disagreement and legitimization during small group argumentation

Leema K. Berland[1] & Victor R. Lee[2]

[1]Department of Curriculum and Instruction, University of Texas at Austin

[2]Department of Instructional Technology and Learning Sciences, Utah State University

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Abstract

In recent years, an emphasis on scientific argumentation in classrooms has brought focus collaborative consensus-building as an instructional strategy. In these situations, students with differing and competing arguments are asked to work with one another in order to establish a shared perspective. However, literature suggests that consensus-building can be challenging for students because their interpretations of the argumentative task and context may not enable their productive engagement with counter-arguments and evidence. Our goal in this paper is to explore the ways in which student interactions support or inhibit their consensus-building. To that end, we examine and describe three cases that represent different ways in which initially dissenting students try to work towards consensus with their peers. Through these cases, we demonstrate that peer legitimization of disparate or incorrect ideas is one vehicle that can enable students whose arguments rely on incorrect ideas feel that were heard by the rest of their group and have value. As such, we suggest that this legitimization is important because it can help students "save face". This enables students to move away from the competitive and persuasive aspects of argumentation and towards interactions that align more closely with sensemaking and consensus building.

Introduction

In recent years, scientific argumentation has been increasingly recognised as an important practice to foster within science classrooms (e.g., Osborne, 2010) because it enables students to actively engage in sensemaking through processes that bear similarity to the practices of the scientific community (Bricker & Bell, 2008; Chin & Osborne, 2010; Duschl, 2000). The term "argumentation," is used to describe discursive processes in which individuals defend claims by providing evidence for their own ideas and challenging alternatives (Osborne & Patterson, in press). In scientific argumentation, the argumentative interactions are done in service of building knowledge (Andriessen, 2007; Longino, 1990; Wegerif, 2007). That is, scientific argumentation is a dynamic social process in which ideas are tested and refined as individuals work to both persuade others of an idea and make sense of the available evidence and counter evidence (Berland & Reiser, 2009). As described by Ford (2008), this negotiation requires that individuals shift between the roles of knowledge critic and knowledge constructor.

The dialogue that is emblematic of scientific argumentation is thought to provide a number of potential benefits for students. Cavagnetto (2010) describes three goals for argumentation in science classrooms: To "teach students argument, science, or ethical and political considerations associated with science" (p. 340). In addition, Hmelo-Silver and Barrows (2008), state that argumentative discussions can support knowledge building as participants "negotiate a fit between their own ideas and those of others, and use the differences they find to catalyse knowledge advancement" (p. 49). In fact, studies of whether and how argumentation affects an individual's understanding consistently show that becoming aware of challenges and counter-arguments is beneficial to students. By confronting counter-arguments, students improve the structure and completeness of their own arguments (e.g., Kuhn, 2010; Kuhn, Shaw, & Felton, 1997; Limón & Carretero, 1997) and improve their understanding of the content under study (Asterhan & Schwarz, 2007; 2009;

Sampson & Clark, 2009; Schwarz, Neuman, & Biezuner, 2000). For example, in a study of 10th graders studying genetics, Venville and Dawson (2010) found that students that engaged in a brief argumentative intervention developed stronger arguments and deeper understandings of the science content than did those students without the intervention.

In conjunction with those empirical findings, science educators have begun to coalesce around key design strategies for supporting student participation in scientific argumentation including asking questions with multiple plausible answers and providing access to the evidence necessary to choose between those answers (e.g., Berland & Reiser, 2011; Clark & Sampson, 2007; Duschl & Osborne, 2002; Hatano & Inagaki, 1991; Kuhn, 2010; Osborne, Erduran, & Simon, 2004; de Vries, Lund, & Michael, 2002). In addition to these guidelines for the types of questions and answers that are discussed in classrooms, research around those design strategies has demonstrated that in order to facilitate student argumentation, the activity structure must help students interpret the situation as one in which argumentation is a sensible and useful discourse practice (e.g., Berland & Hammer, in press; Clark & Sampson, 2007; Cohen, 1994). This is necessary because typical classroom discourse activities limit student opportunity to engage with one another's ideas (Cohen, 1994; Lemke, 1990; Mehan, 1979; Weiss, Pasley, Smith, Banilower, & Heck, 2003).

This paper considers the interactions that take place when activities are designed to facilitate student argumentation by focusing on the explicit goal of reaching consensus, a strategy that has appeared in a number of recent science education design research projects. For example, Clark and Sampson (2007) designed an online tool that facilitated student argumentation in which they "critique each other's principles in light of the evidence and work toward consensus through scientific argumentation based on the evidence" (p. 257). Similarly, de Vries, Lund and Baker (2002) designed CONNECT—a software tool through which

student dyads engaged in scientific argumentation in order to reach consensus. Berland and Reiser (2011) designed an activity structure, an "argument jigsaw", to foster similar consensus-building. In the latter activity structure, pairs of students work together to develop initial arguments. Those pairs of students then join a second pair in their class—to form a foursome—with the goal of reaching a consensus across all four students.

The strategy of fostering argumentative discourse by asking students to reach consensus around a disputed question requires that individuals with disparate ideas converge around a shared idea and, consequently, that at least one individual changes their initial idea. As we will discuss below the research literature suggests that this consensus-building poses challenges for students. Our goal in this paper is to understand how students negotiate these challenges. Following a discussion of the challenges associated with argumentative consensus-building, we describe the consensus-building activity in which the students in this study engaged and the settings in which the data for this study were collected. We then explore three cases that represent different ways in which students engage with the goal of consensus-building. Taken together, these three cases illustrate that, with some persistence, students can respond rationally to counter-evidence and reach consensus, and that peer legitimization of disparate or incorrect ideas can support this consensus-building. Using these cases as a foundation, we suggest that legitimization enables students whose arguments will be abandoned to feel that their ideas, although incorrect, were heard and valued by the rest of their group. This legitimization ultimately moderates the confrontational aspects of argumentative discourse and can enable the students to move towards consensus.

Challenges associated with consensus-building through argumentation

The forging of consensus among disagreeing parties requires that participants consider and respond to arguments that challenge their initial ideas. However, a large body of research suggests that individuals often

struggle with responding productively to arguments and evidence that contradict their own ideas. Instead, in a number of experiments, individuals are seen to display a confirmation bias by differentially favouring evidence that supports, or confirms, their own ideas, rather than engaging with disconfirmatory evidence (e.g., Nickerson, 1998; Wason, 1983).

Kuhn's (1991) work offers one explanatory hypothesis for why individuals would exhibit this confirmation bias. In this work, Kuhn concludes that individuals struggle with differentiating between evidence and theories[1]. This lack of differentiation is seen when an individual alters contradictory evidence so that they can hold their theory constant. In this case, the individual is treating the evidence as though it were a theory—something that could be revised—and the theory as though a thing that must be held constant, much like evidence. As such, the individual would not be appropriately differentiating between the epistemic categories held by evidence and theory. Kuhn demonstrates this with numerous studies and populations, ranging from children discussing the possible connection between carrot cake and health (1989) to teens and young adults debating capital punishment (Felton & Kuhn, 2001).

Kuhn's work has been widely recognized and accepted as an explanation for students' struggles with responding to counter-arguments and evidence in productive and reliable ways (Osborne, 2004; Sampson & Clark, 2009; Southerland et al., 2005). However, alternative perspectives on this phenomenon demonstrate that an individual's argumentative discourse will vary in response to their interpretation of the argumentative task. For example, in a secondary analysis of studies examining confirmation bias, cognitive scientists Mercier and Sperber (2011) demonstrate that an individual's ability or willingness to engage with counter-evidence is largely dependent on the arguer's goals for the argumentative discussion, concluding that

[1] In this work, a theory would be considered an individual's claim for which they are arguing, such as how they are interpreting data or a prediction.

"…contrary to common bleak assessments of human reasoning abilities, people are quite capable of reasoning in an unbiased manner, *at least when they are evaluating arguments rather than producing them, and when they are after the truth rather than trying to win a debate*" (p. 72, emphases added). Zeidler (1997) similarly suggests that individuals are likely to respond to counter-arguments in non-rational, or fallacious, ways in order to protect their core beliefs. As such, individuals might not engage productively with counter-arguments and evidence so that they do not need to revise their pre-conceived and closely held beliefs. And, Engle, Langer-Osuna and McKinney de Royston (in press) reveal that a student's evaluation of evidence is often influenced by their interpretation of the presenter of that evidence—rather than an evaluation of its validity.

This trend to explain whether and how students respond to counter-arguments and counter-evidence in terms of their interpretation of the argumentative task, rather than an ability or skill level, reveals a new and growing focus in this literature (as reviewed in Berland & Hammer, in press; Ryu & Sandoval, under review). It is important to note that this focus on the arguer's interpretation of the argumentative task does not mean to suggest that engaging rationally and productively with counter-arguments and counter-evidence is easily done in the right situation. Instead, this perspective suggests that the way in which an individual engages in argumentation will involve some contingencies. Specifically, how students' engagement in argumentation—including their responses to counter-arguments and evidence—is influenced by factors such as the strength of their beliefs for which they are arguing; their goals for the interaction; their perception of their argumentative opponents; and their understandings of the expectations for the discourse interactions.

The classroom environment and the norms and expectations students associate with that environment will similarly influence student's interpretation of the argumentative task (Berland, in press). Moreover, this influence is often inhibitory with respect to consensus building. In particular, as traditional classroom

activities reward students for demonstrating mastery of the subject matter (Johnson & Johnson, 1994), admitting a weakness in one's own ideas—disconfirming a claim in light of a challenge—can be particularly threatening for students. For example, Hogan and Corey (2001) demonstrate this challenge in a 5th grade classroom in which students struggled with converging on an experimental design and, instead, focused on critiquing one another's proposals. Hogan and Corey hypothesize that this response to consensus-building grew out of the classroom culture that rewarded individual achievement. Radinsky (2008) has similarly documented middle school students actively posturing in order to establish positions of authority over their peers. In addition, Barron (2000) found that a focus on demonstrating an individual's own mathematical competence during small group interactions disrupted students' engagement with one another's ideas.

This brief review suggests that consensus-building that is intended to take place in a classroom environment might involve a number of challenges for students. For example, without proper support or incentive, we might expect to see that asking students to reach consensus in a classroom activity results in students displaying a confirmation bias such that they stand by their own claims and dismiss alternatives, with little discussion. Even with proper support, existing norms of classroom culture might encourage students to focus on demonstrating their competence rather than engage in a knowledge-building activity with their peers. To some extent, careful design and facilitation by a teacher helps to support productive consensus-building through argumentation. However, as the argumentation and consensus building occurs between students, much of this mitigation occurs within the student interactions. Moreover, an individual's interpretation of the context in which they are acting constantly shifts in interaction with other participants in that activity (e.g., Goffman, 2974; Scherr & Hammer, 2009; Leander & Brown, 1999). Thus, this study is designed to provide some images of the ways in which student interactions support or inhibit consensus building.

Methods

As our goal for this study was to explore how the interactions between students support or inhibit their productive engagement with alternative ideas as they work toward building a consensus, we needed to conduct it in actual classrooms. That is, we needed to conduct this study in a situation in which students would genuinely feel typical classroom pressures to demonstrate individual success. In addition, the argumentative lesson needed to motivate the argumentation and enable students to investigate realistically complex situations such that the students could "directly experience the underlying rationality (reasoning) of scientific work" (Choi, Notebaert, Diaz, & Hand, 2008, p. 152). Thus, we observed groups of students as they enacted an argument-jigsaw activity (Berland & Reiser, 2011) designed to focus students on consensus-building around a complex data sets, in their classrooms. In the following sections we describe the activity in which the students were engaged—the context for the study—we then discuss the data sources and analytical process for this work.

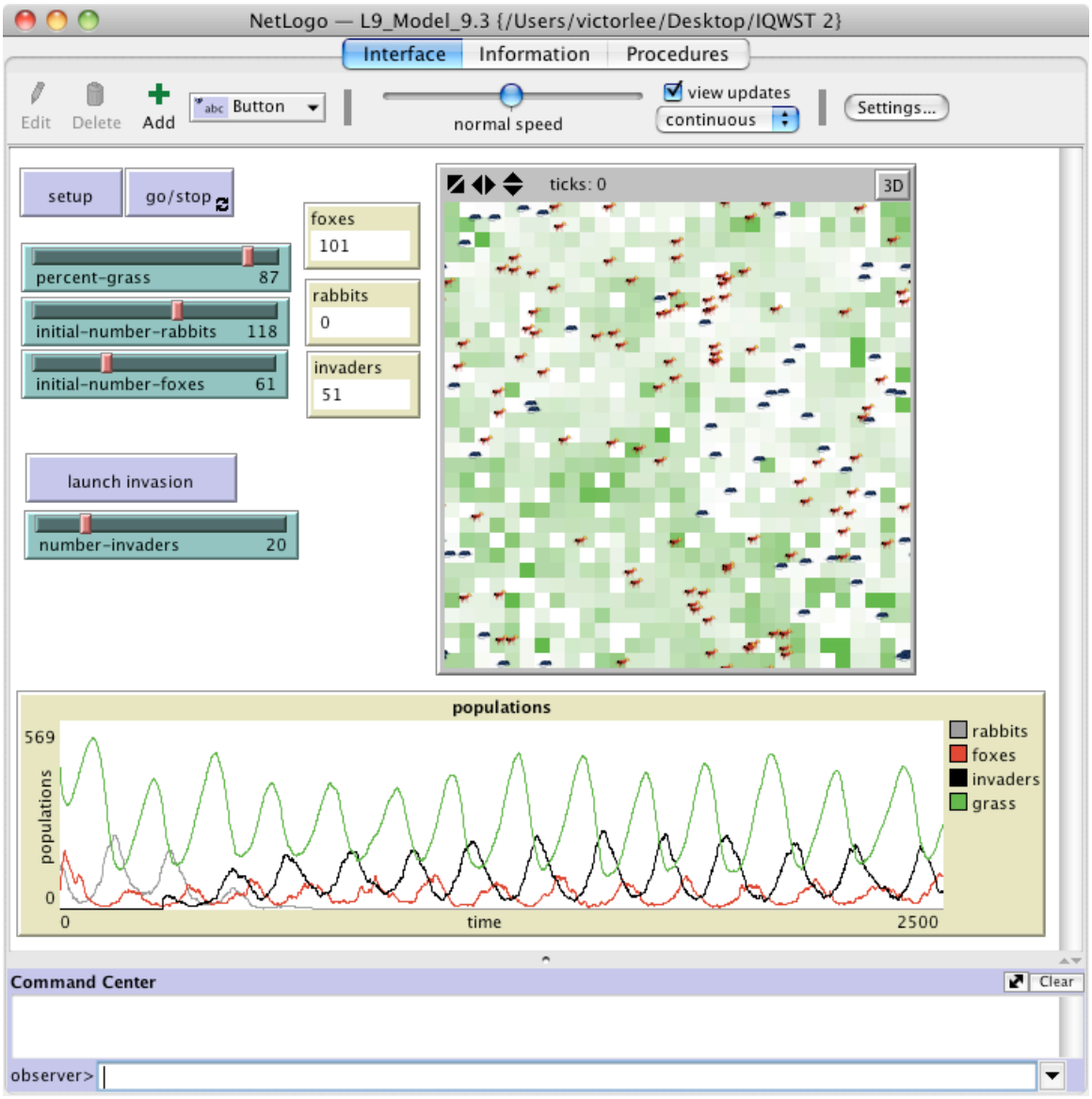
Fostering consensus-building in small groups

The activity used for this study comes from a large curriculum development endeavour to create a comprehensive middle school science curriculum series built upon principles of project-based learning with a focus on scientific practices (Krajcik & Reiser, 2004). The particular activity used for this study came from the ecosystems unit in this series (Finn, L. Kuhn, Whitcomb, Bruozas, & Reiser, 2006) and is based on three design strategies:

1. Creating a need for students to value one another's ideas.
2. Making the epistemic criteria of reliance on evidence and scientific principles explicit
3. Creating a need for students to connect claims and evidence

Berland and Reiser (2011) offer a complete description of these design strategies.

In the activity on which we focus in this study, students explored a NetLogo (Wilensky, 1999) computer-based model of an ecosystem that contained foxes, rabbits, grass, and an unknown organism called an invasive species (or invader). The students' task was to determine what the invasive species ate. In the software environment, students were provided with a set of sliders with which they could set initial population values for the different species, a window showing a graphical display of the simulated organisms moving and interacting in the simulated terrain, and a dynamically generated graph showing the population fluctuations of each organism in the ecosystem (see Figure 1).



<Figure 1. Screenshot of the NetLogo model of a simulated ecosystem used in this activity>

The model was programmed such that the invasive species was able to outcompete the rabbits for a common food source—the grass. After the invasive species was introduced, the rabbit population typically declined. The foxes in the model preyed upon both the rabbits and the invasive species as a food source, and were not negatively impacted by the presence of the invasive species or the decline of the rabbit population. While

students could interpret the resultant population data a number of ways—the most common interpretations[2] were that the invader ate: the rabbits (causing their population decline); the grass; and both rabbits and grass—the program was designed to provide students with an opportunity to explore the scientific concepts of competition and direct and indirect relationships between species in an ecosystem.

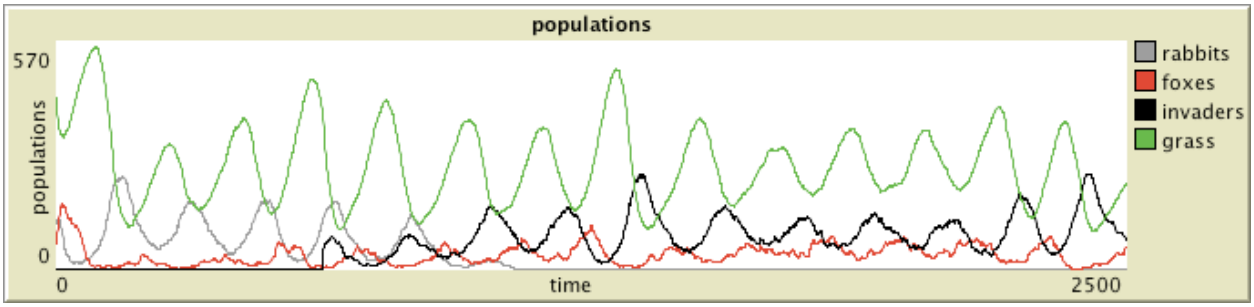


Figure 2: Sample graph of the population fluctuations. Point A identifies the point at which the invader entered the ecosystem

The entire NetLogo lesson took about one week (five forty-minute periods) of class time. For the first activity, student pairs became familiar with the computer environment and then generated and used data in the NetLogo model (exemplified in Figure 2) to identify the invader's food source—and to defend their claims in the form of an argument. Consistent with the argument jigsaw activity structure, pairs of students then joined another pair of students. The larger group was tasked with agreement regarding the invasive species' food. Students had access to computers that they could use if they wished to run the computer model additional times when discussing the invasive species' food in the groups of four. This group argument activity was designed to take about one class period with about 30 minutes of that devoted to the student argumentation. Students were told at the beginning of this activity that the whole class would be presenting and arguing their final answers the following day.

[2] As determined from observations in multiple classrooms, see Berland XXXX (your dissertation?)

We analysed the student discourse that emerged during the students' argumentation in groups of 4 because that group activity was designed with the intent of fostering consensus-building—the phenomenon we hoped to study. It did so first through the activity structure that grouped existing student pairs into larger groups. Second, this study was designed with the expectation that, for the reasons mentioned above, individuals in that newly formed group of students may struggle with responding productively to counter-evidence. The NetLogo interface provides students with visible data that they can manipulate in the moment. As such, there is little need for them to discuss second-hand data that they either didn't collect themselves (Hug & McNeill, ref) or must remember from previous activities. In earlier work, the Berland and Lee (2010) suggested that access to immediately-present data is key to fostering in-depth argumentation and, in the current study, we hoped that this access to data would increase the likelihood that students would challenge one another with evidentiary statements.

Data sources

For this study, we observed and video-recorded 10 groups of fifth- and sixth-grade students engaging in the activity described above. Their argumentation in the combined group—their work to come to consensus—is the focus of this analysis. Due to variation in class size and student absences, these "combined groups" ranged from having 3 to 5 students.

This study required variety to ensure that we were capturing a range of ways that students could respond to the task of building consensus when they initially disagreed with one another. Thus, we worked with students from three different schools, each of which came from a different region of the country. In particular, we worked with five different classrooms (we video-recorded two groups in each class) in three different schools in the United States. The students ranged from 11 to 13 years of age. Six groups of students came from 3 different sixth-grade classes in a predominantly white suburban middle school located in the Midwest region

of the United States (groups 1-6, in Table 1). The same science teacher taught all of these classes. Two groups of students came from a class in a school in a small city in the mountain west region (groups 7 and 8). This set belonged to a self-contained fifth-grade classroom and enacted activities during the final weeks of their academic year. The final two groups of students came out of an urban, self-contained sixth-grade classroom in a privately run elementary school located in a major US metropolitan area (groups 9 and 10). A trained researcher was present for all instructional days involving computer models and argumentation and supervised the videorecording of each group and of larger class discussions.

Existing classroom cultures and teacher practices have a strong influence on how students engage in scientific argumentation (Berland, in press; Cavagnetto, Hand, & Norton, 2010; Naylor & Keogh, & Downing, 2007; McNeill & Pimentel, 2010). We therefore expected the cross-class variation seen in this data set to result in a broad range of responses to the consensus-building task.

Analysis process

After we had obtained the corpus of video, we transcribed and reviewed each recording and classified groups based on whether there was an observable initial disagreement among the groups of students and if a resolution was reached by the end of the class period. Because these groups were recorded in intact classrooms in which the classroom teacher made groupings, usually based on physical proximity of student pairs, not all foursomes disagreed from the outset. Indeed, it turned out that two of the groups that were formed (groups 2 and 6) initially agreed with each other and were thus excluded from further analysis. Another group (group 4) appeared to have initial disagreement, but the one dissenting student participated only minimally. Thus, we removed that group for the analysis as well. Finally, group 5 was removed from the data set because one pair came to the argument without a clear claim. It was therefore not an instance in which

students with disparate arguments were working towards consensus. This left us with 6 groups to explore how they worked towards consensus. See Table 1 for summary of these groups.

Table 1: Summarizes the initial and final positions of each group recorded for this study

Group	Initial positions	Final positions
1	Three students state that the invader eats grass. One student takes the position that the invader eats grass and rabbits because of graphics window	All students state that invader eats grass.
2*	All the students agree immediately that the invader eats rabbits	All the students continue to state that the invader eats rabbits
3	Three students state that the invader eats grass. One student states that the invader eats something in the grass	All the students state that the invader eats grass
4*	Four students state that the invader eats grass. One student is not sure, but does not voice an alternative	All the students state that the invader eats grass
5*	Two students do not know what the invader eats. Two students state that the invader eats rabbits and foxes	All the students state that the invader eats grass
6*	All the students state that the invader eats grass	All the students continue to state that the invader eats grass
7	Two students state that the invader eats rabbits and grass. Two students state that the invader eats grass	All the students state that the invader eats grass
8	One student states that the invader eats grass. One student states that there is poison in the system. Two students state that the invader eats rabbits	All the students state that the invader eats grass
9	Three students state that the invader eats grass, one student states that the invader eats rabbits	Continued disagreement: three students state that the invader eats grass; one student states that the invader eats rabbits
10	Two students state that the invader eats grass. One student states that the invader eats foxes	All the students state that the invader eats grass

* indicates groups that we removed from further analysis.

With the remaining 6 groups of students, we constructed narrative cases—or thick descriptions—and compared across the cases to identify actions or utterances that seemed to promote consensus-building. To do so, we jointly identified portions of one group's discussion in which there was evidence of students shifting their claims such that they were in (or closer to) agreement. We then analysed the transcript of one group and accompanying video segment independently. This analysis was data-driven in that we entered into the process with the expectation that patterns in how students reached consensus would emerge. Regardless of that expectation, we acknowledge that one's analyses are always influenced by existing theories. As such, our analyses were heavily influenced by trends in science education research regarding scientific argumentation REF see review in Sampson. In particular, similar to work by Berland & Reiser (2011), our analyses attended to whether students were making claims, defending claims, questioning and evaluating alternative ideas and revising their claims. Using this argumentation theory as a lens, we constructed summary understandings of the students' arguments including the claims, justifications, counter-arguments and rebuttals. Throughout this process, we were consistently struck by the importance of the social dynamics and the implicit messages students were communicating to one another. As such, we began to focus on interactional dynamics specific to conversation (Clark, 1996; Goodwin, 1981; Goodwin & Heritage, 1990). Considering interactional dynamics, we then independently developed an explanatory hypotheses of how one group's interactions supported their eventual consensus, compared those accounts, and worked towards a mutual understanding of that group's consensus building process. After constructing the explanatory hypothesis of the consensus-building process in one group, we introduced additional groups to the analysis and progressively refined our explanatory scheme (Engle, Conant, & Greeno, 2000) with each addition. This process was similar to the constant-comparative method (Glaser & Strauss,) and resulted in our refined explanatory account of how these groups reached consensus.

Analysis

One of the groups in this study (group 9) never reached consensus. The remaining 5 groups that started with disparate claims converged onto a single claim—the correct claim, in fact. Below, we begin by presenting a case in which students were unable to reach consensus, group 9. We then proceed to describe two groups (groups 1 and 7) that overcame initial struggles with engaging with the opposing ideas in order to eventually reach consensus. Comparing the consensus-building process across these groups suggests that legitimizing one another's ideas enabled disagreeing students to feel more comfortable in changing their positions. Thus, we argue that this peer-legitimization was of central import to the students' consensus-building process.

When consensus doesn't happen

The students in group 9 seemed to struggle with reaching consensus through scientific argumentation. This group came from a self-contained 6th grade classroom in an urban elementary classroom. The group consisted of two pairs. One pair, Darnell[3] and Thomas, believed that the invasive species ate the grass. The other pair, Kendra and Tyler, had an internal disagreement: Kendra believed the invasive species ate the grass while Tyler believed it ate the rabbits. The earlier video footage reveals that Tyler believed that the invader ate rabbits because the rabbit population decreased shortly after the invader was introduced and, most importantly, the rabbit population would then disappear entirely. He did not think that it ate the grass because the grass population never went extinct, and it maintained roughly the same population levels throughout all runs of the computer model[4]. While incorrect, this logic is based on the belief that one population's decrease is always caused by the increase of its prey population. Prior to joining their small group, Kendra appeared to

[3] All student names in this report are pseudonyms.
[4] This is exemplified by statements Tyler made to Kendra a few minutes prior to their small group discussion with Darnell and Thomas: "how can they [the invasive species] eat the grass cause every time it [the invasive species] go up, the rabbits go down but the grass stays the same?,,,I'm tellin' you it [the invasive species] eat rabbits [*sic]*. Cause when the invader came up the rabbits went down."

be sceptical of Tyler's claim and became more vocal about this scepticism when joining the other pair that shared her claim.

Table 2: Beginning of group 9's discussion

Tyler:	What y'all say?
Thomas:	Grass [The invasive species eats grass]
Darnell:	We say grass
Kendra:	Me too
Tyler:	I say rabbits
Thomas:	Listen, rabbits eat grass right? They [the invasive species] eat grass, and the rabbits die cause there ain't no more grass left
Tyler:	It [the invasive species] eat the rabbits—
Thomas:	Ok, . . .Wait. Listen, listen, Tyler. Look, if the invasive eat the rabbits then ain't no more rabbits left so the grass would keep going up 'cuz don't nothing eat grass
Tyler:	No but then when I did it—Hold on!
Thomas:	See that makes sense right, if the invasive eat the rabbits ain't no more rabbits left, then the grass going keep going up 'cuz the fox don't eat the grass and the invasive don't eat the grass
Tyler:	No but like . . . 'Cuz on mine the invasive . . .
Thomas:	How the grass go down if all the rabbits dead?

As seen in Table 2, when this group of students first assembled, Thomas, Darnell, and Kendra made their agreement that the invasive species ate the grass clear. Thomas was the most vocal in this regard and

immediately responded to Tyler's belief that the invasive species ate rabbits by offering an alternative explanation to the rabbit population decrease (see line 6) He also asked Tyler why logical outcomes of his claim about invasive species eating rabbits didn't occur (see lines 8 and 10). In some sense, this reply suggests that Thomas heard what Tyler was saying, but only in a limited way. Moreover, Thomas's response was focused on immediately communicating that Tyler's line of reasoning was incorrect. During this transaction, Tyler struggled to make himself heard (lines 9, 11). From the utterances he did get out, it appears that Tyler was swayed by neither of Thomas's counter-arguments and continued to reference what he had seen on his computer earlier. In this way, one could argue that Tyler was displaying a confirmation bias (e.g., Kuhn 1989; 1991; Nickerson, 1998; Wason, 1983) by ignoring Thomas's counter-evidence and favouring his own. In response to Tyler's reliance on previously viewed data, the group referred to a shared laptop and worked to generate a new data set to discuss. Following this, Tyler tried to argue his point but the others continued to dismiss his argument (Table 3).

Table 3: group 9 discussing with new shared evidence

Tyler:	. . . nahh cuz see how that [Grass] went down then it went right back up, so it must eat rabbits
Thomas:	[Pointing] The rabbits still alive though!
	. . .
Darnell:	Look Tyler Look. Look at that . . . Look what happened. Rabbits completely gone
Tyler:	So it must eat rabbits!
Darnell:	No it eats the grass!
Kendra:	If both of them eat grass, the rabbits gonna die

At this point, the students were using the same data—the graph in front of them—to argue for different conclusions: Darnell continued to restate the others' point that the rabbit population decrease meant the invader ate the grass (the rabbits' food) (line 3), while Tyler took that rabbit decline to mean that he was still correct in thinking that the invader ate rabbits (line 4). Kendra chimed in with a statement suggesting that the rabbits' death was a foregone conclusion if both species were eating the grass (line 4).

As seen in Table 3, the three students who were arguing in favour of grass (Darnell, Thomas, and Kendra) all challenged or dismissed Tyler's ideas quickly. In turn, Tyler also dismissed the points that the other three students were raising. Throughout these episodes, the students' voices were raised. Moreover, Thomas and Darnell occasionally stood up from their seats and physically leaned into Tyler's space as they made their points, while Tyler would look away or shake his head and wave them off with his hands. These behaviours suggest that the students were highly engaged and eager to gain "access to the interactional space" (Engle, Langer-Osuna, & McKinney deRoyston, to appear). In addition, their use of language later in the class period suggests the students were focusing on the persuasive aspects of argumentation. For example, towards the end of their discussion, Kendra asked Tyler to "just throw in the towel and join the grass." Tyler responded to this by saying "nah, nahh, I can't go, I can't go. I ain't going, buddy, I'm proving my point." And, when the discussion concluded, Darnell claimed "we win, we win," even though Tyler never "joined the grass." These observations provide evidence of the challenges discussed above: Tyler's group members tended to emphasize ways in which their own reasoning was sound without acknowledging the substance or plausibility of Tyler's argument. Tyler, similarly, was not open to listening to his group members' arguments. Instead, he continued to restate his point of view and the evidence he thought was most compelling. He remained resistant and separated from his group the following day when the class continued the discussion about what the invasive

species in the model ate. He was even selected to speak in front of the class to defend his claim that the invasive species was eating the rabbits. Because he was such a vocal participant in discussions and because he was later designated as a representative in that larger class discussion, we believe that Tyler was a central member of the classroom community during these discussions; the observed interactions in Tyler's group did not seem to result from a diminished social standing or stigmatization. However, the case and interactions we observed here demonstrate, as might be predicted from the extant literature discussed above, that rather than attempt to engage and consider the legitimacy of arguments, some students can get so caught up in making the points they wish to make that they ultimately fail to reach a consensus.

Enabling consensus-building by legitimizing all ideas

Examining group 9 suggests that the students had not interpreted the situation as one in which acknowledging strengths in alternative ideas and weaknesses in their own were sensible discourse moves: Students were quick to dismiss what was being said by those with an opposing viewpoint. Moreover, we saw few, if any, interactions that made it acceptable or safe for the students to revise their claims as they moved towards consensus. With that as a working hypothesis, we examined the other groups in the corpus and found instances in which student contributions to the conversation were co-located with a shift in how they were participating and responding to counter-arguments and evidence. In particular, students in these groups seemed to find a way to legitimize one another's ideas—so they were not simply 'wrong'—before authors of those ideas revised them in light of the counter-evidence. We illustrate this legitimization with two examples, selected for the sake both brevity and clarity.

Legitimization example 1

Group 7 illustrates students legitimizing the dissenting idea by making a concession that the idea might be right. When group 7 began their discussion, two paired students (Bethany and Natalie) believed that the

invasive species ate both rabbits and grass, as determined by video from their previous day's interactions. The other pair had a dominant member (Cassie), who believed the rabbit population declined because the invader was competing with it for food—the grass—and her partner (Darren), who participated in the argumentative discussion intermittently.

At the beginning of the small-group discussion, Natalie and Bethany made the argument that the invader ate rabbits and grass based on two observed phenomena during the previous day's work with the model: the rabbit population disappeared and the grass population continued to show cycles of increase and decrease even after its consumer (the rabbits) was gone. They therefore stated that the invader caused the rabbit population to disappear and the grass population to fluctuate by eating both organisms. Cassie responded to this by saying: "… that's different from ours."

Once the four students firmly established that they disagreed, they proceeded to work on a shared laptop with the computer model, changing the initial population values and discussing the population fluctuations that occurred during each model run. However, they could not resolve the fact that they were using the *same* evidence to prove different points: Bethany and Natalie thought that the decrease in rabbit population proved that it was being eaten by the invader while Darren and Cassie believed that the decrease was the result of competition for the grass. Throughout this, similar to the latter half of group 9's argument, the discussion focused on how students' interpretations of the data were (or were not) aligned with the available evidence. We therefore contend that it reveals students appropriately distinguishing between evidence and theory (in this case, the theory would be their competing interpretations of the data).

About halfway into discussion, Cassie made an utterance that changed the direction of the group's conversation. Essentially, Cassie legitimized her classmate's opposing idea—without reconciling their fundamental underlying disagreement—by making a concession saying: "We think, kind of like your point, they [the invader] might eat rabbits, but they mostly eat grass."

Through that utterance, Cassie acknowledged that her classmates might be right while simultaneously questioning their claim. That is, she was not saying that the invader *definitely* ate grass *and rabbits*; She was saying that it *might* eat a *few* rabbits. Although this concession was tempered, it was a legitimization of the opposing pair's idea by stating that it might be partially correct. Immediately preceding this statement, Natalie appeared disengaged: on the video she was mostly looking downward, fidgeting with her pencil in one hand, and playing with some chewing gum in her other hand. After Cassie's concession, Natalie stopped playing with her gum, made an upward glance toward Cassie and said "Yeah…" Moments later, Natalie rose from her seat and leaned forward on her desk in order to attend to what Cassie was saying. As Natalie repositioned herself, Cassie followed her concession by defending the new claim, shown in Table 4.

<Table 4: Cassie defends the claim that invaders eat rabbits and grass>

Cassie:	Okay. You see they [the invaders] are doing really really well without rabbits. See look how high that is and look how good that is
Natalie:	[She stands up and leans across her desk to look closely at the laptop display that Cassie is referencing]. Yeah and the foxes have to be eating the invaders
Cassie:	The thing we didn't understand . . . The thing we didn't understand is look how their number goes real real high up and then look at the grass number it just

goes waaaaoh [points at the graph with her pencil]. Completely like bleh [opens both hands dramatically]

Bethany: It's also—it's obvious! The invaders eat the grass!

Notice that in defence of her concessionary claim that the invader ate some rabbits but mostly grass, Cassie focused on the grass. She pointed out that the invader survived without rabbits (line 1) and that, when the invader population increased, the grass population decreased (line 3). Natalie and Bethany both seemed to follow Cassie's argument as they were reiterating claims that could be inferred from her evidence (lines 2 and 4). Thus, we understand this example as showing that Cassie's concession that Natalie and Bethany's claim *might* be right co-occurred with Natalie and Bethany increasing in their engagement with Cassie's evidence. Moreover, Bethany saw this evidence as agreeable with her interpretation (line 4). We therefore understand this to be an important step towards the students reaching consensus. This work of agreeing on the implications of the available evidence, however, did not resolve the question of whether the invader also ate rabbits.

Towards the end of the class session, however, we see evidence that the students had reached consensus regarding the invader's food. This occurred when the classroom teacher visited the group and observed that they still disagreed[5]. The group subsequently presented a newly unified front when talking about their ideas with the teacher, shown in Table 5, in which all students in the group defended the claim that the invader ate grass, and only the grass. This was the first time these students vocalized this agreement in this activity.

Table 5: Group 7 reveals consensus

Natalie: The invaders eat the grass

[5] According to the classroom teacher, disagreement was not unusual as these two groups involved vocal students from the class who were often in competition with each other for the floor during whole class activities.

Cassie: And the invaders have to survive and they eat grass, that's how the foxes survive

Darren: Grass is the really important thing

Bethany: Without grass, the whole ecosystem, everyone goes down

This exchange suggests that the group had converged around a single claim: They all contributed to the argument that the invasive species ate grass, and the rabbits were not mentioned. While that omission leaves open the possibility that Natalie and Bethany were still hold outs (i.e., maybe they were simply not mentioning the rabbits), further examination suggests that was not the case: The following day, when the students were asked to take sides regarding what they believed the invasive species ate, both Bethany and Natalie took the position that the invasive species ate *only* the grass. This suggests that the argumentation in which they engaged resulted in a revision on their part—they moved from claiming that the invader ate grass *and* rabbits to arguing for the claim that it ate *only* grass.

Given the fact that Bethany and Natalie did not identify the point at which they decided to support the new claim, we acknowledge that it is difficult to conclusively explain exactly why they did so. In fact, there could have been a multitude of factors influencing their implicit admission of the weakness of their own ideas as they forged a group consensus, such as more time for Natalie and Bethany to reconsider their position or a desire to put forward a united front for the teacher. However, the point at which the dissenting students' idea was legitimized was co-located with an increase in Bethany and Natalie's physical and verbal engagement with the group. Given these observations, we suggest that the legitimization that occurred through the Cassie's concession represented an important moment that enabled Bethany and Natalie to revise their claim and form a group consensus.

Legitimization example 2

Group 1 illustrates an additional way that students legitimized dissenting ideas as the group moved towards consensus. In this case, which took place in a suburban middle school, three of the students (Emilia, Francis, and Garret) were in agreement that the invasive species ate grass. Harrison believed that the invasive species ate only the rabbits. As seen in Table 6, the four students agreed with the data that the rabbits died but, as with groups 7 and 9, they used it to defend different claims. Emilia, Francis and Garret responded to this disagreement by offering Harrison an alternative explanatory hypothesis: maybe the rabbit population decreased because they were competing with the invader for food (lines 2 and 5). Similar to group 7, these students were debating interpretations of data and, as such, appropriately distinguishing between evidence and theory.

Table 6: Francis and Emilia argue with Harrison

Francis:	Rabbits die
Emilia:	Because, it is competing for the grass
Harrison:	So it does eat the rabbits too
Emilia:	No, it doesn't eat the rabbits
Garret:	No, it . . . it competes for the grass with the rabbits
Emilia:	[inaudible] . . . competing for the grass . . . then . . .
Garret:	We'll put it slower [Garret wants to slow down the model so they can watch the population fluctuations more closely]
Emilia:	Faster [inaudible]. Come on
Harrison:	See? They are so eating the rabbits
Garret:	How?
Harrison:	They're disappearing when they're [the invader and rabbit are] touching each

other

As seen in lines 9 and 11, Harrison did not respond to this new explanation. Instead, he pointed to the graphics window that showed instances in which a rabbit icon disappeared when it was near an invasive species icon. Note that this source of evidence differed from the evidence his group members were discussing and the evidence that was used by other groups in this study: he was focused on the graphics window showing animal icons rather than the dynamically generated graph (see Figure 1). Table 7 reveals that Emilia rejected Harrison's evidence as not important and, instead directed his attention to the population fluctuation graphs.

Table 7: Harrison acknowledges strength of Francis' claim

Emilia:	That doesn't matter. We're looking at the graph at the bottom
Francis:	As the grass decreases, the rabbits increase and then . . . we see . . . [inaudible]
Emilia:	Okay. Do you agree with us now?
Harrison:	I still don't, but yes
Emilia:	So, well, you you agree?
Garret:	Well, he agrees, but disagrees

Harrison responded to this redirection by saying: "I still don't [agree], but yes" (line 4). It is clear that his group members understood that Harrison was aligning himself with both claims when Garret, another group member, said "Well, he agrees, but disagrees" (line 6). It therefore appears that Harrison accepted the group's claim while simultaneously maintaining some commitment to his own. However, even with Harrison's reticence made explicit, the group was able to move forward, identifying evidence for the group's claim and discussing how they would present their argument to the rest of the class. The group's progress suggests that

even though the group members acknowledged Harrison's dissension they did not feel a need to challenge him further, and that Harrison was similarly comfortable with maintaining the two competing claims. In this way, Harrison's voluntary concession removed a roadblock to consensus-building.

Clearly, consensus-building through argumentation should not mean that one student silences his disagreement—as Harrison's statement in line 4 of Table 7 might suggest. However, we suggest that, like Bethany and Natalie, Harrison ultimately took on the group's claim without openly admitting it or formally declaring a change in his thinking. This is seen at the end of the discussion right before class ended, when these students reviewed the group's argument in preparation for sharing their argument with the class the next day. Harrison began this review saying "We think the invader eats grass because--" By voluntarily voicing the group's claim at the end of their discussion, Harrison communicated a willingness to argue for that claim. Granted, this could be for any number of reasons, and he does not indicate explicitly whether he still believed his original claim. However, the fact that he stated the group's claim and presented it as partially owned by him without prompting suggests that he understood it and recognized its potential strength.

Thus, we suggest that Harrison's hedge "I still don't [agree], but yes" enabled him to stand by his claim while exploring his group member's ideas and, as such, it enabled him to explore their argument and gradually revise his ideas without fully admitting that his original idea had weaknesses. Instead, he explicitly stated that he was grudgingly going along with his group and did not draw attention to his shifting understandings. In this way, Harrison did not have to publically delegitimize his early thinking.

Taking these three cases into consideration, we suggest that one way for student discussions to promote consensus-building is by legitimizing ideas such that individual students are able to shift away from their

ideas without publically acknowledging the weaknesses in those ideas. When this happened, students in groups 1 and 7 made progress in their collaboration. When it did not happen, as seen with group 9, the group interactions were more confrontational, and the group members never fully converged on a single idea.

Discussion

This study asked how students co-construct the argumentative task in a way that enabled them to forge a consensus across originally disparate ideas. The analysis began by exploring one group of students (Group 9) that never reached consensus. We argue that, the students' difficulty with reaching consensus can be partially attributed to whether and how students were able to position themselves within the argumentative discourse. In particular, when neither side behaved as if they were being heard by the other side, the interactions appeared confrontational. The additional cases reveal students successfully negotiating these challenges and reaching consensus when all ideas were legitimized, even those that were soon to be abandoned. Thus, we suggest that the students' various ways of legitimizing[6] one another's disparate ideas (in this case, making concessions and maintaining two competing ideas) enabled all students to be perceived as competent in their discussions. This sense of competency made it acceptable for the students to be wrong and revise their thinking even in the face of the typical school goal of demonstrating individual success (Johnson & Johnson, 1994), and the argumentative goal of being persuasive (Berland & Reiser, 2009).

In the language of discourse and interaction analysis, this legitimization could be considered a way of 'saving face' (Goffman, 1974). Students made statements that allowed the contributions of others to be heard and understood in such a way that they were not seen as less competent or inferior to others in the interaction. In

[6] In this case we use the term "legitimization" to refer to the students recognizing the potential value of one another's ideas as opposed to students passing judgment on the scientific validity or accuracy of an idea. We did not observe this second sense of the word. Moreover, scientific legitimization may have had the opposite affect of the peer legitimization, as it may have negated the potential value of all incorrect contributions.

some respects, this is seen as a form of politeness in discourse interaction (Brown & Levinson, 1987): The speech acts that legitimize the dissenting individual's contributions mean that their autonomy or space is not being impinged upon. We believe that what we are discussing here scratches the surface of an important set of considerations for educators interested in designing and facilitating situations in which students work towards consensus through argumentation. While there are certainly important competences that students must (and are indeed able to) hone related to the construction, articulation, and revision of arguments as they move towards consensus, there are also a set of social concerns that must also be addressed in order to enable students to engage with and practice those competencies. That is, in contexts like the schools participating in this study, some students will be more willing participants in consensus-building through argumentation if they feel that they are heard and that their ideas are valued.

As such, the legitimization seemed to be a key way that students co-constructed the argumentative task as a situation in which consensus-building was sensible and possible. In this way, the current study aligns with the growing trend to understand the challenges associated with argumentation, in general—including engaging with counter-arguments and evidence—in light of the context in which the argumentation occurs. In this study, 5 of the 6 disagreeing pairs were able to overcome the confirmation bias predicted within the educational psychology literature (Kuhn, 1989; 1991; Felton & Kuhn, 2001; Nickerson, 1998; Wason, 1983) in order to reach consensus, thereby bolstering the conclusion that individuals will experience this challenge in some contexts, but not others.

As seen in these cases, one way this legitimization can be brought about is to allow students with dissenting ideas to maintain those ideas for a short period of time. That was the case for Harrison, who maintained his incorrect argument while simultaneously entertaining his group's argument. His group allowed him to

disagree, at least partially, as they proceeded in their discussion, and he ultimately came around to form a consensus with his group mates. In other cases, such as with Cassie's group, the legitimization involves using language that implies each speaker's idea has some value, and thereby allowing the dissenting students to "save face" (Goffman, 1974) by suggesting the incorrect idea could potentially be correct. Note that, as we saw with Cassie in group 7, this legitimization does not necessarily mean that the students truly believed the opposing idea. Rather, by conceding that the alternative idea has potential, the students enable the dissenting members of the group to engage with the counter-arguments, so that they can work towards consensus. This is a form of conflict negotiation, a strategy that has been shown elsewhere to be an effective means of resolving disagreements among adolescents in a variety of other contexts (Laursen, Finkelstein, & Betts, 2001).

Because groups who created opportunities for everyone to have their ideas legitimated did not *immediately* converge on a consensus argument, and that students in group 9 shifted from ignoring disconfirmatory evidence to discussing it even without a legitimizing statement, we are not arguing that peer legitimization alone is sufficient for reaching consensus. Rather, peer legitimization may be seen as an interaction that promotes the participants' productive consideration of counter-arguments and evidence, and, as such, consensus-building.

While more systematic experimental work in the future could further our understanding of this relationship, the depiction of argumentation as requiring participants to negotiate the goals of persuasion and sensemaking offers an explanatory hypothesis regarding why legitimization might support consensus-building. Berland and Reiser (2009; 2011) depict scientific argumentation as the negotiation of two goals—sensemaking and persuasion. Or, as depicted by Ford (2008), argumentation requires two roles—knowledge constructor and knowledge critic. The goal of persuasion motivates refutations—or critiques—which could include counter-

evidence or warrants that undermine the veracity of the ideas being discussed. Once identified, the challenging information must be addressed by discounting it or by revising the explanation, and constructing/revising one's knowledge. It is through this process of making sense through persuasive dialogue that the scientific community builds knowledge (Longino, 1990). Thus, engaging in scientific argumentation requires that one engage with both of these goals. However, these two goals may motivate different responses to challenging counter-arguments and evidence. For example, when attending to persuasion, individuals have reason to discount counter-arguments and evidence, thereby displaying a confirmation bias while a sensemaking goal is more likely to inspire productive attention to that counter-argument and evidence. This suggests that one's goal for their argumentation will deeply influence whether and how they engage with the opposing ideas.

In the current study, the students appeared to have entered their discussions with a focus on persuasion as they compared disparate ideas, defended their own claims and challenged the alternatives. This focus on persuasion meant that their immediate goal was to demonstrate the value of their own ideas and, as such, it aligned with discourse moves such as articulating the ideas being discussed, and exploring the evidence that could defend and refute those ideas. As a face-saving move, the legitimization communicated that the students had (at least partially) succeeded at persuading others of the value of their ideas. As such, this legitimization helped the group shift their attention to sensemaking (i.e., attending to challenges and revising claims if necessary). With this new attention to the goal of sensemaking, it is more sensible for students to engage productively with counter-arguments and evidence, rather than simply discrediting those challenges in an attempt to continue demonstrating the value of the original idea.

This analysis raises some additional questions. In particular, why didn't the students from the dissenting group (group 9) eventually shift to focus on sensemaking and productively engage with the counter-arguments and evidence? One possible explanation is that the legitimizing moves seen in the other groups did not occur—so Tyler (the dissenting student) never had an opportunity to have his ideas accepted into the small group discussion and to gradually consider the strength of his classmates' idea. This explanation is consistent with the above hypotheses in that it emphasizes the importance of students experiencing their ideas as being a valuable part of the group discussion. However, this explanation does not account for the lack of legitimization: Why didn't the discourse in Tyler's group enable a shift from the competitive/persuasive goals to sensemaking? While a study of this size does not allow us to empirically explore this question, it is important to note that the students' argumentation was influenced by a multitude of factors including: the students' individual expectations for and comfort with small group discussions; typical classroom norms (Berland, submitted, to appear); and the dynamic process by which individual contributions influenced the group's framing of the task (Berland & Hammer, to appear, in press); and group dynamics (Engle, Langer-Osuna and McKinney de Royston, in press; Scherr & Hammer, 2009).

Instructional implications

Asking groups of students to engage in argumentative discourse that will culminate in consensus has been an increasingly utilized strategy for use in K-12 science education (e.g., Berland & Reiser, 2011; Clark & Sampson, 2007; de Vries et al., 2002). This approach allows students to engage in authentic, but appropriately scaled, practices of scientific communication and reasoning. Moreover, consensus-building through argumentation has the potential to support knowledge construction for individual students as they learn to draw upon and synthesize evidence in order to build stronger arguments (e.g., Asterhan & Schwarz, 2007; 2009; Kuhn, 2010; Kuhn, Shaw, & Felton, 1997; Limón & Carretero, 1997; Sampson & Clark, 2009; Schwarz, Neuman, & Biezuner, 2000). In fact, as seen in Table 1, nearly all groups that began with dissention

moved towards consensus around the correct claim, while discussing the key concept for the activity: competition between species.

However, using consensus-building to foster argumentation is challenging because the argumentative activity can often be interpreted as one in which admitting the strengths of alternative ideas and potential weaknesses in one's own is not a sensible action. As such, students are likely to exhibit a "confirmation bias" (Nickerson, 1998; Wason, 1983), rather than revising their claims in order to reach consensus. This paper has demonstrated that, in these cases, creating a safe space for students to revise their ideas can enable them to balance the sensemaking and persuasion aspects of the consensus-building task such that they are able to engage with the counter-evidence rationally and make sense of it.

In particular, it appears that recognizing the potential value of students' ideas may support them in revising those ideas, later in the discussion. In saying this, it is important to note that the students in this study engaged in these legitimization moves—thereby supporting one another's productive responses to counter-evidence—largely on their own. In cases such as group 9, it may behoove a teacher to interject and help to support the disagreeing students in balancing the goals of sensemaking and persuading. However, research in framing in classroom discussions reveals that these interjections can be remarkably subtle (e.g., Leander & Brown, 1999; Lidar, Lundqvist, & Ostman, 2006; Rosenberg, Hammer, & Phelan, 2006) and that extended, explicit instruction in these social negotiations may result in students framing—or interpreting—the activity as a "classroom game" Jimenez-Aleixandre, Rodriguez, & Duschl, 2000), rather than a productive, scientific discussion (Berland & Hammer, in press).

Moreover, based on the current data set, and literature identifying the multitude of epistemological resources that students have for engaging in a variety of discussions (Hammer & Elby, 2003; Redish, 2004), we suspect that students can and often do independently legitimize one another's ideas. These are among the many competencies that children, when given the opportunity in science classrooms, can demonstrate. That is, while the activity enacted in this study offered explicit supports regarding the structure of the students' arguments (Berland & Reiser, 2011), the student interactions were left to the teacher to scaffold as he or she felt necessary. Moreover, each of the three different teachers worked at markedly different schools and naturally had different expectations regarding group work and student collaboration. In addition, the one group that was unable to reach consensus (group 9) was in the same class as another group that successfully did so (group 10). As such, it is difficult to attribute the students' legitimization of alternative ideas to particular teaching strategies. We therefore hesitate to offer any overt prescriptions for activity design or teacher behaviour. We instead attribute it to the students' skill at balancing the goals of sensemaking and persuasion while engaged in a consensus-building discussion. In a sense, the argumentation that took place for most groups was not 'broke' so we do not feel that educators should feel compelled to 'fix it'. Instead, in keeping with the focus on the ways in which the argumentative context influences students' argumentation, we conclude that students are likely to legitimize one another's ideas when doing so aligns with their understandings of the situation. As such, teachers can best foster consensus-building through argumentation by establishing classroom norms that enable and necessitate attention to counter-arguments and thoughtful revision of ideas.

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