Guiding Principles for Fostering Productive Disciplinary Engagement: Explaining an Emergent Argument in a Community of Learners Classroom

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This article suggests that productive disciplinary engagement can be fostered by designing learning environments that support (a) problematizing subject matter, (b) giving students authority to address such problems, (c) holding students accountable to others and to shared disciplinary norms, and (d) providing students with relevant resources. To provide empirical support for this suggestion, we use these 4 guiding principles to explain a case of productive disciplinary engagement from a Fostering Communities of Learners classroom. We use the principles to understand 1 group of students' emergent and sustained controversy over a species' classification. The students became passionately engaged, used evidence in scholarly ways, developed several arguments, and generated questions regarding biological classification. We propose the controversy as an example of productive disciplinary engagement, and show how it was supported by: the treatment of the classification as a legitimate problem by the students and teacher; the students having the authority to resolve the issue for themselves while being held accountable to relevant contributions from peers and outside sources as well as to classroom disciplinary norms for using evidence; and students having access to multiple sources of information, models of argumentation, and other relevant resources. The article closes by reflecting

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on the generality of the principles, showing how they can be used to understand 2 other cases of productive disciplinary engagement from the literature on reform programs in science and mathematics. By specifying differences as well as similarities in the ways the principles were embodied in these cases, the article may provide learning designers with a landscape of possibilities for promoting the specific kinds of productive disciplinary engagement that they most value.

> At the heart of teaching well is the core challenge of getting learners engaged in productive work.
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> —Deborah Ball (2000, p. ix)

Current educational goals envision learning environments in which students are genuinely engaged in productive disciplinary work (e.g., Gardner, 1999; Lamon et al., 1996; National Council of Teachers of Mathematics [NCTM], 1991, 2000; National Science Foundation, 1997). Yet creating environments in which such experiences occur is neither common nor easy. For example, mathematics reform documents in the United States suggest that students should be engaged in frequent discussions of mathematical ideas (California State Department of Education, 1992; NCTM, 1991, 2000). However, research shows that such mathematical discussions are relatively rare in U.S. classrooms (Goodlad, 1984; Stein, Smith, Henningsen, & Silver, 2000; Stodolsky, 1988). Even those who have succeeded in involving students in mathematical discussions have commented on how difficult it can be to transform mathematics classrooms from places in which students simply apply procedures to ones in which they publicly investigate their mathematical basis (e.g., Ball, 1993; Cobb, Gravemeijer, Yackel, McClain, & Whitenack, 1997; Lampert, 1990a, 1990b). Similar challenges characterize efforts to foster productive engagement in science (e.g., Herrenkohl & Guerra, 1998; Schauble, Glaser, Duschl, Schulze, & John, 1995).

To address these challenges, this article proposes a set of guiding principles for fostering such *productive disciplinary engagement.* This notion, which we expand on later, combines moment-by-moment, interactional aspects of student engagement with ideas of what constitutes productive discourse in a content domain. Briefly, we suggest that one way to foster productive disciplinary engagement is by creating learning environments that embody the following four principles:

1. *Problematizing*: Students are encouraged to take on intellectual problems (e.g., Hiebert et al., 1996; Warren & Rosebery, 1996).
2. *Authority*: Students are given authority in addressing such problems (e.g., Lampert, 1990b; Scardamalia, Bereiter, & Lamon, 1994; Wertsch & Toma, 1995).

3. *Accountability*: Students' intellectual work is made accountable to others and to disciplinary norms (e.g., Cobb et al., 1997; Lampert, 1990a; Resnick & Hall, 2001[1]).
4. *Resources*: Students are provided with sufficient resources to do all of the above (e.g., Barron et al., 1998).

We formulated these principles to account for a case of productive disciplinary engagement from a Fostering Communities of Learners (FCL) classroom. Our goal was to abstract a small set of underlying principles from the case that could help account for it, while being general enough to be useful in understanding other cases and guiding future design efforts. We also refer to them as guiding principles to suggest their potential role in informing the moment-by-moment decisions of practitioners as they work to engage students with the ideas and practices of a discipline.

To some extent, these guiding principles can also be considered "design principles" (Brown, 1992; Brown & Campione, 1994, 1996; Cole, 2001; Lamon et al., 1996) in that they abstract from the surface features of learning environments to help explain how they work. However, unlike many design principles, our guiding principles were not created in the act of designing and redesigning such an environment, but instead while trying to explain a complex phenomenon after the fact. Thus, our principles identify underlying regularities in what the FCL teachers, curriculum developers, and other learning designers did that may help explain the students' engagement, rather than ideas they necessarily had in mind at the time they were fostering it. Moreover, although several FCL design principles (to be discussed later) can be viewed in terms of the principles we propose here, our goal is not to promote FCL or any other particular program. Instead, we hope to contribute to the development of a working consensus in the educational research community about the variety of ways in which productive disciplinary engagement may be fostered (cf. Gelman, 2001 and Scardamalia, 2001).[2]

Drawing on the work of others, this article begins by briefly defining productive disciplinary engagement and the four principles, commenting on their relationship to FCL design principles. Using this as background, we provide an initial sketch of how embodying the principles might help to foster such engagement. We then turn to the FCL case to ground and illustrate these ideas. First, we describe

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[1]For more information on accountable talk and the other principles of learning espoused by the Institute for Learning, LRDC, University of Pittsburgh, see http://www.instituteforlearning.org.

[2]In discussions at a conference commemorating the contributions of Ann Brown, Gelman (2001) challenged the learning sciences community to come to a consensus about their design principles. Scardamalia (2001) suggested that there is a core set of design principles that the community implicitly agrees on, with a larger set that distinguishes programs. In this article, we respond to Gelman's (2001) challenge by making explicit one set of core principles that the learning sciences community might share.

and analyze the ways in which a group of FCL students became productively engaged in an unplanned controversy over a species' classification. Next, we use the principles to understand and thus help explain the case. Our explanation focuses on how we see the principles embodied in the design of the unit and in key teacher and student moves, and how these relate to the students' subsequent engagement in the controversy. We conclude by showing how the principles can be used to understand two other documented cases of productive disciplinary engagement.

PRODUCTIVE DISCIPLINARY ENGAGEMENT

What do we mean by productive disciplinary engagement? We briefly define each part of the phrase.

Engagement

Like Herrenkohl and Guerra (1998), we suggest that evidence for student engagement can best be seen by analyzing students' discourse, broadly construed. Such an analysis considers such questions as: How are students participating? What proportion of students are participating? And how are students' contributions responsive to those of other students? Expressions of engagement are both culturally relative and subject to interpretation. For the diverse group of U.S. students whose discourse we analyzed, however, it seemed appropriate to infer greater engagement to the extent that: (a) More students in the group sought to make, and made, substantive contributions to the topic under discussion; (b) students' contributions were more often made in coordination with each other, rather than independently of each other (Barron, 2000; Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001); (c) few students were involved in unrelated "off-task" activities; (d) students were attending to each other as assessed by alignment of eye gaze and body positioning (McDermott, Gospodinoff, & Aron, 1978; Shultz, Florio, & Erickson, 1982); (e) students often expressed passionate involvement by making emotional displays (Tannen, 1989); and (f) students spontaneously got reengaged in the topic and continued being engaged in it over a long period of time.

Disciplinary Engagement

All of the characteristics above may show engagement, but they do not necessarily indicate that students' engagement is disciplinary. By using the term *disciplinary engagement* in a school context, we mean that there is some contact between what students are doing and the issues and practices of a discipline's discourse

(or "Discourse," see Gee, 1999; see also Erickson & Shultz's, 1992, "curricular engagement"). However, because educators differ in their conceptions of disciplines and the kinds of contact students should make with them, what may be valued as disciplinary engagement by one educator may appear insufficient to another. Without claiming it as an ideal, we will make the case that the FCL students made contact with both scholarly discourse in general and biological discourse in particular.

Productive Disciplinary Engagement

Finally, students' engagement is productive to the extent that they make intellectual progress, or, in more colloquial language, "get somewhere" (Hatano & Inagaki, 1991; Herrenkohl & Guerra, 1998; Hiebert et al., 1996). What constitutes productivity depends on the discipline, the specific task and topic, and where students are when they begin addressing a problem. In the FCL case, we show that the students' arguments for their claims became increasingly sophisticated over time (Hatano & Inagaki, 1991), and that their discussion prompted them to raise new questions. In other situations, such productivity might involve things like recognizing a confusion, making a new connection among ideas, or designing something to satisfy a goal.

It is difficult to imagine learning deeply in a domain without becoming productively engaged in the disciplinary issues involved. Such engagement is an aspect of lived activity that one can experience for oneself and witness in others (Erickson & Shultz, 1992). Focusing on productive disciplinary engagement allows one to trace the moment-by-moment development of new ideas and disciplinary understandings as they unfold in real-life settings. It provides a complementary perspective to views of learning that rely on static comparisons of student understanding with pre- and post measures. By incorporating content and interaction, this perspective also highlights the ways in which learning is a simultaneously cognitive and social process (Erickson & Shultz, 1992; Greeno, Benke, Engle, Lachapelle, & Wiebe, 1998; Greeno & the Middle-school Mathematics through Applications Project, 1998).

FOUR PRINCIPLES FOR FOSTERING PRODUCTIVE DISCIPLINARY ENGAGEMENT

Although we both ground and elaborate on the principles in detail in the context of the case, in this section we provide a rough outline of what we mean by them, drawing on relevant literature where possible. We then address their relationship to FCL design principles. Finally, we discuss, in general terms, how we hypothesize that the principles may help foster productive disciplinary engagement.

Problematizing Content

The core idea behind *problematizing* content is that teachers should encourage students' questions, proposals, challenges, and other intellectual contributions, rather than expecting that they should simply assimilate facts, procedures, and other "answers" (Hiebert et al., 1996; Lemke, 1990; Warren & Rosebery, 1996). As Hiebert et al. (1996) put it, "Students should be allowed and encouraged to problematize what they study, to define problems that elicit their curiosities and sense-making skills" (p. 12). Problems may be presented to students by their teachers (Barron et al., 1998; Hatano & Inagaki, 1991; Lampert, 1990a, 1990b; Michaels, 1999; Sohmer, 2000) or emerge in the course of student activity as in the present case (see also O'Connor, Godfrey, & Moses, 1998; Warren & Rosebery, 1996). As this FCL case demonstrates, even seemingly closed issues can be opened up and problematized (Hiebert et al., 1996). Previously accepted facts can be treated as examinable claims, common explanatory accounts as needing evidence, and standard procedures as needing explanation for their functionality. Thus, problems do not need to be open from the perspective of experts in a discipline, but rather open from the perspective of students interpreting them, using their available knowledge and resources (Hiebert et al., 1996; Henningsen & Stein, 1997).

Giving Students Authority

What we are calling *authority* refers to a number of aspects of students' discourse and relationships to problems in a discipline. Part of such authority is a matter of students having an active role, or *agency,* in defining, addressing, and resolving such problems (Cobb et al., 1997; Lampert, 1990a, 1990b; Stipek et al., 1998). In addition, authority includes teachers and other members of the learning community positioning students as *stakeholders* by publicly identifying them with the claims, approaches, explanations, designs, and other responses to problems that they pursue (Lampert, 1990a, 1990b; O'Connor & Michaels, 1996; Toma 1991a; Wertsch & Toma, 1995). Students may also be positioned as potential *contributors* who may change the shape of collaborative projects (Schwartz, 1999) and even develop into classroom *experts* to whom others may turn (Brown et al., 1993). Such forms of student authority may apply at the level of individual students, groups of students, or whole classrooms. In general, by giving students authority, we mean that the tasks, teachers, and other members of the learning community generally encourage students to be authors and producers of knowledge, with ownership over it, rather than mere consumers of it (Lamon et al., 1996; Lampert, 1990a; Lehrer, Carpenter, Schauble, & Putz, 2000; Magnusson & Palinscar, 1995; Scardamalia et al., 1994).

Holding Students Accountable to Others and to Disciplinary Norms

Holding students "accountable to others and to disciplinary norms" means that the teacher and other members of the learning community foster students' responsibility for ensuring that their intellectual work is responsive to content and practices established by intellectual stakeholders inside and outside their immediate learning environment (Resnick & Hall, 2001) as well as to relevant disciplinary norms, to the extent that these can be embodied in a classroom (Cobb et al., 1997). To be accountable in our sense of the term, students are expected to consult others in constructing their understandings in a domain; they cannot purposely ignore the relevant work of others without justification (Resnick & Hall, 2001). Thus, such accountability does not require acceptance of others' views, but instead responsiveness to them. In addition, students are held responsible for either respecting classroom disciplinary norms or explaining why they are doing otherwise. We wish to emphasize that the accountability we refer to here is not an external accountability, in which outsiders decide whether students have met standards. Instead we refer to an internal accountability, in which students' influence within their learning environment is affected by how well they account for how what they are doing is responsive to what others have done and to community norms for good practice (Lerner & Tetlock, 1999).[3] The principle is an expression of the value that each member of a learning community is not an authority unto himself or herself, but one intellectual stakeholder among many in the classroom and beyond.

Providing Relevant Resources

Although we include the provision of *resources* as a fourth principle, it functions at a somewhat different level in that resources may be seen as necessary to support not only students' productive disciplinary engagement, but also the embodiment of the other principles. Resources supporting productive disciplinary engagement may be as fundamental having sufficient time to pursue a problem in depth (Collins, 1998; Henningsen & Stein, 1997) or having access to sources of information relevant to it. Other resources may be more closely linked to the specific nature of the problem under investigation. For example, students charged with designing a blueprint for a playground might be shown, as a scaffold for their own work, a video of an architect using top and side views of a swing set (Barron et al., 1998). Resources supporting discourse practices involved in problematizing content might include home-based modes of discussion (Corson, 1995; Hudicourt-Barnes,

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[3]This is similar to Lerner and Tetlock's (1999) definition of accountability as "the implicit or explicit expectation that one may be called on to justify one's beliefs, feelings, and actions to others" (p. 255).

2000; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001) as well as models and norms developed in the classroom (Lampert, 1990a, 1990b; Michaels, 1999; Sohmer, 2000; Toma, 1991a). Resources for fostering student authority and accountability might include the establishment of public forums for student work and access to disciplinary experts (Hall, 1997).

RELATIONSHIP OF THESE PRINCIPLES TO THOSE PROPOSED FOR FOSTERING COMMUNITIES OF LEARNERS

Although our guiding principles are designed to account for productive disciplinary engagement rather than to characterize FCL per se, they do overlap substantially in content with some specific FCL design principles. This is not surprising given that our principles were developed in the course of analyzing an FCL case. To investigate the nature of this overlap, the left column of Table 1 reprints the full set of FCL design principles proposed in Brown and Campione (1996, p. 318). The right column indicates which of our principles appear to (at least partly) correspond to theirs, with question marks indicating points of uncertainty.

One example of the overlap involves the guiding principle of problematizing, which is in part captured by the FCL subprinciple of an "atmosphere of wondering, querying, worrying knowledge" (within FCL Principle 2). There are many other

TABLE 1
Mapping Between FCL Principles and the Proposed Guiding Principles
for Productive Disciplinary Engagement

Principles of Learning to Support FCL	*Guiding Principles*
1. Systems and cycles	
• Seasonal cycles of research-share-perform (RPS) activities	• N/A: FCL-specific
• Supported by repetitive participant structures	• Resources?
• Participant structures can be replaced if and only if the replacement serves the simple RSP system	• N/A: FCL-specific
• Constancy at level of deep structure, variability at level of surface ritual	• N/A: general stance for good design
• All activities for a purpose, a purpose for all activities	• N/A: general design stance
2. Metacognitive environment, reflective environment	
• Active, strategic nature of learning	• Authority: agency?
• Self-regulation and other regulation for common good	• Accountability to others
• Autocriticism, comprehension monitoring	
• Effort after meaning, search for understanding	• Problematizing
• Atmosphere of wondering, querying, worrying knowledge	• Problematizing
• Reflective practices	• Problematizing?

(continued)

TABLE 1 (*Continued*)

Principles of Learning to Support FCL	Guiding Principles
3. Discourse	
• Dialogic base	• Problematizing?
• Shared discourse, common knowledge	• Resources
• Seeding, migration, and appropriation of ideas	• Accountability to others
• Mutual appropriation	• Authority: contributors, accountability to others
• An interpretive community	• Problematizing?
4. Deep content knowledge	
• Developmental sensitivity	
• Intellectually honest and demanding	• Problematizing,
	• Accountability to disciplinary norms
• Developmental corridors from children's intuitive knowledge to deep principles of a discipline of inquiry	• Resources
• Intermediate goals and levels of abstraction	• Resources
• Support, sharing	• Accountability to others, resources
• Enriched by diversity	• Resources
5. Distributed expertise	• *Authority: experts*
• Sharing for a purpose	• Authority: contributors
• Collaboration not just nice but necessary	• Authority: contributors, accountability to others
• Major, identity, and respect	• Authority: stakeholders
• Multiple ways in, multiple intelligences	• Resources?
• Community building	
6. Instruction and assessment	
• Deliberately aligned	• N/A: General design stance
• Based on same theory, loosely Vygotskian	
• Guided practice, guided participation	• Resources
• Multiple zones of proximal development	• Resources
• Legitimation of differences	• Authority: agency
• Transparent, authentic, and purposeful	• N/A: General design stance?
7. Community features	
• Community of practice	
• Communities of practice with multiple overlapping roles	
• Links between current practice and expert practice emphasized	• Accountability to disciplinary norms
• Elements of ownership and choice	• Authority: stakeholders, authority: agency
• Community beyond the classroom wall	• Accountability to others, resources

Note. The principles and subprinciples listed in column 1 are from *Innovations in Learning: New Environments for Education*, by A. L. Brown and J. C. Campione, 1996, Mahwah, NJ: Lawrence Erlbaum Associates, Inc. Copyright 1996 by Lawrence Erlbaum Associates, Inc. Reprinted with permission. FCL = Fostering Communities of Learners.

such examples. Some FCL subprinciples do not correspond to ours because they are either too general or too specific given our goal of understanding how productive disciplinary engagement is fostered. For instance, constancy at level of deep structure (within Principle 1, systems and cycles) is a general principle important for many design activities, whether the goal is productive disciplinary engagement, a working FCL classroom, or something else. On the other hand, "seasonal cycles of research-share-perform activities" (also within Principle 1) refers to the specific way that FCL curriculum units are structured. In addition, our principles and theirs seem to use orthogonal categorization schemes. Each of our principles appears within several categories of the FCL principles. For example, in our view, aspects of accountability to others are evident within FCL Principles 2, 3, 4, 5, and 7. Essentially, our principles consist of a small set of broad ideas that incorporate (and in some cases, generalize from) those FCL subprinciples that are specifically relevant to understanding how to foster productive disciplinary engagement.

HOW ATTENDING TO THESE PRINCIPLES MIGHT FOSTER PRODUCTIVE DISCIPLINARY ENGAGEMENT

In this section, we briefly sketch how each principle might contribute to fostering productive disciplinary engagement.

Problematizing content creates opportunities for students to participate actively in resolving substantive problems. To the extent that such problems have a disciplinary basis, such participation is disciplinary engagement. Problematizing content may also promote productive engagement if, in the process of trying to resolve a problem, students refine their ideas, generate new questions, reorganize their initial understandings, etc. (Hiebert et al., 1996).

The types and extent of student authority present in a classroom may also critically shape students' engagement. First, by being "allowed and encouraged to . . . define problems" (Hiebert et al., 1996, p. 12), students are positioned in more active intellectual roles, which may encourage them to become more engaged (cf. Turner et al., 1998). To the extent that they also become public stakeholders, contributors, and experts with respect to disciplinary issues, the quality of their work may reflect on their identities, potentially motivating them to engage more productively than they might otherwise. Finally, when students have developed recognized expertise in the classroom, their disciplinary knowledge may be more easily incorporated into problem solving, making students' engagement more productive and disciplinary.

Consistent with these views on problematizing and authority, studies have suggested that productive disciplinary engagement can be short-circuited when learning environments communicate to students that there is a single valid response to every question and that students' job is merely to determine what it is (Cazden, 1988; Lemke, 1990; Mehan, 1979; Stein, Grover, & Henningsen 1996).

In such environments, students may become highly engaged in getting possession of the right answer and having it validated by an authority. However, this kind of engagement is not characteristic of most authentic disciplinary practice, often makes less contact with deep disciplinary issues, and tends to be reproductive rather than productive (Collins, 1998).

The extent to which students are held accountable to others may also promote productive disciplinary engagement. Students who take the ideas of others into account may be better positioned to persuade other members of the learning community to engage with their own ideas, thus motivating further participation. By attending to others' ideas, students gain opportunities to learn from and be taken into account by other members of their classroom, making the class' work more productive than it might be otherwise. Also, to the extent that students feel their own ideas will be taken into account, they may be more inclined to make higher quality contributions (Schwartz, 1999).

In addition, the extent to which students are held accountable to disciplinary norms established in the classroom may also critically affect the quality of their engagement. If productive disciplinary engagement is a goal, students cannot have untrammeled authority to construct any response to a problem in a discipline and declare the matter resolved (Resnick & Hall, 2001). By failing to take disciplinary norms into account, students may be less likely to become deeply engaged with disciplinary ideas. It is in part teachers' and curriculum designers' decisions about which disciplinary norms to emphasize that help shape the type of disciplinary engagement most likely to occur in a classroom. Thus, balancing student authority with accountability to the discipline increases the chance that students will be engaged in generally more productive and disciplinary ways.

Finally, the provision of relevant resources can critically affect productive disciplinary engagement (Barron et al., 1998). Learning environments designed to promote disciplinary engagement need to support students in developing and applying the skills, knowledge, representations, materials, and technologies relevant to the disciplinary questions they are pursuing. Although what constitutes relevant resources must be negotiated by the learning community (Conant, Rosebery, Warren, & Hudicourt-Barnes, 2001), without them, students may give up in frustration or not be able to work effectively on problems, despite their best efforts. Simply put, notions of giving students authority in addressing disciplinary problems and making them accountable to disciplinary norms are moot if students do not have access to resources necessary for this work (Barron et al., 1998; Herrenkohl & Guerra, 1998).

Although for ease of exposition we presented each principle separately, we believe it is through their combined interactions in real settings that productive disciplinary engagement can be fostered. Synergy among problematizing, authority, accountability, and resources helps students avoid disengagement due to boredom, frustration, or lack of personal interest. This synergy also helps students avoid the kinds of engagement that have few disciplinary connections or make little progress.

Realizing the guiding principles proposed here does not guarantee that productive disciplinary engagement will occur. We hypothesize, however, that embodying these principles creates affordances that not only allow it to occur, but also make it more likely.

Binding these principles together is the notion of respect (Brown & Campione, 1996; Prawat, 1996). In the words of Brown and Campione (1996), "The essential underlying principle is that all members [of the learning community] are co-researchers, co-learners, and co-teachers, who listen to and respect each other" (p. 300). In a climate of respect, each student or group of students has the authority to express and develop ideas, balanced by accountability to the ideas of everyone else in the learning community. Respect for a discipline necessitates a commitment to raising authentic problems in it, being accountable to its disciplinary norms, and seeking or providing relevant resources.

THE ORCA CONTROVERSY: A CASE OF PRODUCTIVE DISCIPLINARY ENGAGEMENT

Setting and Data Collection

We present an example of productive disciplinary engagement taken from two 5th-grade classrooms organized according to the FCL literacy and environmental science program (Brown & Campione, 1994). The socioeconomically and ethnically diverse classes in the Grove School[4] in the San Francisco Bay Area were involved in a version of the FCL "Endangered Species" unit that was adapted by Laurie Wingate and Jeannie Kohl for their students (Kohl & Wingate, 1995). The unit was designed to focus the students' attention on the guiding question, "How do animals survive?" (Kohl & Wingate, 1995, p. 2).

A detailed description and timeline of events and activities during the unit appears in Table 2. The unit began on December 4, 1995 and ended about 4 months later, on April 2, 1996, with significant gaps for the winter holidays (2 weeks), a teacher's strike (5 weeks), and the school's science camp (1 week, immediately following the strike). Thirty-four sessions (usually 90 min long) were devoted to the unit, occurring approximately 3 days per week when school was in session.

To begin the unit, the students watched a nature video and wrote questions about animals in response to it. Their questions were then organized through whole-class benchmark discussions (di Sessa & Minstrell, 1998; Minstrell, 1989) and categorized according to subtopics. Next, groups of four or five students wrote proposals to study specific endangered animals (whales, manatees, eagles, etc.). The groups were assigned their animal of study based on the (externally judged) quality of these proposals. Each student in a group was

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[4]This is the standard pseudonym for this school used in reports about FCL.

TABLE 2
Timeline of 1995–1996 Endangered Species Unit in the Grove School with Focus
on Ms. Wingate's Whale Research Group

Days of Unit	Dates	Name and Description
1–7	12/4/95–12/15/95	Unit introduction (7 days) • Watched video about habitat destruction and extinction in Hawaii • Generated questions about animals and sorted them into categories • Organized initial categories into survival needs subtopics in benchmark • Wrote and presented research proposals to judges (other teachers) • Judges decided which endangered animal each research group would study
8–23	12/18/95–2/5/96	Doing research (~16 days) • Individual group members consulted books and other sources about their topic • On days 10–13, 15, and 18–19, shared findings on topics in breakout groups • With Ms. Kohl's whale group, worked on bulletin board on days 13, 22, and 24 • Went on field trip to Marine World on day 21 (2/1/96) • In preparation for writing, participated in benchmark on outlining
24–28	2/8/96–3/28/96	Writing individual chapters (~5 days, spanning strike and science camp) • Each student began and finished writing at different times; this is a typical timeline • Most chapters had several drafts, many prompted by Ms. Wingate
29–31	3/29/96–4/2/96	Writing group conclusion and preparing for jigsaw (~3 days) • Made initial and final draft of group conclusion on first two days • On third day, quizzed each other in preparation for jigsaw presentations
32–34	4/3/96–4/4/96	Presenting reports in jigsaw sessions (3 days) • Samantha, Brian, Jonelle, and Toscan with Racquel each presented the group's report to classmates who had studied other endangered animals

responsible for researching a subtopic (such as the animal's physical features, reproduction strategies, or eating habits) and writing a chapter about it for inclusion in a group report about how various factors contributed to the animal's endangerment. Each group then collaboratively wrote an introduction and a conclusion for the group report. At the end of the unit, each student was

expected to make a presentation of the whole group's report to other classmates in a "jigsaw" session (Aronson, 1978).[5]

Researchers in the classrooms observed and videotaped four groups of students to trace their learning during the unit. In particular, data were collected on the whale and eagle research groups in Ms. Wingate's classroom as well as the gorilla and eagle groups in Ms. Kohl's class. The data for this article come primarily from records of the classroom work done by the five members of the whale group in Ms. Wingate's classroom (Brian, Jonelle, Racquel, Samantha, and Toscan), including work they did in collaboration with the five students studying whales in Ms. Kohl's classroom (Devonae, Jonah, Liana, Shantelle, and Sione). All student names are pseudonyms.

A controversy emerged in this group of students over whether killer whales (also called orcas) are whales or dolphins. At first glance, this question does not seem inherently interesting, relevant, or even especially open: Why does it matter whether they are whales or dolphins? How does this relate to understanding why whales are endangered? Haven't scientists already determined the classification? Couldn't the students just look up the answer somewhere? Moreover, Ms. Wingate's whale group was originally unhappy to be studying whales at all—It was their last choice, their preferred animals having been assigned to other students whose research proposals were judged superior. Given the nature of the question and the students' initial lack of interest in whales, it may seem surprising that they were interested in discussing the orca's classification at all.

The group nevertheless passionately argued the question of the orca's classification, initially sparked while they were making a bulletin board display, for more than 27 min in class. This discussion was what one student later referred to as a "Big Ol' Argument" (BOA, day 24, 2/2/96, see Table 3). The controversy remained an issue for the group until the end of the unit, resurfacing on eight different occasions over a period of more than 8 weeks. Table 3 provides a timeline of the events in the controversy, which provides the core data for our analysis.[6] Full transcripts of all the orca controversy events are available for interested readers at http://ed.stanford.edu/~greeno/PrinciplesPaper/.

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[5]In addition to these activities, throughout the unit each research group read a general article about species endangerment using reciprocal teaching (Palinscar & Brown, 1984). Also, early in their research (days 10–20) each student shared his or her research findings with students studying the same subtopic (but usually different animals) in what were called breakout groups (Kohl & Wingate, 1995). Finally, the students went on field trips, consulted outside experts, and were required to display their research findings to a variety of audiences in a variety of formats including outlines, discussions, electronic mail, a bulletin board, and oral and written reports. Unlike more recent versions of FCL, there was no consequential task after the unit that would have required students to apply the knowledge they learned in jigsaw (Brown & Campione, 1996, pp. 302–303, 310–312).

[6]Because recording equipment was usually not focused on them, we are likely to have missed occasions in which Ms. Kohl's whale group was engaged by themselves with the orca question as well as how Ms. Kohl supported the students' engagement.

TABLE 3
Orca Controversy Events

Day of Unit	Dates	Name and Description
19	Thursday, 2/1/96	Marine World field trip (MW): At killer whale show, trainer announces that killer whales are not whales, but dolphins; question and answer session follows
20	Friday, 2/2/96	Hallway argument (HW): In the hallway, the two whale groups argue about whether killer whales should be included in their bulletin board
20	Friday, 2/2/96	Big Ol' Argument (BOA): Ms. Wingate brings the two groups into classroom and they argue until the end of the session about whether killer whales are whales or dolphins
20	Friday, 2/2/96	Wrap-up sessions (WU): At the end of the Big Ol' Argument, each group reports on the controversy to their class; Ms. Kohl's group reports the issue is still open because one person is not convinced they are whales; in Ms. Wingate's class, the students' report about the issue leads to a meta-level discussion of how to decide which sources to believe
23	Friday, 2/9/96	Continuing disagreement and new evidence: In update on their research to parent volunteer, Ms. Kohl's whale group says the controversy is continuing; Devonae twice mentions Sione found a book saying orcas are the largest dolphin
23	Friday, 2/9/96	Both groups continue their discussions, sharing more new evidence: Representatives of Ms. Kohl's whale group visits Ms. Wingate's whale group several times to discuss the status of the controversy and share evidence:

- First, Liana lets Ms. Wingate's whale group know that Devonae and Sione from her group now think orcas are dolphins because they read it in two new books; Samantha says she also has read it in two books, and gives one to Liana to share with her group
- A minute later, Shantelle suggests the two groups need to meet, as they do not have a consensus; when Ms. Wingate's whale group resists, Shantelle asks them which claim is true, but the students shout different answers; Shantelle then has them vote, and declares whales the winner; 1 min later she returns, however, saying they still need to convince Sione that orcas are whales; Ms. Wingate sends her away, saying the group has other work to do
- Three minutes later, Ms. Wingate's group discovers a book about evolutionary ancestors of whales and dolphins that they use to claim that orcas are not dolphins; when Liana returns, reporting that her group still doesn't "know what to beLIEVE," the group shares this new evidence with her and Ms. Wingate

(continued)

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TABLE 3 (*Continued*)

Day of Unit	Dates	Name and Description
		• Four minutes later, Samantha uses a picture of a dolphin to point out its visual similarities to orcas; in response, Toscan argues that none of their newer books claim that killer whales are dolphins
Five-week teachers' strike followed by 1 week of science camp focusing on other topics		
24	Tuesday, 3/26/96	Report to new student teacher (NST): During Brian's report on whale features, Ms. Wingate's group reanimates the argument with each other and then recounts its history to the new student teacher
25	Wednesday, 3/27/96	Continuing disagreement 2: When Shantelle approaches Ms. Wingate's group saying only, "Can I ask you a question?," Toscan and Samantha respond by vehemently expressing their disagreement about the controversy
25	Wednesday, 3/27/96	Negotiating the written account: Over 30 min later, Brian has Samantha read what he wrote about the controversy in his report, with explicit work between them on how to manage their disagreement publicly and privately; 4 min later, Ms. Wingate urges Brian to include more evidence in his report for both positions, asking him to consult with Samantha for her side; Samantha is busy and gives only minimal help
29	Tuesday, 4/2/96	Continuing disagreement 3 and negotiating the oral presentation: While Brian quizzes the group about his report on features in preparation for jigsaw, Toscan finds two occasions to shout that "they're NOT, a DOLphin" (during questions about dorsal fins and baleen versus toothed whales); 1 min later when Brian jokingly asks them, "What is a killer whale?," the group expresses their disagreement and begins negotiating how to present it to classmates in jigsaw, which turns into jokes about the vagaries of classifying species

After the BOA, both whale groups continued to engage with the controversy by including it as a salient part of their wrap-up (WU) reports. The next set of events occurred a week after the BOA (day 23, 2/9/96), and involved exchanges of documentary evidence between the two classes. On this day, Brian and Toscan persisted in finding and showing such evidence to teachers and peers (despite having been told explicitly by Ms. Wingate that they needed to work on the rest of their research). On the next day of the unit, which was 6 weeks later due to the teachers' strike and science camp, the controversy reignited yet again. In this episode, Ms. Wingate's group updated a new student teacher (NST) on their research (day 26, 3/26/96). The students expressed their disagreement on at least two other days

(day 27, 3/27/96 and day 30, 4/2/96). During those occasions, the group also carefully negotiated how to present the controversy to others, first in Brian's part of the group report, and then in each student's oral presentation about their report to classmates in jigsaw sessions. All 10 of the students who were studying whales made substantive contributions at some point during the discussions.

According to former FCL teacher-researcher Doris Ash (2001), such student debates frequently arose in the course of FCL work (see Brown & Campione, 1994, pp. 240-244, for another example). In the unit we observed, smaller controversies arose over other topics, but the orca controversy was exceptional in its intensity and length. As an unforeseen and tangential topic, it was supported at times despite the other FCL work in the unit, rather than as a focus of it. However, we believe the level of engagement observed in the orca case justifies a careful study of the specific ways in which it developed. As we shall see, the students' engagement in the controversy was skillfully fostered by a teacher who recognized its value, as well as supported by certain aspects of the FCL design.

In the following section, we describe the origins of the controversy. We then provide evidence of the students' engagement, and argue that it was, to a large extent, both disciplinary and productive. In the core of the article, we show how embodiments of the principles may have fostered the particular form of productive disciplinary engagement observed in this case.

Origins and Initial Eruption of the Orca Controversy

For the first 20 days of the unit, the two groups of students studying whales had been operating on the assumption that orcas (killer whales) were a type of whale (as had their teachers). Furthermore, none of their previous readings or other information sources had prompted them to think otherwise. Thus, when asked to prepare a bulletin board about their research for the school, some of the students had made paper cutouts of killer whales to be put on the board. The whale groups then took a field trip to Marine World (MW) to see killer whales and interview what they were told would be whale experts there [day 21, 2/1/96].

During the killer whale show, a MW trainer made the following announcement (in this and other transcripts, capitalization indicates especially salient emphatic stress on particular words or syllables):

1   Through the years, there has been a lot of misinformation, and inaccuracies, and [*inaudible*] about these animals, that we do try to correct, whenever possible.
2   For example, did you know, that these [*orcas are swimming around*], are NOT whales?
3   And that they are the largest member of the dolphin family.

4   Those things on their sides [*one of the orca's flippers are in view*], they're not fins, they're actual flippers.
5   They have a bone structure similar to our own hands [*trainer holds out one of her hands*].
6   And on the middle of the back of the killer whale, is the dorsal fin [*an orca's dorsal fin is now in view*].
7   Scientists aren't sure what makes the dorsal fin flop over, but they're positively sure that it's not a mood indicator. It's found in the wild as well as here at Marine World.
8   What you see is a dol-PHIN! [*orca's fluke, which looks like a fin, is now in view*]

(MW, 2/1/96)

The announcement that killer whales are "NOT whales" directly contradicted the students' implicit understanding that killer whales were whales. The students did not visibly react to this revelation while they were at Marine World, however. It was only the next day, when the group returned to work on their bulletin board, that the classification of killer whales became problematic. The controversy began when one student (Samantha) suggested that, based on what had been said at MW, the group should not put the killer whale cutouts on their bulletin board, since they are not whales.

Samantha's suggestion provoked a 25-min argument in the hallway (HW) over what to do. Brian insisted that killer whales were not dolphins because "there is a BIG difference between them" and argued that he should be believed on the basis of his authority as the group's specialist in whale features (HW, 2/2/96). Samantha reminded the others of what they had "learned" from the MW trainers, and argued that researching orcas was no longer their responsibility (HW, 2/2/96). Other students indicated some willingness to ignore intellectually problematic aspects to achieve a practical solution. For example, Jonah declared, "I don't care what (animals they are, but let's) put these things [*the orca cutouts*] on" (here and throughout, parentheses around words from transcripts indicate transcriber uncertainty about them; HW, 2/2/96). Jonelle complained to Ms. Wingate, "We made about TWENty little WHALES, and um now they're saying, that they're not going to put them UP!" (HW, 2/2/96). An orca was put up on the board, then disappointedly ripped down. Several students became visibly upset. Eventually, the students' arguing got so loud that a teacher from another classroom complained about the noise.

There was no end in sight, and Ms. Wingate eventually decided to bring the 10 students into her classroom to have a more structured discussion about the controversy (which became the BOA). When Ms. Wingate told the students 26 min later to stop their discussion so that each class could gather to share their research progress in wrap-up sessions, one student complained, "Uuunhhh! we were only

having one little ARgument!" Another student implored, "Can we finish the- we (still had more) evidence" (BOA, 2/2/96).

Thus far, we have presented several types of evidence to suggest that the students were strongly engaged in the orca question: They showed signs of emotional involvement in the issue, they often continued arguing about it even when adults told them to stop or be quieter, and they returned to the issue on multiple occasions.

Additional Evidence of the Students' Engagement in the Controversy: The Report to the NST

As further evidence that the students' were engaged in the orca controversy, we present here qualitative and quantitative analyses of part of the students' report to the new student teacher (see Table 3). In the episode, which occurred near the end of the unit, four members of Ms. Wingate's whale group (Brian, Toscan, Jonelle, and Samantha; Racquel was absent) presented their research to a new student teacher (see Appendix A for a transcript). In the course of an otherwise unremarkable reporting session, the students became highly animated at the first mention of the orca controversy. The report took place more than 7 weeks after the controversy first erupted and immediately followed a 6-week break from the unit. The students nevertheless both remembered and became passionately engaged in debating subtle details of the issue. Here, we contrast the students' discourse and interactions before and after the killer whale issue was raised as evidence of their sustained engagement in it.

Qualitative Description of the Students' Engagement

At the reporting session, the new student teacher asked the students to report what they most "remembered" about their topics (3/26/96). Brian, Toscan, Jonelle, and Samantha each reported the results of their research on whale protection, feeding, reproduction, and communication, respectively. Each presenter told the student teacher about his or her topic while the other students more or less politely listened, occasionally adding a comment or two.

Brian's second report, on whale features, came last. Like the others before it, his report consisted primarily of a series of uncontested whale facts.[7] He began by listing and describing various whale features (baleen, blowholes, etc.):

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[7]With extensive teacher guidance, later in the unit students would go from these lists of whale facts to written reports, which also included explanations that linked those facts with each other and with consideration of how to explain whales' endangerment. For more information about this process of (in the teachers' words), "turning their research away from little animal reports full of facts to more thorough papers that displayed a deeper understanding of the biological principles" (Kohl & Wingate, 1995, p. 10), see Engle (2001).

8	Ms. P:	can you tell us about features.
9	Brian:	[*to Ms. P*] well um- (pause) (uh um) (pause),
11		well
12		actually like Toscan said [*pointing to him*],
13		they have like these TOOTH BRUSH bristles (on it/that are)
		[*gesturing to show the vertical threads of baleen*],
14		THAT long [*shows length by stretching out hands horizontally*].
16		the (the baleen whales).
20		they're really HUGE.

(NST, 3/26/96)

As he did this, other students engaged in parallel activities (descriptions of these activities account for the missing line numbers, see Appendix A). Toscan mouthed words to a song (lines 8–9), and Samantha and Jonelle passed papers back and forth and organized their folders (lines 11–21). As Brian continued, Jonelle whispered to Samantha, "How long is this taking?" (line 31). Except perhaps for Brian, the students seemed ready to leave for the wrap-up session and lunch.

Upon mentioning the orca's dorsal fin, however, Brian cast a sidelong glance at the other students (extending to Samantha, sitting on the end of the table). Beginning to smile, he declared, "Some people believe that the KILLer whale are actually the biggest dolphin, but scientists prov- proved that is NOT TRUE" (NST, 3/26/96, lines 61–62, 66, 70; see Appendix A for Brian's nonverbal behavior and other students' immediate responses).

At this point, a dramatic shift in participation occurred. Hands went up. The students moved closer together. They began interrupting and contradicting one another, finishing each other's sentences. What had begun as Brian's turn suddenly became an animated group construction, with neither direction from the teacher nor any protest from Brian (here and throughout, large, vertically aligned brackets indicate where overlapping speech and actions begin):

71	Samantha:	[*to Brian and other students, very quietly*] (no it doesn't),
72		(no it doesn't).
73	Jonelle:	[*raises her hand*]
74	Toscan:	[*raises his hand*]
75		[*to Ms. P*] oh yeah I have a thing to add to that,
76		I have a thing to add to that.
77	Brian:	[*grins wider, as if he's trying to hold in his delight*]
78	Ms. P:	[*apparently calls on Toscan*]
79	Tos & Jon:	[*set down their hands*]
80	Samantha:	[*moves in closer to everyone else on the bench*]
81	Toscan:	[*to Ms. P*] um they all think that [[*pause*
82	Jonelle:	[*quietly to Toscan*] [killer whales are dolphins,
83	Toscan:	[*continuing to Ms. P*] killer whales are dolphins,

84		because they have a	[dorsal fin,
85	Jonelle:		[[*raises her hand and sets it down*]
86	Toscan:	just like the	[dolphins,
87	Samantha:	[*to other students*]	[no [*shaking her head slightly*],
88		that's not (the only) ((reason)).	

(NST, 3/26/96)

Although Brian's comment that "scientists proved that is not true" seemed to frame the matter as settled by experts (and so no longer open for discussion), this very claim in fact reignited the students' debate. Judging from his smile, Brian may have been aware of the potential effect of his remark, which can be seen as a deliberate overstatement intended to provoke a reaction from Samantha and the other students.

Quantitative Findings About the Students' Engagement

To confirm our intuitive sense that the students became more engaged following Brian's mention of the orca question, we coded a variety of interactional measures. We then compared their occurrence before and after the apparent shift in engagement (see Appendix B for details). We summarize the findings here, each statistically reliable at the $p < .01$ level.

First, we found that prior to his remark, Brian alone was addressing the student teacher, whereas afterward, all four students were speakers, addressing both the student teacher and each other. In the beginning of Brian's presentation, the other students were frequently engaged in quiet alternate activities, such as singing, shuffling unrelated papers, and remarking to others about the passage of time. In contrast, after the remark, the only ostensibly off-task behavior was actually a metacomment by Jonelle on the shift itself, something to the effect of "here we go again." Instead of engaging in alternate activities, the students overlapped each others' utterances as they fought for the floor, and jumped in to complete each others' sentences. They were also more passionate after the remark. Before the shift, there was at most one pronounced emotional display (an especially exaggerated facial gesture by Toscan that illustrated Brian's description of baleen [NST, 3/26/96, line 23]). After the shift, the students made 16 such emotional displays, including exaggerated grins, rolling of the eyes, high fives, and celebratory handshakes.

Thus, in terms of who was speaking, to whom they were talking, and how they participated, the students were more engaged in the orca classification question than in other parts of Brian's report on features. Comparable levels and types of engagement were observed in the students' other discussions of the orca issue, although there was variation across students, with some becoming less engaged over time and others maintaining a high level of engagement.

How Was the Orca Controversy Disciplinary?

The students' orca discussions made contact with disciplinary issues and practices in at least two ways. First, throughout their discussions, students were attuned to an important value in scientific and scholarly work: Claims need to be supported by evidence. Second, the content of the debate focused on issues and used types of evidence recognizably related to biological discourse about classification. We will discuss our own evidence for each in turn.

Use of Evidence as a Form of Scholarly Practice

The students used and were explicitly aware of the value of providing support for their positions and claims, a cross-disciplinary feature of scholarly practice.

Evidence that students often provided evidence.   To support this claim, we first coded each of the 308 student turns in which the group discussed the controversy from the BOA onward (sound quality in the hallway being too poor for reliable coding of arguments taking place there prior to the BOA) to see how often the students used evidence in support of their claims (see Appendix C for examples and other methodological details). We coded as evidence turns that included any of the following forms of evidence, each recognized as such in the unit:

1. *Documentary evidence*: mentioning that a particular source had made a relevant claim or otherwise using such a source to support, challenge, or reject a claim.
2. *Anatomical evidence*: investigating relevant anatomical features of species of dolphins or whales, often to compare them.
3. *Lexical evidence*: exploring ways in which lexical similarities or differences may relate to classificatory differences (e.g., probing the potential significance of the fact that orcas are often called killer whales).
4. *Evidence about credibility of sources*: examining evidence about whether particular sources should be trusted based on criteria like training, knowledge, certainty, and so forth.

Each turn about the controversy was specifically coded as providing zero, one, or more than one piece of such evidence. The authors independently coded a quarter of the turns and agreed on 90% of their decisions ($\kappa = .85$), so the second author coded the rest, consulting with the first author on potentially problematic cases.

Overall, the students provided one piece of evidence in 37% of their turns and more than one piece of evidence in 15% of them, for a total of 52% of turns with

evidence. These proportions are comparable with findings from other science classrooms that stress evidence-based argumentation (Hsi, 1997). Use of evidence varied across events, however, apparently reflecting differences in their purposes (see Table C.1 in Appendix C for complete results by event). Students provided evidence most frequently during the BOA (75% of turns), in their wrap-up reports about it (45% of turns), and when reanimating and reporting about the argument to the new student teacher (43%). In contrast, the students provided evidence in only 9% of turns when they negotiated how to present their positions on the controversy in jigsaw, and 17% of turns when negotiating their written report. In general, the students provided less evidence as the controversy continued, perhaps reflecting that, over time, new arguments became more difficult to find and many old ones did not need to be rehashed.

Evidence that students may have been aware of the importance of evidence.   We also looked at how frequently the students explicitly marked their own or others' contributions as providing evidence, indicating potential metacognitive awareness of its use. We did this in two ways. First, we coded the students' turns about the controversy for whether they used connecting phrases such as "because" or "so" (and related interrogatives like "why?," "how do you know?," etc.) that explicitly link evidence with claims. Second, we coded whether their turns included explicit references to evidence by directly referencing it with nouns such as "evidence," "point," or "reason," or by explicitly referring to the process of persuading or giving evidence by using verbs such as "argue," "prove," or "convince." Like the previous coding, the authors achieved sufficient reliability on one fourth of the turns for both codings (see Appendix C for specifics), allowing the second author to finish the rest.

We found that students used explicit connectors in 19% of turns and metatalk about evidence in 27% of turns, indicating that students not only provided evidence, but also may have been aware of their and others' uses of it. Metatalk about evidence was much more frequent when the students negotiated with Ms. Wingate about getting more evidence into their written report (58% of turns), when they reported about their argument in wrap-up sessions (55% of them), and during the BOA (41%) than in any other events. There was variation in use of claim-evidence connectors, but it did not seem so closely tied to the purposes of different events. Connectors were used the most when negotiating the written report (50% of turns) and during the wrap-up sessions (36% of them), and the least when finding new evidence 1 week after the original argument (2%) and when negotiating the oral reports (5%; again, see Appendix C for results by event).

Finally, the students clearly viewed evidence as important for supporting claims in that they explicitly used the existence of evidence as a basis for evaluating the claims and credibility of others. With respect to the Marine World trainers, for

example, Toscan declared that truly knowledgeable people provide specific evidence for their claims. He noted that the trainers had provided insufficient reasons for the students to accept their claim, specifically citing the lack of an explicit connector to link the claim with evidence (here and throughout, colons in transcripts indicate that the preceding sound is lengthened, with more colons indicating more lengthening)[8]:

```
255   Toscan:     [pause] THEY didn't say that much about it,
256               if they REA:::LY really knew that it was a dolphin
257               they would say, [pause] beCAUSE [
258   Samantha:                            [they DID,
259               they said beCAU:SE of the-
. . .
262   Toscan:     they didn't say ANYthing after THAT,
263               they didn't even say beCAU:SE it has a dorsal fin,
264               because it has a sow patch, beCAU:::SE -
265               they didn't say all that
```
(BOA, 2/2/96)

In response, Samantha did not dispute the notion that claims require evidence to be justified or that credibility is in part established through being able to present evidence; instead she argued here and throughout that the trainers had provided it ("they DID, they said beCAU:SE of the-", [lines 258–259 earlier]).

Less evidence-oriented aspects of the students' discussions.   We do not wish to convey the impression that the students' discussion of the controversy was always a model of evidence-based argumentation. There was a tension between pursuing what Keefer, Zeitz, and Resnick (2000) call a "critical discussion," in which the goal is to develop greater understanding by examining evidence for alternate positions, and a "position-driven" argument, in which the primary goal is to win. In efforts to win the argument, students attempted to intimidate other students by yelling things, making rude noises, overasserting their own expertise, and strategically controlling the floor. For example, at one point in the BOA, Brian went so far as to declare that Samantha could not challenge him as features expert because "I'M ME and I KNOW what's in my HEAD . . . and you CAN'T go there" (BOA, 2/2/96, lines 236–237, 241). This and other examples (see "Less evidence-based aspects of the students' debate" at http://ed.stanford.edu/~greeno/PrinciplesPaper/for a fuller discussion) suggest that the debate was highly partisan and, at times, in danger of devolving into an unproductive competition.

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[8]We thank Fred Erickson for his detailed and illuminating transcript of the BOA. For consistency with other transcripts in the article, we had to simplify his transcript somewhat. Interested readers can view the original transcript at http://ed.stanford.edu/~greeno/PrinciplesPaper/.

The group generally did not let this happen, however. Other students continued providing evidence for their claims, and even those who had stepped out of bounds would again contribute substantively to the discussion. Even in this way, the students' debate was not wholly uncharacteristic of authentic scholarly practice, which often combines partisanship with a concern for developing better ideas.

Content Specifically Related to Biology

The primary aim of FCL is to engage students in scholarly research in a domain, in this case, biology. Thus, the students took a scholarly, rather than empirical, approach to the orca question. In several identifiable ways, the content of their discussions was recognizably related to issues and evidentiary practices specific to scholarship in biology.

First, the students' primary question, whether killer whales are whales or dolphins, is an ostensibly biological one. Taxonomic issues have been at the heart of biology since before Linnaeus, critically shaping (and being shaped by) the theories that biologists construct (Gould, 1998; Mayr, 1997). In fact, the students' debate actually resembles a discussion that has arisen among biologists over whether the Pacific and the Atlantic populations of northern right whales constitute distinct species (Sivitz, 2001).

In addition, as mentioned earlier, the students examined the role of anatomy in the orca's classification, the primary method originally used by biologists to resolve such questions (Gould, 1998) and one still used today in concert with other methods (Mayr, 1997). For example, having heard the MW trainers mention that orcas have dorsal fins, the students investigated whether the presence of a dorsal fin could be used diagnostically to classify them as dolphins rather than whales (see the subsequent section, Development of anatomical arguments, for more on this). Such investigation resembles modern ones involving genetic features. In the context of the northern right whale debate mentioned previously, scientists are currently arguing over whether the proportion of shared DNA between the Pacific and the Atlantic populations is small enough to justify considering them different species (Sivitz, 2001). Similarly, the FCL students argued over whether the tiny dorsal fin of the blue whale was sufficient to count as an exception to the idea that whales do not have them.

Finally, the students examined a lexical argument for the orca's classification and in the process raised issues of concern to biologists. In Jonelle's words, "If a killer whale was a dolphin, how come they would call it, how come they're not called the 'killer DOLphin?" (NST, 3/26/96, lines 97–99). The students expected the term *whale* to be both precise and consistent with current scientific understanding, and required an explanation if this was not the case.

By questioning the term whale in this way, the students in effect made an argument for the importance of a standardized nomenclature, like the one biologists in fact use (*International Code of Zoological Nomenclature,* 1985, cited in Mayr, 1997).

How Was the Orca Controversy Productive?

The orca controversy was productive in at least three ways. First, the students searched for additional sources of evidence to settle the question, finding ways that each line of argument could be used to address each position in the debate. Second, as a result of this process, the students' specific arguments got more elaborate over time. Finally, in the course of the argument, students raised new questions about classification, linguistics, and the credibility of sources.

The Students Found More Evidence and Developed Counterarguments

The students did not simply make evidence-based arguments, but made them in response to others' arguments, critically evaluating arguments for the opposing position. The students reinterpreted the evidence used to support a particular side of the debate, making it consistent with the other one as well, so that in the end every argument was associated with a counterargument. For example, killer whales and dolphins both have dorsal fins, but so do blue whales (dorsal fin argument); orcas are called killer "whales," but such everyday terms may not have caught up with current scientific understanding (lexical argument); and one of the trainers was unsure about what she was saying, but the trainers had been working with whales longer than the students had been doing research (credibility of the trainers). This form of argument followed by counterargument characterized the students' discourse throughout their debate over the killer whale's classification.

Proponents of particular positions also continued searching for additional sources of evidence for their side and against the other one. For example, 1 week after the original debate, Ms. Wingate's whale group was informed by Ms. Kohl's whale group that Sione had found two books stating that the killer whale was the largest dolphin. In response, Ms. Wingate's whale group found a book that seemed to provide prehistoric evidence to the contrary. Toscan exclaimed, "We have distant proof, they aren't dolphins," and rushed over to Ms. Wingate to show her the book (2/9/96). Such discoveries of additional sources of evidence occurred at least four times after the controversy initially erupted in the hallway.

The Students Developed More Sophisticated Arguments

The students not only made evidence-based arguments, but also elaborated and refined them during the debate, often in response to challenges from those holding the opposing position (Hatano & Inagaki, 1991). Some students (including Brian and Samantha) maintained a consistent position on the question despite increasingly convincing arguments for the other side, whereas others (including Liana and Jonah) changed their position in response to them.

Development of anatomical arguments.   One example of such elaboration can be seen in the students' investigation of anatomy-based arguments for classification. In the following excerpt from the BOA, the students collaboratively assessed for themselves whether the presence of a dorsal fin could be used to distinguish between whales and dolphins, as the Marine World trainers seemed to imply. As they considered the question for themselves, one student sought to establish whether dolphins have dorsal fins:

136   Toscan: Do dolphins have a dorsal fin?
137   Brian: [no, no.
138   Jonah: [duhhh [*to Toscan*]
139   Toscan: No they: don't, [*pause*] flat. [*starts to gesture back and forth horizontally*]
140   Jonah: yeah they do, see. [*holds up book and shows a picture*]
141   Toscan: and they have- [*pause*] okay.
(BOA, 2/2/96)

Having established that dolphins do have dorsal fins, the group considered whether whales also had dorsal fins. Liana and Samantha suggested that only killer whales did:

142   Samantha: and I don't think whales do usually
143   Brian: um, yeah, some do.
144   Samantha: no
145   Liana: no, only the killer whale has it.
(BOA, 2/2/96)

The suggestion was challenged in turn by Toscan's claim that the blue whale has a dorsal fin, albeit a very small one:

146   Toscan: the blue whale has one.
. . .
148   [*general laughter*]
149   Brian: [*to Samantha*] yeah, the blue whale has- yeah the blue whale has one.

150   Toscan: the blue whale has a teeny one.
151   Brian: yep, it's like that [*shows size with gesture, seems absurdly small*]
152   Toscan: it has a teeny one, at the back of the fin, so,
153   the blue WHALE could be a dolphin.
154   Samantha: [*laughs*]
(BOA, 2/2/96)

If a blue whale is not a whale, what is? This *reductio ad absurdum* argument was acknowledged even by Samantha, the most diehard proponent of the orca-as-dolphin view.

Through their discussion, the students determined that the dorsal fin alone could not be the decisive factor in deciding the orca's status as a whale or a dolphin. The students' investigation both precluded this facile, single-feature-based explanation for the classification and furthered the debate by undermining the trainers' credibility. After this exchange, at least one student, Liana, changed her position to support the orca-as-whale view. Samantha, for her part, now allowed that the dorsal fin was "not the only reason" for the classification (NST, 3/26/96, lines 85–86) and cited the "bone structure" of their flippers as another possibility (NST, 3/26/96, line 340, drawing from MW, 2/1/96, lines 4–5). Thus, by developing the dorsal fin argument, the students made progress by changing positions, reevaluating their belief in an information source, and beginning to question the adequacy of using physical features to determine classifications.

Development of the lexical argument.   With respect to the lexical argument, several points were raised and met. In response to Ms. Wingate's point that orcas appeared in a book titled *Album of Whales,* Samantha argued that publishers might need to assume novice understanding: "Everybody thinks they're whales, so if they want (to know about killer whales they'll) look in a whale book" (BOA, 2/1/96, line 70). Brian and Jonelle's question, "Why don't they call it a killer dolphin?," became addressed as potentially a problem of a lag between everyday terms and scientific knowledge. Samantha's explanation "because they just found it out" (NST, 3/26/96, line 104) served as a placeholder for an as-yet-unexplained aspect of the killer whale. Noting that other whales are not in this linguistic bind ("I mean they don't go around saying other whales are dolphins, so why're they saying this one is?" [BOA, 2/2/96, lines 441, 445.3]), Samantha concluded that the problem must relate to a biological issue specific to the killer whale. Without more explanation, however, the others were not convinced.

Development of standards for credibility of sources.   Finally, in the matter of trusting the Marine World authorities, Brian, Toscan, Jonelle, Liana, and others became more elaborate about why the trainers could not be trusted. For example, Jonelle, Toscan, Brian, and Racquel noted that one of the trainers

contradicted herself, expressed uncertainty, and asked others for help remembering facts. These observations caused them to declare her too ignorant to be trusted (BOA, 2/2/96, lines 274–278, 300–303, 364–365, 379–382, 396–397, 407–408; NST, 3/26/96, lines 109–119, 122–129, among others). Brian, in a caricature, depicted persons working at MW as having minimal training, and therefore merely doing and saying whatever their bosses asked:

285   Brian: okay I'm gonna change and be one of the persons who works at
                    Marine World for
286   [*Liana puts her hand down*]
287   the whale training. I apply for a job um and then my boss tells me,
288   "take this stick, tap the water, and then the whale will come up."
289   [*here Brian demonstrates use of stick*] and then then the trainer
                    might just tell him,
290   "say uh just tell 'em a little bit about them",
291   [*Liana raises hand and keeps it up*]
292   then, they'd just work there,
293   and they'd (knew ((about))) whales,
294   only a tiny/know only a tiny bit about them.
(BOA, 2/2/96)

Brian later explicitly contrasted the trainers with scientists ("like they're really *sci:entists*- they just apply for a job one day, got told a little bit about it" [BOA, 2/2/96, lines 347–378]). Both remarks raised issues of training and of personal investment in making claims. In addition, Liana and Sione chastised Samantha that she had heard only "one person" make the claim, not many, implying that Samantha was not skeptical enough to search for corroborating evidence (BOA, 2/2/96, lines 342–344, 429.3).

Samantha and others arguing the other side of the credibility issue made progress as well. They went from simply accepting the words of the Marine World trainers ("I think we should believe the trainers" [BOA, 2/2/96, line 181]) to defending only one of them as having been certain (NST, 3/26/96, lines 139–140). Samantha also specified that trainers would be likely to have done things relevant to whales and dolphins for longer than the students had, and asserted that they did present evidence (NST, 3/26/96, lines 337–340).

In their criticisms, the students effectively created a list of specific criteria necessary for someone to be regarded as an expert. They applied these standards to other information sources, including themselves. Stated positively, the students appeared to value consistency, competence, training, professionalism, personal investment, evidence, and corroboration in assessing credibility.

Overall position of the group on the controversy.   Although ideally the students would have found a satisfying answer to the question, in their final report on

whales, the group concluded that the argument was a draw. Samantha consistently countered the challenges raised by her peers, but was gradually reduced to defending the possibility that the trainers' claim could be correct, rather than demonstrating it to be so (e.g., Samantha's "How do you know, maybe they had the research" [BOA, 2/2/96, line 351]). Brian, who had earlier declared that "nobody's going to change my mind" (BOA, 2/2/96, line 125), acknowledged in his part of the report on whale features that the matter was still open and that there were valid arguments on both sides. In effect, the students had developed what Hatano and Inagaki (1991, p. 346) would call a "healthy dissatisfaction" with their current understanding.

In fact, there was good reason that the matter was still open to the group. Killer whales can be understood to be both whales and dolphins: Killer whales (the species *Orcinus orca*) are part of the dolphin family (*Delphinidae*), all of which belong in a suborder often called toothed whales (*Odontocetes*; Gordon & Flaherty, 1990). So killer whales are dolphins, which are all whales.

The Students Raised New, Deep Questions

In trying to resolve the orca's classification for themselves, the students raised new questions about classification and its relationship to biological discourse. These questions—available to guide the students in their future learning about biology—were yet another important product of the students' intellectual engagement (Hiebert et al., 1996).

Questions about classification.   The students raised new questions related to biological classification in general: What constitutes being a member of an animal group versus simply being related or sharing some similarities? How are related animals (such as dolphins and whales, or monkeys and humans) distinguished and grouped? For example, Brian argued that being related is not the same as being another species, choosing a suggestively evolutionary analogy involving humans and monkeys:

102   Brian: [*to Samantha*] we're um-, that's like saying see um,
103   ah we're very close related to monkeys but that doesn't necessarily
                    mean we're monkeys. that's, that's what it's like to put it,
104   that's how it- you put it
(BOA, 2/2/96)

Samantha countered that, on the contrary, the killer whale may be a dolphin and may simply be related to whales. The students thus raised the notion of superordinate categories into which a species might fall, a key move for being able to resolve the issue.

In addition, the students began to uncover some of the problems of relying purely on physical features to determine classifications (Mayr, 1997). If similarities

and differences in features play a role in making such distinctions, which features were relevant for the orca, asked the students: The dorsal fin? Sow patch? Bone structure? How does one make a classification when comparing different physical features leads to conflicting results?

Metalinguistic questions.   In considering the lexical argument, the students also raised metalinguistic questions. For example, Brian demanded to know why two different things would ever be called the same thing, alluding to the linguistic "contrast principle" (Clark, 1990):

267   Brian: I mean if it I:S TRUE,
268   then why shouldn't they just be ca- I mean why shouldn't they
269   A:LL be called whales, why shouldn't they ALL be called
                   dolphins, okay?
270   that's why they're TWO different things, 'swhyth're TWO different
                   things.
271   because if they WERE the same, they:d be CALLED the same
                   thing.

(BOA, 2/2/96)

Moreover, if indeed they were to be grouped together, how would one choose which term (whale or dolphin) to use? In addition, Samantha's allusions to colloquial terms lagging scientific understanding raised issues about historical linguistics as well.

Summary

For the reader's reference, Table 4 compiles, in capsule form, our evidence for the whale students' productive disciplinary engagement in the orca question.[9]

EXPLAINING THE CASE

Was it simply chance that a group of 5th-grade students studying endangered species would become passionately invested in debating the biological classification for orcas? The issue was not part of their assigned work, and as noted earlier, on its face does not initially appear especially compelling. Why were these specific students so engaged by this particular question? Why did it spark such an extensive and extended argument, one that continued throughout the rest of the

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[9]We thank Brigid Barron for suggesting that we include this summary table as well as later summary tables about how the teachers and the unit embodied the guiding principles (Table 5) and how the students responded to this (Table 6).

TABLE 4
Summary of Evidence for the Students' Productive, Disciplinary
Engagement in the Orca Controversy

Productive	Disciplinary	Engagement
Sought and found more evidence	Used evidence in scholarly ways:	Argued (off and on) for 8 weeks
Developed counter-evidence	• Used evidence frequently	More students participated as speakers and addressees than for other topics
Developed more sophisticated arguments	• Made meta-references to it	Fought for floor, completed sentences
Raised new questions about classification and use of terminology	• Used claim-evidence connectors	Made pronounced emotional displays
BUT: did not solve problem	• Evaluated credibility with evidence	Focused on issue, even without teacher
	• BUT: tried to win without evidence	Continued to debate despite opportunities to suspend
	Made contact with biological scholarship:	
	• Argued about a taxonomic problem	
	• Used anatomical evidence	
	• Addressed related biological issues	

unit? Where there any features of the learning environment that particularly fostered the students' productive engagement with the question?

In this section, we relate the four principles proposed in this article to the events in the classroom to help explain why the students became engaged in the orca controversy in the ways that they did. We begin by showing how the teacher and unit embodied the principles in the classroom before the controversy erupted. We then show how the teacher's moment-by-moment moves embodied the principles during the controversy itself, supporting the students' productive disciplinary engagement in it. We end the explanation section by providing evidence from the data set as a whole that the students did in fact view themselves as stakeholders and held themselves accountable to others.

Embodiment of Each Principle Before the Controversy Erupted

We first show how the four principles were embodied in the classroom prior to the orca controversy, setting the stage for students' later productive disciplinary engagement in it.

Problematizing Information Sources

Although the specific problem of determining species' classifications was not projected as part of the curriculum or during the unit, the general problem of dealing with discrepant sources was (Brown & Campione, 1996; Kohl & Wingate, 1995; also see Rutherford, 2000, on FCL as a "dilemma-based literacy project"). By the time the orca controversy erupted, it was anticipated that research groups would encounter discrepancies among sources and would be responsible for resolving them. At least one such incident had occurred in the teacher's previous experience with the unit (Kohl & Wingate, 1995), and on the first day of research Ms. Wingate instructed the class that when "one book says one thing, and another book says another thing . . . you need to FIGure out which one is right" (1/3/96). Moreover, the whale students had started discussing how they might address such discrepancies. In one discussion, the students discounted something they had been told by the school science expert in favor of information from a nature video made by "professionals" (12/8/95). Later, when members of the whale group complained that the information in the books they were reading was redundant, Ms. Wingate asserted that this was a good sign, because one way to find out "if something's true" is to "compare sources, and see if they're the same" (1/18/96). She reminded them that they had done similar work with discrepancies in sources during a previous history unit involving different accounts of the life of Pocahontas; the students themselves made this comparison later. Thus, the stage had been set for the students to problematize their information sources about killer whales. As it turned out, the students did use the specific factors that had been brought up—professionalism and corroboration—to criticize the Marine World trainers.

The Students' Authority Vis-à-Vis Whales and
Problematic Issues Involving Them

The students' agency in making decisions regarding problematic issues like the orca's classification was also explicitly supported in the unit. Ms. Wingate's announcement to the class that they would be responsible for deciding which sources were right was a case in point. In addition, Ms. Wingate explicitly indicated that she valued her students' engagement with controversial issues. For example, when Toscan let her know (with some concern) that a nearby research group was "having a FIGHT, over research," Ms. Wingate responded by saying, "I LOVE that!" (1/18/96). Thus, when the orca controversy came up, the whale group had been led to expect that they would be encouraged to resolve such problems themselves.

In addition, by the time the students visited Marine World, a classroom expectation had been set up that the members of the whale group would serve as experts on whales. Each student had been assigned to become a classroom expert on their subtopic (see Brown et al., 1993, for more about such distributed expertise), which meant becoming, in Ms. Wingate's words, "THE person who knows EVerything about that" (1/3/96). Soon before they went to Marine World and after a long struggle to prove themselves,[10] the two whale groups were judged by both teachers as finally having sufficient expertise to make a bulletin board teaching the rest of the school about whales. Thus, when the Marine World trainers challenged the group's assumption that killer whales were whales, this was not simply a new idea—it was a challenge to the group's hard-won identity as incipient whale experts, giving them a stake in the issue right away.

It was an especially strong challenge to Brian's status as features expert because the students understood the Marine World trainers to have justified their claim by implicating the existence of common anatomical features of dolphins and killer whales. As Toscan put it, "If Brian is studying features, why didn't HE get the information" (BOA, 2/2/96, lines 218–219). This challenge to his expertise may help explain Brian's particularly high level of engagement in the controversy, especially his active opposition to the trainers' claim. His defensive remark, "I study FEATURES, believe me I should know, I should know. They TRA:IN whales, there's a BIG old difference," speaks to this aspect of Brian's stake in the debate (BOA, 2/2/96, lines 199–200).

Finally, the idea that teachers and other adults may not always be experts—a notion that the students built on with vengeance in the case of the Marine World trainers—had been seeded early in the unit. Ms. Wingate specified that each student would become an expert in a part of the intellectual territory about which no one else, including Ms. Wingate herself, would know:

> And you guys are researching a lot of things that I don't know things about. And so when you find information, I'M going to ask you questions about it, just like anyone in the classroom is, who doesn't know things about it. (1/3/96)

In the first benchmark of the unit, even the school's science expert noted that the students would be learning things she would not know. Thus, the stage had been set for the students to doubt the knowledge of others, even those called experts, including the school's science expert and, in the orca controversy, the Marine World trainers.

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[10]Two weeks earlier, the teachers stopped the whale groups from doing their bulletin board because, in Ms. W's words, "The whales definitely need to- to- to do a little more work in becoming- becoming experts in their areas" (1/12/96). The whale group in Ms. Wingate's classroom complained bitterly and lobbied hard to be considered experts so they would finally be permitted to do the bulletin board.

Accountability to Others

Accountability for building on others' ideas. Consistent with descriptions of FCL learning communities, Ms. Wingate explicitly emphasized that the students were accountable for incorporating into their research the contributions from an ever-widening network of other people, both inside and outside the classroom (Brown & Campione, 1996, p. 300). For example, early in the unit, she encouraged the students to consult "as many books as you can, and experts, and the computer, and write to the science desk [graduate students available via e-mail], and do as many things as you can" to learn about their research areas (12/18/95). As the members of the class developed expertise in their subtopics, Ms. Wingate began holding students accountable for learning from each other as well. These and similar moves helped establish a practice of building on and reacting to others' ideas, something the students did extensively during the controversy itself. This helped them develop more sophisticated arguments over time. In addition, the teachers specifically framed the trip to Marine World as an opportunity for the students to add to their ongoing research by consulting with experts there, making it difficult for the students to simply ignore the Marine World trainer's claim about the orca's status.

Accountability for presenting research to others. In addition, the students were regularly made accountable for being able to cogently present their research to a variety of real audiences including parents, teachers, other members of the school, outside specialists like zoo researchers, and each other (Brown & Campione, 1996). Thus, they were also positioned as contributors to others' understandings of the topic. To varying degrees, we saw these audiences doing what Brown and Campione (1996) suggested they can do: "Demand coherence, push for higher levels of understanding, require satisfactory explanations, request clarification of obscure points, and so on" (p. 294). Such actions may have prompted the students to be more disciplinarily productive, both during such presentations (e.g., when the students were working on their bulletin board) and in anticipation of future ones (e.g., when the students were planning their jigsaw presentations).

Accountability for developing group expertise. Ms. Wingate especially highlighted each student's accountability for being able to eventually share their specific areas of expertise with other members of their group to forge a sense of group expertise. As she explained on the second day of the unit:

> Let's say, Ron, you become an expert on panther babies, and Jamal becomes an expert on panther protection. You'll need to teach Jamal everything you know about babies, and he'll teach you everything he knows about protection, so when you go to the jigsaw group, you'll be able to talk about the whole panther, not just the panther babies. (12/5/95)

Eventually every member of the group was to understand the whole topic, not just his or her individual subtopic, and to extend individual contributions by incorporating them into a group consensus about why their animal was endangered. Similarly, Ms. Wingate stressed that each member of the combined whale groups would need to contribute expertise to the production of the bulletin board. For instance, at one point when the group was anxious to work on the bulletin board, the teachers told them they would have to wait until each member had enough expertise so the group as a whole could decide what to include on it (1/12/96).

"Hot seat" merging of accountability and authority.   Finally, it was through accountability that each student established his or her authority in a particular subtopic. Specifically, when a student wished to be declared an expert in a subtopic, that student had to volunteer to be "on the hot seat" (1/12/96). This meant that anyone could ask the student any question about the topic. If the student could answer all questions, he or she was provisionally considered an expert; if not, the student was responsible for doing additional relevant research. This practice of putting students on the hot seat is one of the ways in which student authority and accountability were tightly linked in this version of FCL, helping to develop the students' sense of a personal stake in their areas of expertise. It was this sense that was to be challenged by the Marine World trainer's statement.

In sum, each student was accountable for both sharing expertise skillfully with others and learning from what others had to share. Moreover, the students were accountable to other members of the classroom for helping to establish their authority as experts. Each student's research, then, was not a private matter between a solitary student and her or his teacher, but a public endeavor supported within a network of social relationships.

Accountability to the Disciplinary Norm of Having Evidence

In the first part of the unit, the students were explicitly made accountable to one disciplinary norm in particular: providing appropriate evidence for their claims (cf. Lampert, 1990a, 1990b). As they were largely engaged in scholarly research, such evidence often involved documenting the source of claims, whether from a book, video, discussion, or e-mail consultation. On at least six occasions during the first weeks of the unit, Ms. Wingate instructed the students to record the names of their sources. For example, on the first day of the unit, she instructed the students to write in their research notebooks the title of the film they would be watching because:

> You may find some information in this movie, that's going to be important to you at some
> other time. And if you ever want to say where you got your EVidence, you can look back

in your book, and say "Ah! I saw it in *Hawaii: Threatened Paradise."* . . . So it's really important that we start writing down WHERE we get our information. (12/4/95)

Later in the unit, Ms. Wingate explained that students would be specifically held accountable for having such documentary support: "The name and the author, that's what we're gonna really hold you to . . . That- that's the information that we want you to have about everything" (12/18/95). At one point, Samantha actually rejected information that a classmate tried to share with her because he had not "writ[ten] down what book it's from, and who wrote it" (1/18/96).

The students were made accountable for providing documentary evidence especially in cases of disputed or surprising claims. For example, when at one point Brian asserted that whale babies "grow over 200 pounds an hour," Ms. Wingate responded, "The babies grow over 200 pounds an HOUR? . . . Wait a minute, wait a minute, WHERE does it say that?" (1/12/96).[11] In a perhaps more telling example, Ron, a specialist in eagle habitat, tried to put up a statement on the eagle bulletin board that eagle nests weigh as much as 2 tons.[12] Skeptical, Ms. Wingate asked him for evidence. Ron insisted he had read it, but—after much searching—could not produce the book. In hopes of getting corroboration, he called someone at the zoo, who laughed at the idea of such an enormous nest. However, soon after, Ron happened upon the passage he had read, and triumphantly presented it to the class. Ron's seemingly unbelievable claim had been vindicated, and the crucial turning point was being able to produce the original source of the claim. Thus, it was an established norm that students were expected to provide documentary evidence for their claims, especially for those that were disputed—such as the one that launched the orca controversy.

Resources

Multiple information sources.   FCL units are specifically designed to include multiple sources of information to support students' scholarly research (Brown & Campione, 1996; Brown, Ellery, & Campione, 1998). The multiplicity of sources increased the likelihood that the whale students would discover inconsistent information at some point in their work and begin to problematize their topic (Collins, 1998). As Collins (1998) wrote, specifically referring to FCL,

> The fact that students use books as sources probably means that they treat them as authoritative knowledge, at least at first. However, as they explore topics more deeply, they will come up against contradictions and unanswered questions, which

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[11]In fact, a video the group had seen had claimed that blue whale babies grow 200 pounds a day.
[12]This incident was reported by James Greeno.

will eventually lead them to view sources in the same way that scientists do: as something that can be challenged if counterevidence can be mustered. (p. 403)

In fact, this is what happened in the orca controversy: Discrepancies among sources helped give rise to the students' debate, ultimately leading them to challenge the credibility of at least one of them.

Discrepancies in terminology.   One discrepancy in particular affected the course of the controversy. Specifically, the terms "whale," "killer whale," and "dolphin" in the students' information sources did not map clearly or consistently to biological nomenclature, with different sources using the terms differently. This had both positive and negative effects on the students' disciplinary engagement. On the one hand, the existence of discrepancies helped drive the students' engagement by constituting a real problem and compelling them to question the relationship between colloquial and technical usage. On the other hand, discrepancies in terminology made it difficult for the students to keep straight what claims were being made (for similar cases of children having difficulty because of terminological discrepancies, see O'Connor, 1999 on distinctions between geometric shapes, and Stenning & Sommerfeld, 2000 on conceptions of birthrate), and to resolve the debate to their satisfaction. For example, the Marine World trainer's claim that orcas were "not whales" may have led the students away from considering that the animal could legitimately be both a whale and a dolphin.[13] Thus, inconsistent uses of terms both drove and confounded aspects of the orca debate.

Previous classroom experiences.   The students' participation in the orca controversy also had significant precursors on which the students could draw. First, as previously mentioned, the students had dealt with the issue of discrepant sources during the Pocahontas history unit, to which they explicitly referred during the BOA. Also, at the end of the previous FCL unit (on 11/22/95), the students had participated in an evidence-based argument about the pros and cons of using DDT to combat malaria. In it, Ms. Wingate structured student participation in ways that embodied each of the principles. For this reason, and because this argument is yet another example of productive disciplinary engagement, we devote the following paragraph to detailing how she embodied the principles in helping her students learn how to engage in an evidence-based debate.

In preparation for the DDT discussion, Ms. Wingate first asked each student to write a paragraph expressing his or her position and reasons for holding it. By

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[13]In addition, as far as we know there was nothing that the teachers or other adults in the classroom did that steered the students away from the assumption that they had a binary choice to make or that encouraged them to think about biological classification systems as hierarchical.

doing so, she positioned the students as stakeholders and emphasized the importance of providing support for arguments. Just before the discussion, she announced to the class that in their paragraphs different students had presented different positions and reasons. In this way, she helped problematize the issue. Ms. Wingate then gave the students the agency (and responsibility) to "convince other people that what you decided, was, what they should have decided," comparing this activity to yet another discursive resource, a "Convince Me" activity in math class (11/22/95). Ms. Wingate emphasized that the students would need to give reasons for their opinions, modeling such evidence-based argument for the students at least six times, as in this excerpt:

> So maybe I decided malaria [was worse], and Ms. A [the current student teacher] decided DDT [*was*]. Ms. A might say "I think DDT because of THIS," and then I would raise my hand [*is raising her hand*] because I have something to say to that. I'd either wanna BACK her up and say "yeah and also THIS" [*gestures a point*], or I'd want to say "oh NO, I don't think that, because I think malaria is worse, because of THESE reasons" [*gestures multiple reasons*]. (11/22/95)

The specific phrases she suggested were in fact used by students in the DDT debate and later in the orca controversy. Ms. Wingate also encouraged her students to be accountable to one another by telling them that after the debate they would be "revising, or changing, or improving" their paragraphs by incorporating other students' reasons, responding to their arguments, or even changing their positions as a result of other students' contributions (11/22/95). This is, in effect, what also happened in the orca discussions. Each student was thus positioned as a stakeholder in the discussion, while having the potential to be a contributor to other students' thinking. This clearly relevant experience may have informed the students' engagement in the orca controversy, which also involved a debate over two alternatives.

Information about modern methods for classifying species. The students' ability to resolve the orca question was limited, however, by a lack of resources such as a classificatory chart explaining distinctions among species, genus, family, order, and so forth, and other information about how biologists currently make such classifications. This frustrated some students, like Jonelle, who complained to the new student teacher that "this could go on for HOURS, and HOURS, and HOURS, and HOURS, and HOURS" (NST, 3/26/96, lines 173–177), and may have led to their later disengagement in the question. The lack of these resources may have reflected the fact that the orca question emerged unexpectedly, was not a specific curricular focus, and involved only one group of students. In addition, providing such information at too early a juncture might have served to short-circuit the students' engaged sense-making, questioning, and compelling modes of argument with the resources they did have. The students' experience with the orca

controversy may nevertheless have primed them to later appreciate, in ways they might not have otherwise, hierarchical classification and the use of evolutionary and genetic evidence. As Brown and Campione (1996) explained it, "The idea is that by the time students *are* introduced to contemporary disciplinary knowledge, they will have developed a thirst for that knowledge" (p. 307).

Time.   Finally, the students were given the precious resource of time to revisit and revise their claims and arguments (Collins, 1998; Henningsen & Stein, 1997). Although the controversy was in some competition for time with other goals of the unit, the extent to which the teachers valued the controversy as a learning opportunity was reflected in the time allotted to it at the bulletin board, during the BOA, in the wrap-up sessions, during ongoing research, in the report to the student teacher, and during the writing of the group report. Even when time was not alloted for the controversy, the students lobbied for more time and found ways to pursue the question.

How Realization of the Principles Helped the Controversy Erupt

We now turn to the orca controversy events to explain how participants' (especially the teachers') moment-by-moment actions embodied the four principles and appeared to have fostered students' productive disciplinary engagement. We will note ways in which these local actions were built upon the stage already set by the events and unit design issues that we have just discussed.

Why Did the Issue of the Orca's Classification Become Problematic at the Bulletin Board?

As mentioned earlier, the mere revelation of discrepancies between the students' previous readings and the trainers' statements during the Marine World show was insufficient to trigger the students' engagement at that time. (The first author accompanied the whale groups on the trip and videotaped their entire visit, but heard no comments about this part of the show that day.) It was only once the students returned to work on their bulletin board that the issue became a problem. How did the bulletin board activity function as a catalyst? At the bulletin board, the group as a whole had to decide whether the orca was a whale or a dolphin and display their decision to a school-wide audience. If the students made the wrong decision and presented incorrect information on the bulletin board, this could have consequences for their emerging identities as whale experts. Thus, it was not simply a conflict of ideas that prompted the students' engagement, but the

public consequences of the conflict for their identities as experts in a domain for which they were accountable.

Initial Embodiment of the Principles During the Hallway Arguments

Teachers and other adults supported the students' emerging engagement with the orca question as they became aware of it. When Jonelle complained to Ms. Wingate that her orca cutouts were not being used (HW, 2/2/96, 10:20:33), Ms. Wingate supported the group's agency to resolve the issue themselves by instructing Jonelle to return to her group to discuss the matter. Later, Ms. Kohl suggested to some of the students that they use their bulletin board to inform the rest of the school that orcas are not whales, but dolphins (HW, 2/2/96, 10:27:22). In explaining the suggestion, Ms. Kohl emphasized the group's accountability to each other's work ("they put a lot of work in that, and they would like to see, some representation of their knowledge, on the bulletin board too" [HW, 2/2/96, 10:29:56]). For her part, Ms. Wingate suggested to Brian that the students include the cutouts, but explain that there was a disagreement in the group about whether they were whales or not (HW, 2/2/96, segment starting at 10:36:30). The group exercised their agency to consider the issue unresolved by rejecting both suggestions, a decision the teachers respected. In discussing the problem with Brian, Ms. Wingate underscored a view of students as stakeholders accountable to the whole group by asking whether "most people think that they are whales" (HW, 2/2/96, segment starting at 10:36:30). She also further emphasized Brian's accountability to evidence by asking him for his reasons for thinking orcas are whales.

Teacher's Initial Framing of the Classroom Big Ol' Argument

Following the scene at the bulletin board display, Ms. Wingate urged the group as a whole to come into her classroom to discuss the matter so that they could "come to a conclusion" (HW, 2/2/96, approximately 10:42:00). In doing so, she emphasized the group's agency in deciding the issue for itself. In her introduction to this discussion, which became the 26-min-long BOA, Ms. Wingate first reframed the Marine World trainer's ostensibly closed assertions ("Did you know, that these, are NOT whales? and that they are the largest member of the dolphin family" [MW, 2/1/96, lines 2–3]) as an open question:

25   Ms. W: So um um one of- one thing came out as a question of what
              happened during the Marine World trip yesterday.
26   and the question was "is the killer whale, a whale, or a dolphin?"
(BOA, 2/2/96, for this and rest of the quotes in this section unless otherwise
   indicated)

Ms. Wingate thus used her authority to legitimize the students' problematizing of the Marine World trainers' assertion, already begun in the hallway. Together, she and the students implicitly rejected the Marine World trainers' attempt to cast their remarks as a simple "correct[ion]" of "misinformation . . . about these animals" (MW, 2/1/96, line 1). Instead, the FCL students and teacher took up the remarks as a claim to be investigated, implicitly calling into question the authority of the MW trainers and the trustworthiness of their comments.

Ms. Wingate then specified that resolving the question meant being accountable for giving evidence for one's position:

27   Ms. W: and,
28   "why do you think that?" [*pause*]

This simple instruction built upon both her extensive modeling of how to present reasons in the DDT debate as well as her specific instructions to use sources as evidence in the unit itself. As we showed earlier, the students took up this challenge, both in making their own claims and in evaluating those of others.

Ms. Wingate next invoked the group's accountability to the rest of the school for presenting information about whales in their bulletin board:

29   Ms. W: and "how can you convey the information that you're discussing
                  or arguing
30   with the group on your bulletin board?"

Because the bulletin board had been framed as a public display of their expertise, the students were accountable for ensuring that information on it was correct.

Ms. Wingate next underscored each student's accountability to the group by suggesting that a consensus was required to resolve the problem:

31   Ms. W: because it sounds like there's not a group decision on this.

This stance is consistent with her earlier positioning of the group ("you" in lines 28 and 29) as the responsible agents for developing reasons for their claims and conveying them to others.

Ms. Wingate then commented that:

32   Ms. W: an that an that you you I mean I think you have got
33   different sides of an argument
34   that both sides I feel like have good points.

Thus, she explicitly indicated that the question was worthy of disciplinary engagement, both in being legitimately unresolved and in already having some evidence behind it. In this way, Ms. Wingate again acknowledged the students' agency while underscoring the classroom norm of students being accountable to each other's points. She then cast Brian's "serious points" as constituting a legitimate minority view, with which the group needed to engage:

35	Ms. W:	and I feel like Brian's point, although you guys are all on one side,
36		Brian's got some pretty serious points that that you- you
37		need to consider before you decide this.

In these two sets of moves (lines 32–34 and 35–37), Ms. Wingate projected a discussion in which both sides would get to present their points, and in particular one in which Brian's challenge of the trainers would not be ignored. At the same time, she made it clear that it would be the students, not she, who would "decide this" (line 37).

Having thus supported the group's authority to resolve the problem while reminding the students of a host of accountabilities, Ms. Wingate launched the discussion by explicitly encouraging the students to weigh in on the issue, as stakeholders:

| 38 | Ms. W: | so go ahead, I'd like to hear what you have to say. |

Teacher's Role in Supporting the Students' Engagement During the Big Ol' Argument

Following this initial framing of the discussion, Ms. Wingate alternately supported and challenged each side of the argument for another 4 min, in effect preventing premature closure and keeping the issue problematic. She also encouraged less vocal students to participate by asking them to "weigh in," implicitly signaling the more vocal students that they would have to listen to their classmates' ideas (lines 114–117). Finally she indicated that all of the students were accountable for giving evidence that was specific and referenced relevant sources.

Preventing Premature Closure (i.e., Problematizing)

The first student to respond to Ms. Wingate's invitation to "go ahead" (line 38) was Jonah. Among other things, he presented a book that referred to killer whales as "flesh-eating dolphins," thus textually corroborating the trainer's claim:

45	Jonah:	I got uh I got two ah, two ah, evi- evidence that ah- do-
46		killer whales are dolphins.
47		the trainers told us that they were giant dolphins,
48		n' it [*he's holding up a book*] says flesh eating dolphins are killer whales,
49		and they also talk about it [*points to book page*] inside the book
50		[*Ms. W picks up the book*]

51   that they are the biggest- um the biggest dolphins,
52   and the fastest.
(BOA, 2/2/96, for this and the rest of the quotes in this section)

In the context of norms already set up for evidence in the unit and the current state of play of their argument, this move was likely to be compelling to the students. Jonah specifically presented himself as a bearer of "evidence" for a claim most students were leaning toward at the time. Moreover, he had in hand the resource of an actual text to back up his claim and he specified two ways it corroborated what the trainers had said.

Because of its high quality, there was a real danger that students would see Jonah's evidence as sufficient to decide that orcas are dolphins and close the debate prematurely without hearing arguments for the other side. Thus, in response, Ms. Wingate used the book Jonah presented to point out an apparent internal contradiction:

53   Ms. W: [*holding book open so rest of group can see the page Jonah pointed
                to*]
54   so this talks about them as dolphins?
55   Jonah: [*nods slightly*] uh huh.
56   Ms. W: ah ah but I have a question to ask all of you.
57   [*holds up book "Album of Whales" with front cover displayed*]
58   what what book are they in,
59   what book did they put 'em in,
60   Jonah: a:::::::h-
61   Ms. W: what's the name of the book? [*pause*]
62   [*Ms. W points to title on cover*]
63   [*reads*] "Album of Whales."
64   Brian: [my point exactly.
65   Ms. W: [[*smiles and laughs*]
66   it's confusing, it's confusing.

Ms. Wingate used the title of the book, *Album of Whales,* to problematize the claim within it. What was an orca doing in a book about whales if it was not a whale? She herself may have been genuinely unsure of the basis on which orcas are classified as dolphins or whales. In any case, she implied that opposing views were justifiable based on the evidence presented so far, including her own. She did not expect her challenge to be the last word, however, as she deemed the current configuration of evidence "confusing." On the contrary, her apparent goal in challenging Jonah's evidence with a form of counterevidence was apparently not to close off debate, but again to maintain the question's openness.

Moreover, although Ms. Wingate characterized the issue as confusing, it was clearly also pleasing to her—she laughed even as she acknowledged the

confusion. She thus modeled a form of engagement in which the challenge of negotiating evidence was both a problem of accountability (in the need to account for alternative views) and a potential source of pleasure and creativity in authoring points.

Following this legitimization of his minority view, Brian made his first utterance on the scene ("My point exactly" [line 64]), claiming Ms. Wingate's point as his own. Jonah selected Brian to speak next, and Brian proceeded to catalog a variety of physical features shared by killer whales and other whales to argue that they were, in fact, whales (lines 76–82).

Brian's disciplinary engagement was strongly supported by both the resource of specific knowledge that he had gleaned by specializing in whale features and the authority that he had established within the classroom learning community from having pursued this specialization. In fact, he specifically referred to his experience as one form of justification, stating that "all the research" and "everything I've done on- on killer whales . . . points to that they are whales" (lines 77–79).

At this point, the debate might have shifted too far in the other direction. Ms. Wingate had used her authority to support Brian's side of the argument twice, and he had used his authority as features expert to provide anatomical evidence for orcas being whales rather than dolphins. Moreover, Toscan—a student who was often influential with his peers—appeared to be shifting to Brian's side (line 84) after having taken an ambiguous position during the hallway arguments. Would other students follow him without taking account of Jonah's contributions or fully exploring the question on their own?

Ms. Wingate's next move was to again reframe the discussion as an open problem and to specifically validate Jonah's contribution as providing evidence, emphasizing the students' accountability to this norm:

96   Ms. W: what we're discussing
97   do we think killer whales are dolphins or not. [*pause*]
98   and Jonah is coming up with evidence.
99   he's the first person I've seen with evidence.

By saying that Jonah was the first person with evidence, Ms. Wingate implied that Brian and others had to do more to provide sufficient evidence, although she did not clearly indicate what was lacking in their contributions. Unique in Jonah's contribution, however, was his use of supporting textual references, a form of evidence that had been stressed as particularly important during the unit, as noted earlier. Ms. Wingate's comment shows again that, from her perspective, a student's authority in the class was at least partially derived from being able to make and account for such references to outside authorities.

Next, Ms. Wingate continued to prevent premature closure of the question by exhorting students who had not yet expressed their position to do so:

114	Ms. W:	I want to hear Sione weigh in, I want to hear Liana weigh in,
115		I want to hear Racquel weigh in, I want to hear Shantelle weigh in,
116		I want to hear Jonelle weigh in [*pointing at each student*].
117		come on, tell us what you think.

She thus again encouraged every member of the whale groups to become public stakeholders in the debate.

Continued Emphasis on Students' Accountability for Giving Evidence

In addition to valuing corroboration and documentation of sources, Ms. Wingate also requested specification of evidence. When Brian again weighed in (lines 120–125), his evidence was underspecified ("everything in our research") and he declared himself impervious to the evidence provided by Jonah (or indeed any evidence), thus making a bid to not be accountable to others:

120	Brian:	[*pause*] in weighing in it's kinda, it's kinda disappointing
121		if it IS true, which I seriously DOUBT.
122		because everything in our research kind of says that they're whales,
123		and points to that they're whales.
124		I didn't read that book, and if I did read it I wouldn't believe it.
125		and no one's going to change my mind [about it.

(BOA, 2/2/96)

Ms. Wingate cut in, ignored the inflammatory remarks, and focused instead on the substance of Brian's point, asking him to specify his argument:

126	Ms. W:	[*to Brian*] [what what
127		what characteristics do you think they have that make them whales?
128	Brian:	the teeth, the blubber, the blowhole, the eyes, and the body.

(BOA, 2/2/96)

Ms. Wingate's response communicated that the resolution of the issue would not depend on Brian's self-proclaimed authority and conviction. It would depend on the weight and specificity of his and others' evidence.

Maintaining Agency and Engagement in the Group for the Remainder of the Big Ol' Argument

Ms. Wingate absented herself for most of the rest of the discussion to work with other groups in the class. At one point, as she passed nearby, Toscan began commenting to her that "we're still talkin' about-" (BOA, 2/2/96, line 394), as if it could be a problem that the group was spending so much time discussing the

issue. In response, Ms. Wingate cut in and, with a smile and a tone of approval, commented that "this group is getting closer and closer and closer together!" (line 395). She was clearly pleased with the group's continued, intense engagement. Soon after, Brian attempted to engage Ms. Wingate in a conversation, but she motioned him to sit down and rejoin the group's discussion ("go back to THEM, *I* don't know!" [line 400]), thereby keeping agency in the group.

The students continued the discussion without Ms. Wingate for the remaining 21 min of the session. They argued with passion, made evidence-based arguments and counterarguments, and raised new questions. They also drew on rhetorical forms from sources as diverse as sports, religion, law, and children's play to make their points and express their passionate involvement (see Erickson, Conant, Engle, & Wiebe (2002), for more about the use of such rhetorical forms).

Some less productive moments related to the students' stake in wanting to win the debate. The classroom practice of giving currently speaking students the authority to hand off speaking turns to other students fostered their engagement by giving them the opportunity to construct arguments in cooperation with one another. However, it also provided a tool that they could—and sometimes did—use to shut down opposing voices in an effort to win the argument. With respect to turn-taking at least, there was a tension between the authority of individual students and maintaining accountability to others. The focus on the question and the students' intense engagement with it did not wane, however.

Support for Continued Productive Disciplinary Engagement During the Rest of the Unit

Following this extended intensive argument, the students continued to discuss the issue of the orca's classification for the rest of the unit. We now use the principles to help account for this continued engagement.

Accountability for Regularly Reporting Research to Others

Many of the later re-raisings of the controversy can be partly understood because, as described earlier, the students were accountable for reporting their research to others on a variety of occasions throughout the unit. Each class whale group reported on the discussion of the orca problem in its wrap-up session immediately following the BOA. The question thus became publicly associated with each group as part of their research activities. The students then became accountable for reporting on it later as well, which they did on at least four other occasions, sometimes revising their positions or arguments in the process.

The Teacher's Continuing Influence

In addition, Ms. Wingate generally continued to work to keep the issue problematic, to support the group's agency in addressing it, and to encourage them to use evidence in doing so. For example, in Brian's account of the BOA during wrap-up, he attempted to portray the controversy as almost resolved, with only one stubborn holdout for the orca-as-dolphin view resisting despite contrary evidence (WU, 2/2/96). In response, Ms. Wingate characterized the argument as having two legitimate sides, each with its own evidence. To take another example, in response to an unelaborated reference to the controversy in an initial draft of the group's report by Brian, Ms. Wingate asked him to rewrite the draft, and "explain why people thought it was a whale and why people thought it was a dolphin" (3/27/96). When Brian subsequently did not represent any reasons for the orca-as-dolphin view, Ms. Wingate pressed him to consult with Samantha, the group's most vocal proponent of that side of the debate. By insisting that students take others' contributions into account, Ms. Wingate helped to keep the controversy productive and informed.

On one occasion, Ms. Wingate did not encourage students' engagement with the orca question. When a student from Ms. Kohl's room came in to re-raise the discussion with Ms. Wingate's whale group for a third time in the same day (on 2/9/96), Ms. Wingate sent her away, telling her that the whale group in her classroom needed to get the rest of their research done.[14] The interaction serves as a reminder that the orca controversy, although recognized as part of the group's research, competed for time with the central focus of the students' FCL work, explaining why whales were endangered.

Group Authority and Accountability

The students' commitment to the authority of the group as a whole to decide when the debate was settled also contributed to keeping the controversy alive. As long as there were holdouts in the group who were not convinced, the controversy continued to be an issue. This commitment reflected a strong form of accountability to others in which no group member's opinion could be ignored. For example, in Ms. Kohl's wrap-up session, Liana reported that "we still have to convince ONE more person [i.e., Samantha] so we still haven't WRAPPED it up yet" (WU, 2/2/96). In another example, 1 week after the BOA, Shantelle tried to settle the matter by putting the question to a vote of Ms. Wingate's whale group (2/9/96).

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[14]Despite this discouragement, Ms. Wingate's whale group soon found a new piece of evidence for the orca-as-whale view.

Despite the fact that everyone but Samantha voted for orcas being whales (with Shantelle declaring, "They're WHALES!"), the problem remained open. A little over 1 min after the vote, Shantelle returned, saying, "We need somebody to convince Sione."

Evidence that the Students Treated Themselves as Stakeholders Accountable to Others

As shown in previous sections, the teachers and the design of the unit strongly encouraged the students to become stakeholders accountable to the contributions of others. However, the students could have chosen to resist such encouragement. They generally did not do so. They did appear to view themselves as stakeholders in the controversy, and they also often held themselves accountable to the contributions of others, both inside and outside the classroom. Evidence for each will be discussed in turn.

Students showed they viewed themselves as stakeholders in the controversy by frequently associating themselves or other students with respect to claims, evidence, knowledge, or activities about it (Toma, 1991a). To see this, we coded each student turn about the controversy from the BOA onward for explicit cases of such positioning of students by students (see Appendix D for methodological details and event-by-event results). These commonly occurred when students stated that they, another student, or the student group "thought" or "believed" something about the controversy or when they identified a student with a particular claim or piece of evidence (e.g., "Brian's point"). To count as positioning a student, a statement had to explicitly refer to a specific student or group of students. So, for this coding, simply stating a claim—no matter how vehemently—was not sufficient to count as positioning oneself (in such cases it can be difficult to distinguish between when students are simply mentioning a claim versus associating themselves with it). Even with this conservative criterion, the students positioned themselves or other students as stakeholders in 39% of turns about the controversy. Specifically, the students positioned other students (e.g., "you" or "Toscan") in 23% of the turns, themselves (e.g., "I") in 18% of the turns, and themselves with others, as a group (e.g., "we"), in 14% of them.[15] Thus, through their discourse, the students explicitly treated themselves and other students as stakeholders in the controversy, both individually and collectively.

The students' discourse about the controversy also provided evidence that they were explicitly attentive to the positions and arguments of others, demonstrating their accountability to them. First, the students' positioning of other students as stakeholders in 23% of their turns is also evidence that the students were explicitly

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[15]The percentages do not add up to 39% because in a single turn students often positioned not just themselves, for example, but also other students, or the group as a whole.

attending to other students' contributions. In addition, they showed they were taking into account the contributions of authors of texts, the Marine World trainers, and other such outside sources by explicitly positioning them in 30% of turns (again, see Appendix D for details). Overall, the students positioned one or more such "others" during 46% of their turns about the controversy.[16]

GENERAL DISCUSSION

How the FCL Students' Productive Disciplinary Engagement Was Fostered

For ease of reference, Table 5 lists the ways that the teacher's moves and the design of the FCL unit embodied the four principles. We will now summarize how they may have affected the students' productive disciplinary engagement.

In several ways, the teachers and the unit's design fostered the students' problematizing of the content with which they became engaged. First, the FCL practice of using multiple sources in research supported the emergence of the problem itself. Although the Marine World trainer's statement about the orca's classification was not predictable, the trip to consult the trainers in the first place was planned, allowing the problem of discrepant sources to emerge. Several books, read by the students before and after the statement, also contributed to problematizing the issue. Second, dealing with discrepant sources was an explicit curricular goal, and the teachers and students discussed both their possibility and potential ways of dealing with them on several occasions. Third, the teacher supported participation in arguments over problematic issues by orchestrating the DDT debate. Finally, Ms. Wingate and others further supported the students' engagement with this specific problem once it emerged, by framing it as legitimate and worthwhile and by preventing premature closure of the debate during the BOA discussion and afterward. Thus, problematizing was in part responsible for why the students initially got engaged in the issue and kept being engaged in it over time. This extended engagement gave them many opportunities to improve their arguments.

The students' engagement was clearly deepened by their having a sense of agency and a stake in dealing with the problem themselves, which was supported in multiple ways. The bulletin board in particular was a showcase of the whale group's expertise, increasing the students' stakes in its accuracy. The unit also supported the

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[16]Again, percentages do not add up because in the same turn students sometimes positioned both outsiders and other students.

TABLE 5

Summary of How the Teacher and the Unit Embodied the Guiding Principles for Fostering Productive Disciplinary Engagement

Problematizing	Authority	Accountability	Resources
Prior to controversy:			
• Encouraged students to consult multiple sources	• Encouraged participation in argument (agency)	• Had group present to multiple, real audiences (others)	• Provided multiple sources including books, field trips
• Prepared students for discrepancies in sources	• Positioned self and other adults as co-learners	• Modeled responding to others' contributions in DDT debate	• Existence of discrepancies about orca classification
• Set up debate on problematic issue (DDT debate)	• Encouraged students to become experts	• Instituted "hot seat" to assess student's expertise	• Existence of discrepancies in use of terminology
	• Made group members responsible for whales (stake)	• Urged students to document their sources (norm)	• Experience with discrepancies in Pocahontas unit
	• Encouraged students to share expertise (contributors)	• Modeled uses of evidence in DDT debate (norm)	• Experience with argument in DDT debate
During controversy:			
• Legitimated controversy when it arose	• Bulletin board as representation of group's emerging expertise	• Urged students to consider both sides of the debate	• Time to revisit the issue
• Framed trainers' claim as an open question	• Positioned whale group as responsible for the issue	• Exhorted students' to address others' points (BOA)	• Students' diverse rhetorical skills
• Supported both sides, keeping question open	• Repeatedly encouraged students to "weigh in" on controversy	• Insisted Brian's draft include evidence for both sides	BUT:
		• Repeatedly asked for and emphasized evidence	• Issue competed for time with rest of unit
		• Modeled use of evidence to counter claims (BOA)	• Lack of classificatory chart or info on how biologists resolve such issues

Note. BOA = Big Ol' Argument.

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notion of authority as a product of research and debate rather than an inherent attribute of teachers, texts, or other potential authority figures. In addition, all of the students were encouraged to weigh in on the problem, especially during the BOA, but also at times when a group consensus was needed for a specific task or audience. At various times during the controversy, Ms. Wingate resisted weighing in, to maintain the locus of agency in the group. Thus, the students' sense of authority helped contribute to the intensity with which they engaged in the issue and may also have contributed to the productiveness of the controversy by encouraging them to raise the quality of their contributions.

The students were also continually made aware that they would have to take others' points and claims into account, even if they chose to challenge them. The principle of accountability to others, embodied by the FCL practice of having students present to "multiple, real audiences" (Brown & Campione, 1996), affected the productivity and continuation of the students' engagement by providing multiple contexts in which to develop their arguments. Such contexts included the DDT debate, oral presentations to and arguments with others, written research, grappling with various texts, and the hot seat. Had the students been less attuned to the contributions of others, they might have ignored the trainer's statement, never getting into the debate in the first place. Had they been able to ignore classmates' positions and arguments, they might not have productively improved their own arguments or developed counterarguments to address them.

In the FCL community of discourse, accountability to the disciplinary norm of presenting evidence for claims was particularly strongly supported. The support came in the form of frequent requests by both teachers and students for students to explain their reasoning and to provide corroborating evidence and references. These interactions appear to have led the students to improve their arguments and raise new questions. Such realizations of the principle of accountability in the classroom may help explain why the students' engagement was disciplinarily productive.

Finally, the students' engagement with the orca controversy was affected by their access to a variety of resources. The multiple sources for the students' research provided information that the students used to develop the arguments and counterarguments that constituted productive progress in the debate. The apparent discrepancies in classification and terminology themselves can be seen as resources for problematizing the issue. Additional resources included a previous history unit about Pocahontas focusing on how to address discrepancies in sources and explicit modeling of evidence-based argument in the DDT debate. The learning environment also provided multiple contexts and times for revisiting the debate. However, the students lacked some resources that might have helped them resolve the issue more satisfactorily from a disciplinary perspective.

Thus, we argue that it was not simply a coincidence that these students became engaged by the trainer's statement that "orcas are not whales." Whether the statement constituted a problem in their subsequent classes for the other hundreds of schoolchildren at Marine World that day is not known. It is probably safe to assume, however, that few other students in the audience were debating the orca's classification 8 weeks after the show. Perhaps some children in the audience were surprised. Of these, perhaps some simply edited their previous belief that a killer whale was a whale, on the basis of the trainers' perceived authority, without examining the question further (as Samantha did initially). Perhaps a few others looked orcas up in a classificatory chart and learned why they could be called both whales and dolphins. In these imagined cases, the students would not have engaged in a scholarly debate using evidence nor gained the experience of working with others to achieve a group consensus on a problem. This type of productive disciplinary engagement was explicitly valued and fostered by the designers and teachers of FCL (Brown & Campione, 1990, 1996). At the time they encountered the trainer's remark, these FCL students were uniquely positioned—by their identities and stakes as potential school whale experts, by their multiple readings about whales, and by their responsibility for the task of creating the bulletin board—to become productively engaged by it.

Moreover, as Table 6 shows, the students generally took up this positioning and other ways in which the principles were embodied. In general, they: (a) problematized several aspects of the issue; (b) were the key agents, stakeholders, contributors and experts who addressed it; (c) conducted their discussions while holding themselves accountable to others and to the cross-disciplinary norm of providing evidence; and (d) took advantage of the variety of resources that were made available to them.

Explaining Other Cases of Productive Disciplinary Engagement

Having found the principles useful in explaining this one case of productive disciplinary engagement, we wondered if they could be useful in understanding other cases of productive disciplinary engagement. We surveyed several cases of productive disciplinary engagement from math and science programs and found that they were. For the purposes of the article, we discuss two of them, the Japanese Hypothesis-Experiment-Instruction (HEI) method (e.g., Hatano & Inagaki, 1991; Wertsch & Toma, 1995) and the Water Taste Test investigation from the Chèche Konnen (CK) project (Rosebery, Warren, & Conant, 1992). We chose these two because they are well documented in the literature and provide useful contrasts to the orca controversy. We first present the cases individually. Later, we compare them to explore the similarities and differences in how each principle was embodied and the effects this may have had on students' productive disciplinary engagement.

TABLE 6
Summary of How the Students Responded to the Guiding Principles

Problematizing	Authority	Accountability	Resources
• Problematized claim that orcas are dolphins • Questioned terminological discrepancies • Evaluated credibility of sources	• Defined, debated, made decisions about the problem (agency) • Positioned themselves re controversy (stakeholders) • All students contributed to debate (contributors) • Supported and challenged others' claims (contributors) • Convinced others to change positions (contributors) • Viewed themselves as experts BUT: sometimes made unsupported assertions of authority (experts)	• Repeatedly positioned other students and sources • Took others' claims into account when developing arguments • Would not let issue be closed without group consensus • Frequently used evidence • Used evidence to evaluate credibility of others	• Sought additional sources of information • Used available time to discuss issue • Lobbied for more time • Drew on experiences with Pocahontas, DDT debate • Used rhetorical skills from law, religion, sports, etc.

Student Discussions in Hypothesis-Experiment-Instruction Method Classrooms

Productive disciplinary engagement similar to that observed in the orca controversy is reported in research on student discussions from math and science classrooms organized according to the Japanese HEI method (Hatano & Inagaki, 1991; Inagaki, 1981; Inagaki, Hatano, & Morita, 1998; Kobayashi, 1984; Toma, 1991a, 1991b; Wertsch & Toma, 1995). As in the orca discussions, HEI discussions are partisan, position-driven arguments in which students give reasons for their positions (Hatano & Inagaki, 1991; Toma, 1991a). Students are engaged enough in them to celebrate when they successfully persuade others to switch their positions (Hatano & Inagaki, 1991). In addition, arguments for particular positions get more sophisticated over the course of an HEI discussion (Hatano & Inagaki, 1991; Inagaki et al., 1998).

How is this apparently very similar type of productive engagement achieved? Although we see evidence that the proposed principles support the engagement in this case as well, their specific embodiments often differ markedly.

In HEI, teachers problematize content by presenting a class with a multiple-choice question that has a clear right answer, but one which is not likely to be recognized by a majority of the students (Hatano & Inagaki, 1991). Teachers carefully tune the question to their students' understanding (Henningsen & Stein, 1997), purposely including answer alternatives that are incorrect but potentially plausible to many students. As a result, it is likely that members of the class will disagree about what the correct answer should be, making the question genuinely problematic for them.

HEI teachers further encourage students' engagement with the question by initially withholding the correct answer from them and (if it is a science question) not allowing them to do the relevant experimental demonstration to find out what the answer is. Instead, the class is encouraged to try to resolve the question themselves through discussion. This gives the students the agency to fully address the question and come up with their own arguments for and against each alternative answer. Students are also asked to publicly indicate which alternative they support (Hatano & Inagaki, 1991; Inagaki, 1981; Inagaki et al., 1998; Toma, 1991a; Wertsch & Toma, 1995), thus inducing students to declare themselves as stakeholders (similar to practices in Lampert, 1990a, 1990b; Michaels, 1999; and Sohmer, 2000). The teacher is careful to avoid evaluating the quality of students' arguments, leaving it to proponents of each answer to identify flaws in the arguments of others as they try to convince them. According to Hatano and Inagaki (1991), because "no authoritative right answers are expected to come immediately," students are on a level playing field with respect to expertise, which encourages a "horizontal . . . flow of information" between them (p. 333).

The presence of other classmates as proponents of other positions and as an audience for public arguments helps strengthen each HEI student's accountability to other students, helping to drive their engagement and make it more productive. According to Hatano and Inagaki (1991), the lack of a consensus among students leads them to try to convince each other of the correctness of their choice of alternative and to defend it from counterarguments made by the other side. Discussion is "livelier and more enduring, because [it] becomes an intellectual game for gaining supporters to form the majority" (p. 334). As students see which arguments do (and do not) prompt their classmates to change their positions, they are also often prompted to reflect on which arguments are convincing and why (Hatano & Inagaki, 1991). In addition, teachers encourage students to explicitly relate their contributions to those of fellow students by using phrases like, "I agree with (name)'s opinion," to present their positions (Toma, 1991a; Wertsch & Toma, 1995).

The students' accountability to mathematical or scientific disciplinary norms is embodied in two main ways. First, teachers encourage students to give evidence by suggesting that they should follow statements of their positions with phrases such as, "this is because [reason]" (Toma, 1991a). Second, in most versions of HEI, students leave the process knowing what the relevant discipline views as the correct answer. At the end of the lesson, after the students have fully discussed the question, the teacher either tells them the correct answer (if the topic is from mathematics) or has the students do an experimental demonstration intended to determine the correct answer (if the topic is from science). In response to receiving a correct answer from an authoritative source, most students revise their understandings, sometimes reflecting on which arguments were and which were not decisive (Hatano & Inagaki, 1991).

Finally, the primary resources supporting students' productive disciplinary engagement in HEI discussions are the carefully designed multiple-choice question that launches the discussions, the existence of a full class of students who are likely to have different positions on it and can serve as an audience for others' contributions (i.e., Hatano & Inagaki's, 1991, factor of "three or more members"), and a set of standard phrases (often posted on the walls of Japanese classrooms; see Toma, 1991a) that help students in positioning their contributions with respect to others and providing evidence for their claims.

The Water Taste Test Problem in Chèche Konnen

We also find the principles useful for understanding a case of productive disciplinary engagement from the CK project (NSF, 1997; Rosebery et al., 1992). In this case, a teacher finishing a unit on water quality had noticed that her 7th- and 8th-grade Haitian bilingual students were always running up to the third floor fountain to get drinks of water, even from the playground. She discovered that they believed that the water from the third-floor water fountain of the school tasted better than that from the first floor. The teacher challenged the students' belief, and suggested a blind taste test. When the results of the test showed that, in fact, students preferred the taste of the first-floor water, both the students (who expected a preference for the third-floor water) and the teacher (who expected no significant difference in preference) were surprised. The students repeated the taste test, this time school-wide. When the unexpected preference for the first floor water was confirmed through this test, the students sought an explanation for the preference by conducting salinity, bacteria, temperature, and pH tests of the water. The students finally concluded that a temperature difference in the water accounted for the preference.

The students were deeply engaged during the Water Taste Test episodes. Their horror at the finding that they actually preferred the water from the first-floor

fountain (in which, they noted with disgust, kindergartners drooled) prompted enthusiasm for a school-wide test to check the surprising results. The students participated in several disciplinary aspects of science in the course of investigating the issue. They reconciled the results of a blind taste test with their beliefs, and attributed significance to the results of the various water quality tests, in the context of a question. They developed further questions about the water (e.g., Why was the first floor water preferred?). The students' work was clearly productive. The students used experimental techniques to answer real questions, and produced new knowledge through their activity. Both the students' bias against the first-floor water and the teacher's assumption that the different water samples would be indistinguishable were proved unfounded.

As in the orca example, the problematizing of an issue in which students had a stake was a first step in provoking engagement in this case. The teacher and students opened ostensibly closed claims and assumptions about the school's water to empirical investigation. Moreover, although each side had expectations, the results of the test were not known by anyone, anywhere, in advance.

With respect to authority, in the Water Taste Test example, the students believed they knew their own preferences, but the teacher challenged them and demonstrated the power of a scientific approach to their claim. In conducting the taste test, the students preserved their agency as arbiters of their own taste, but their experience with experimental methods and their test results changed their beliefs about actual differences in the water. In conducting the school-wide test, the students were not only active agents in challenging the results of the earlier test, but they also appeared to the rest of the school as local science experts, a significant social event for the Haitian bilingual students. The challenge posed by the test results to the students' initial claims about the water was offset, in a sense, by the increased authority the students accrued through their participation in an authentic scientific inquiry.

Accountability to others in the Water Taste Test example was not unidirectional to adult expertise, as the problem was genuinely open. The teacher's as well as the students' beliefs were held accountable to and challenged by the taste test results, and those results were in turn held accountable by the students to the larger school-wide sample. Even city officials were compelled to take note of the students' results, which also documented a potentially high level of bacteria in some of the water samples.

The teacher encouraged the students to be accountable to scientific disciplinary norms by introducing useful scientific ideas and practices in the context of the investigation. These included blind testing, exploring underlying causes, and replicating results using larger samples in response to surprising data.

In the Water Taste Test, the teacher made use of the students' ideas as a resource for problematizing. She also provided the students with resources, including practices (e.g., considering multiple possibilities as hypotheses), experimental strategies (e.g., salinity and bacteria tests), materials (e.g., pH paper and

thermometers), and the time and place to pursue the question, both in class and in the wider school (Rosebery et al., 1992).

Comparing How the Principles Were Embodied Across the Three Cases

We have thus found the principles useful in understanding some documented cases of engagement from different programs, even though each program has somewhat different goals. Briefly, the FCL program "is designed to promote the critical thinking and reflection skills underlying multiple forms of higher literacy" by introducing students to the practices of scholarly research in an academic subject (Brown & Campione, 1996, p. 290; also see Brown & Campione, 1994; Rutherford, 2000). At the time of the Water Taste Test study, CK was an "inquiry science" project, with the goal of having teachers and students participate in science through investigating authentic questions in ways characteristic of scientific practice (Warren, Rosebery, & Conant, 1989; Rosebery et al., 1992). The HEI program is designed to teach specific subject-matter concepts as well as to develop students' ability to construct knowledge as a group (Hatano & Inagaki, 1991; Wertsch & Toma, 1995). Content in the examples presented from these cases also differed widely: Deciding how to classify a species (FCL) is different from investigating water quality (CK), which is different from predicting what will happen in an experimental demonstration (HEI). Differences in goals and conceptualizations of learning and disciplinary knowledge also affected the ways in which the principles were weighted and embodied in the programs.

All three cases involved problems that, according to researchers' accounts, engaged students. Several aspects of the problems varied, however. In the FCL and CK examples cited, problems emerged in part out of students' activity, whereas in HEI, problems were designed in advance and presented to students by teachers (cf. Stevens, 2000). From a disciplinary perspective, the HEI and orca classification problems involved known answers, whereas the question of the water's quality in the Water Taste Test example was genuinely open. In all three cases, the problems were opened to the students' sense-making, however, thus helping drive their disciplinary engagement.

The cases all embodied the principle of giving students agency to address such problematic issues. Teachers refrained from using their authority to settle or close questions being debated by students (until after the discussions, in the case of HEI), in contrast to common modes of classroom discourse (Cazden, 1988; Lemke, 1990). When teachers in the CK and FCL examples challenged students' claims and beliefs, they did so to keep questions problematic, thus also maintaining with the students the locus of agency to pursue or decide questions. In HEI, students do not

define problems, are given scripts for how to talk, and know that there is a correct answer associated with the problem that someone will ultimately tell them. Thus they do not have the same degree of agency to define and decide issues that the students in the FCL and CK examples did. During their discussions, however, the HEI students have sole agency in arguing for and against each answer alternative.

Moreover, HEI debates, in combination with a resolution, ultimately position HEI students authoritatively with respect to a problem's relationship to disciplinary knowledge. In contrast, at the end of the orca controversy, the FCL students did not reach an authoritative understanding of how the orca was classified or why, and can thus be seen as less productive in this sense. In the CK example, the students' original beliefs about the school fountain water were refuted, but the students gained authority by pursuing scientific methods to investigate a problem and obtain credible results.

In all of the cases, the students were positioned as stakeholders, although in different ways. In the FCL case, the students' stake in the orca issue was increased by the group's identity as developing experts in their topic and by their agency (and responsibility) to design an accurate bulletin board exhibit for a school-wide audience to whom they were accountable. In the CK case, the students' beliefs, the school-wide Water Taste Test, and the public display of its results similarly enhanced the Haitian students' sense of stake, authority, and agency in resolving the problem. In HEI debates, students are not positioned as experts in subject-matter topics. They must, however, publicly choose an answer and give reasons for supporting it (similar to Lampert, 1990b; and I-Club in Michaels, 1999, and in Sohmer, 2000). In this respect, HEI debates resemble the planned DDT versus malaria debate in the FCL class, for which Ms. Wingate asked the students to state their positions and reasons and explicitly modeled how to do this. In contrast, in the orca controversy, the students were not required to indicate which side they supported or given any templates for how to talk. The sense one gets is that in HEI discussions and the DDT debate, it was part of the students' task to act as stakeholders, whereas in the orca controversy and the Water Taste Test, the students were stakeholders and that is why they acted as such. This may reflect the fact that in the HEI and the DDT examples, students were presented with problems, whereas in the orca and the Water Taste Test examples, problems emerged out of their ongoing activities.

Such differences in the kinds of authority present and their relationship to eventual outcomes in the cases reflect the goals and emphases of the different programs. However, all included a crucial role for the principle of authority in fostering student engagement.

Embodiments of the principle of accountability to others affected student engagement in all three cases and deepened its productiveness and disciplinary connections. In the FCL case, the orca controversy arose in part because the students were forced to account for discrepancies among their beliefs, their readings, and the Marine World trainers' claims to the real audience that would view the bulletin board.

The group's subsequent progress on the issue depended on listening and responding to each other's points. In HEI, accountability to others' ideas in structured debate is promoted explicitly as a part of classroom discourse norms, and the students' hypotheses are ultimately accountable to the results of the demonstration. In the CK case, accountability to others was evident in the teachers' acknowledgment and challenge of the students' beliefs and was in some sense mediated by the test results. In all of the cases, students were exhorted to take multiple others' points and claims into account through references, support, or counterarguments.

The cases also show differences with respect to embodiments of accountability to others. In FCL and CK, accountability was established as bidirectional with respect to adult participants. In the FCL case, most of the students eventually deemed the adult trainers to have provided insufficient evidence for their claims. In the CK example, the teacher's assumptions (as well as the students') were challenged by the results of the blind taste test, as both the teacher and her students submitted to the authority of its results. In HEI, in contrast, the eventual demonstration or adult teacher's answer is assumed decisive.

With respect to accountability to disciplinary norms, there were differences as well as similarities among the cases. In all three cases, giving evidence was important, though they varied in how directly this was supported. In HEI, phrases with which to present evidence were provided, even affixed to the classroom wall. In the orca case, the teacher modeled giving documentary evidence and asked for it frequently. In the Water Taste Test, the students gathered additional evidence when their test results did not match their expectations. There were also differences in how disciplinary knowledge and practices were embodied in the cases. In FCL, the main sources of disciplinary knowledge were the texts and other information resources the students had; however, they lacked some biological knowledge that may have helped them resolve the debate more effectively. In HEI, the views of the discipline were represented at the very end of the discussions when the students did the experimental demonstration or the teacher told them the correct answer. Finally, in the CK classroom, the students made contact with disciplinary norms by participating in its practices as empirical investigators.

Resources differed widely among the cases, reflecting differences in the activities. In CK, resources included training in water quality tests, the students' beliefs, scientific methodology in the form of a taste test model, a community of test participants, and data from the test. In HEI, resources included a carefully designed problem with predetermined, plausible answer alternatives, specific templates for productively participating in discussions, and a final demonstration providing the correct answer. In the FCL case, resources for the orca controversy included multiple sources of information, models for engaging in similar problems and discussions, as well as time for the students to revise and revisit their ideas in multiple contexts for multiple audiences. The controversy involved only one group of students, was peripheral to the main tasks of the unit,

and was thus in some competition with those tasks for time and other resources, however, affecting the students' ability to resolve it. These examples give a sense of the range of resources and practices that can support productive disciplinary engagement, depending on the goals and content of a particular program.

Concluding Thoughts

In this article, we introduced the notion of productive disciplinary engagement and proposed a set of guiding principles for fostering it. We exemplified the principles in a case of such engagement from FCL and showed how their embodiment in the case may have helped foster the engagement observed. Finally, we reviewed two other cases of productive disciplinary engagement available in the literature and found that it is possible to use these principles in understanding those cases as well.

In proposing the principles, we do not wish to imply that productive disciplinary engagement can be engineered on the one hand nor that it occurs by chance on the other. We do not mean to suggest, in interpreting certain elements of FCL, HEI, and CK as supportive of the principles, that specific formal elements of classroom design (such as stipulated participation structures) guarantee certain kinds of student engagement. This point has been ably argued elsewhere (e.g., Brown & Campione, 1996; Lamon et al., 1996). On the other hand, things can be done—both in advance and in the moment—to make productive disciplinary engagement more likely. As human beings working with other human beings, that is the best we can hope for. As Prawat (1996) observed, "One builds a learning community . . . by engendering commitment in individuals, not by manipulating control" (p. 101).

Throughout, our aim has been to provide a potentially fruitful way of thinking about how to foster productive disciplinary engagement in learning environments. We hope that the principles will prove useful for a variety of purposes, such as in designing a new program or lesson, trying to evaluate or understand an existing learning environment, or even while making moment-by-moment decisions about how to respond to students' contributions. In general, we suggest that those interested in engaging students productively in disciplinary issues and activities ask themselves questions such as the following:

1. What kinds of productive disciplinary engagement are most valued in the learning environment? What views of the discipline, of appropriate student engagement, and of standards for productivity are being explicitly or implicitly espoused?

2. How is each principle for productive disciplinary engagement being embodied in the environment? How are the specific means of embodying each one responsive to the values, personalities, and backgrounds of the particular learners one is working with?

3. In this particular setting, is an effective balance being maintained between authority and accountability, and between problematizing and resources?

We anticipate such questions will provoke discussion and raise further questions. The key to progress is to ground discussions in specific evidence while being aware of how values necessarily inform them.

Ultimately, we hope readers will find the four principles—and the questions they raise—useful in thinking about the cases of productive disciplinary engagement with which they are already familiar as well as those they may hope to foster in the future.

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APPENDIX A
Transcript of Brain's Report to the New Student Teacher on His "Whale Features" Research

Legend

Each line is a spoken intonation unit and/or any co-occurring nonspeech moves. At the end of each spoken intonation unit, punctuation indicates the type of intonational contour:

.   = falling/end intonation contour
?   = rising/questioning intonation contour
!   = an exclamation
,   = anything else, usually a slightly falling/continuing intonation contour

Line numbers for lines that include no speech are in italics. Numbers for lines judged as being off the main topic of the conversation are underlined. When two or more topical threads were competing to be the main topic, they were both coded as on it. A question mark around a line number indicates a line that was not sufficiently audible for it to be coded. Other symbols include:

[*inaudible*]   = word cannot be identified
[*description*]   = transcriber's description of nonspeech moves or other behaviors
(word(s))   = transcriber uncertain that the word(s) has been correctly identified

((word(s)))	= transcriber especially uncertain about correct word identi- fication
(word1/word2)	= either word1 or word2 could have been spoken
wor-	= word or intonation unit cut off midstream
exte::::nd	= vowel lengthened, with more colons indicating more lengthening

Points of overlap across participants are indicated by pairs of large opening brackets that are aligned from one line to the next to indicate where overlap begins (e.g., see lines 4 and 5). When useful, pairs of closing brackets indicate where overlap ends (e.g., see lines 37 and 40). Finally, capitals are used to indicate syllables given particularly strong emphasis by the speaker through especially salient changes in pitch, volume, or (more rarely) speed.

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As this segment begins, each student has been telling the new student teacher (Ms. P) what he or she has learned so far about his or her research topic. According to Ms. Wingate's instructions at the beginning of class, the purpose of the session is twofold: The group is to begin teaching each other what they know and help catch up the new student teacher on what she doesn't know. Brian's report on whale features is the last one before they return to class.

The coding described in Appendix B compared the first 70 sec of this presentation (lines 1–56) to the next 70 sec after it (lines 57–130), which starts with Brian's allusion to the controversy (lines 57–58, 60–62, 66–67, 70).

11:05:59. Brian's second turn in the panel presentation.

1	Brian:	[to *Ms. P*] I did features of whales.
2	Ms. P:	you did what?
3	Brian:	features.
4		[(I did features).
5	Ms. P:	[features?
6	Brian:	[*nods*]
7	Toscan:	[[*appears to be mouthing words to a song*]]
8	Ms. P:	[can you tell us about features.
9	Brian:	[*to Ms. P*] well um- [*pause*] (uh um) [*pause*],]
10	Samantha:	[[*picks up set of papers from her or Jonelle's folder and starts looking at it*]]
11	Brian:	[*continuing*] [well [*glances towards Toscan, returning to Ms. P*],

12   actually like Toscan said [*pointing to him*],
13   they have like these TOOTH BRUSH bristles (on it/that are)
                                        [*gesturing to show the vertical threads of baleen*],
14   THAT long [*shows length by stretching
                                        out hands horizontally*].   ]
15   Jonelle: [[*sorts through her folder*]   ]
16   Brian: [[*continuing to Ms. P*] the   [(the baleen whales).   ]
?17?   Toscan: [([*inaudible, so not coded*])
18   Samantha: [*returns papers to Jonelle's folder*]
19   Jonelle: [[*closes it, saying/mouthing something to
                                        Samantha like* "oh thanks"]   ]
20   Brian: [[*to Ms. P*] they're really   [HUGE.
21   Toscan: [*also to Ms. P*]   [they're almost as long as this
                                                         table [*looking and gesturing
                                                         across table towards Jonelle*].]
22   huge [*opens mouth wide, exaggeratedly stretching the rest
                                                         of his face*].
23   Jonelle: [*begins to add a book to her pile of things while Samantha
                                                         starts pulling it back*]
24   [*mouths/says something like "that's okay" to Samantha*]
25   Brian: [*to Ms. P*] and they're round,
26   ba- they're called baleen.
27   Jonelle: [*to Samantha, with amazement*] as big as this TABle!
28   Brian: [*continuing*] they SUCK in the plankton,
29   (then/and)   [FILter the water [*demos water moving past
                                                         pretend baleen in his mouth*],
30   (and the air) [*shows air escaping from baleen mouth*].
31   Jonelle: [[*whispering to Samantha*] how long
                                        is this taking?
32   [*she raises her hand towards Ms. P*]
33   Jonelle: [[*motions to Toscan to attend to her*]
34   [*gestures and says something to him about having to go soon*]
35   Toscan: [*at first gives a confused look*]
36   [*but eventually nods "yes" and says something inaudible*]]
37   Brian: [[*continuing to Ms. P*] they have like,
38   they breathe through like,
39   a blow hole thing on top of their HEAD
                                        [*shows it by circling his hand on top of his head*].
40   some whales can like,
41   stay under water for about,   ]
42   two HOURS,
43   before (breathing/breeching).

44		[(mm-) but most whales don't do that.]
45	Jonelle:	[[*shakes head "no" at Toscan*]]
46	Brian:	[*continuing to Ms. P*] and the baleen whales,
47		[they have two blow holes,
48		right next to each other
		[*puts both hands on top of his head*].]
49	Jonelle:	[[*yawns, looking away from table*]]
50	Brian	[*continuing*] and the killer whale-,
51		I mean the toothed whales,
52		have- they're like SMALLer,
53		and they have [*pause*] one blow hole
		[*puts one hand at back of head*].
54		um [*long pause*] and they have like this thing on their back
		[*shows location with hand on his upper back*],
55		called a DORsal [fin,
56	Jonelle:	[[*turns back to look at Brian*]

11:07:09. The big shift, 70 sec after Brian started.

57	Brian:	and um
58		[*starts smiling and looks briefly at the other students,*
		especially Toscan]
59	Toscan:	[*smiles back a little at Brian*]
60	Brian:	[*returns gaze to Ms. P*]
61		some people believe that the KILLer whales,
62		are actually the biggest dolphin,
63	Samantha:	[*to Brian, mouths something, maybe,*
		"I do," "they are," "oh no"—*2 syllables*]
64	Jonelle:	[*turns toward Brian*]
65	Toscan:	[*shakes his head "no" while rolling his eyes*]
66	Brian:	[*to Ms. P*] but scientists prov-
67		[[*his mouth widens into a grinning smirk and he turns*
		from Ms. P to Samantha, looking askance at her]
68	Jonelle:	[[*turns to Samantha and whispers something to her*
		that looks like a complaint, something on the order
		of "here we go again"]
69	Samantha:	[*smiles, perhaps in response to Brian or Jonelle or both*]
70	Brian:	[*continuing, back to Ms. P*] proved that is NOT TRUE.
		[*Brian holds his grin*]

11:07:20

71	Samantha:	[*to Brian and other students, very quietly, almost whispering*]
		(no it doesn't),
72		(no it doesn't).
73	Jonelle:	[*raises her hand*]

74	Toscan:	[*raises his hand*]
75		[*to Ma. P*] oh yeah I have a thing to add to that,
76		I have a thing to add to that.
77	Brian:	[*grins wider, as if he's trying to hold in his delight*]
78	Ms. P:	[*apparently calls on Toscan, not sure how, but:*]
79	Tos&Jon:	[*set down their hands*]
80	Samantha:	[*moves in closer to everyone else on the bench*]
81	Toscan:	[*to Ms. P*]
		um they all think that [[*pause*]
82	Jonelle:	[*quietly to Toscan*] [killer whales are dolphins,
83	Toscan:	[*continuing to Ms. P*] killer whales are dolphins,
84		because they have a [dorsal fin,
85	Jonelle:	[[*raises her hand*
		and sets it down]
86	Toscan:	[*continuing*] just like the [dolphins,
87	Samantha:	[*to other students*] [no [*shaking her head slightly*],
88		that's not (the only) ((reason)).
89	Brian:	[*to Ms. P*] [BUT [*smiling broadly*]
		all the other whales have a dorsal fin TOO.
90	Toscan:	[to Ms. P] [BUT [*smiling broadly*]
		all the other whales have dorsal fins,
91		so they go [*zigzags his finger up and down several times*].
92		so [*quickly glances over at Samantha during pause*]
		maybe they're ALL [*spreads his hands out dramatically*]
		dolphins.
93	Brian:	[*to Toscan*] no,
94		[[*pause*] maybe the DOLphins are WHALES!
95	Jonelle:	[*to Ms. P*] [but- but if-
96	Toscan:	[*to Brian*] oh yeah!
97	Tos&Bri:	[*they "high five," beaming*]
98	Jonelle:	[*to Ms. P*] if a killer whale-
99		if a killer whale was a DOLphin,
100		how come they would call it,
101		how come they're not called the "killer DOLphins"?
102	Brian:	[*to Jonelle*] thank YOU!
103	Jonelle:	[[*shakes Brian's outstretched hand*]
104	Brian:	[[*continuing to Jonelle*] that's my point!
105	Toscan:	[thank you [*Toscan holds out his hand for Jonelle*
		who doesn't take it]
106	Samantha:	[to *J*] [because [*pause*] [they just found it out.
107	Toscan:	[thank you VERY much
		[*taps Jonelle on arm*].
108	Jonelle:	[*shakes Toscan's hand*]

109 Samantha: [*to students*] and I still don't see why you guys
                   won't believe the TRAINers.
110? Jonelle: [[*inaudible 3 syllables, so not coded*]
111 Toscan: [[*turns to S*]   they said   ["MA:::YBE"
                                   [*puffs face up, bugs eyes out*]
112 Brian: [*turns to S*]   [because they've only been working,
113   they- we knew more than THEY did!
114 Brian: [*continuing*]   [They   didn't   know   what-
115 Jonelle: [*to students*] [They   didn't   know   ((hardly))   ANY!
116   [*to Ms. P*] they (didn't even-) they had to keep asking people.
117 Brian: [*to Ms. P*] they were like,
118   "is that   [RIGHT?"
119 Jonelle: [RIGHT?"
120 Toscan: [*to Ms. P, smiling*]   [yeah,
121   they kept asking.
122 Samantha: [*to students*]   [the other one was-
123   [you guys you guys let me (just say this)
                   [*indicates her point with her right index finger*]
124 Brian: [[*to Ms. P*] we were at Marine World,
125   and they   [were like
126 Toscan: [they kept saying,
127   "is that right?"
128   ["well it's this and this,
129   not that and that."
130 Brian: [*making fun*]   ["I think they have forty teeth,

11:08:19. End of 70-sec coded segment after the big shift.
131 Brian: [*continuing*] well no no it's the other way around!"
132 Samantha: no,
133   but it's [like
134 Ms. P: [did you go as a class?
135 Jon, Tos & Bri: no
136 Samantha: [*to Ms. P*] no we went with our whale group,
137   [*to other students*] but see,
138   you guys,
139   I don't see-
140   there were two trainers right?
141   and ONE of them was doing all the talking,
142   and SHE was the one that wasn't sure,
143   the other one was ABsolutely positive.
144   so why won't you believe the other trainer?

145	Toscan:	[*to Samantha*] but ⌈the- in their sci- en- ti- FIC!
146	Brian:	[*to Samantha*] ⌈we don't believe both of them.
147	Toscan:	[*to Samantha*] that their skin is LIKE a dolphin,
148		and their dorsal fin is like a dolphin,
149		and it goes like that [*moving his arm like a swimming dolphin*].
150		and all the other whales go like that
		[*again moving his arm like a swimming dolphin*].
151		they don't go [*moving his arm to swim like a fish*].
152		so maybe they're A:::LL dolphins [*sweeps hand forward*],
153		or maybe they're A:::LL [*sweeps hand back towards
		original position*] whales!
154	Brian:	my point exactly!
155	Toscan:	they don't go [*arm swimming like a fish*],
156	Brian:	or you ⌈could just SEparate them
		[*demos splitting into two with hands*],
157		and they're two different things.
158	Toscan:	⌈they go [*arm swimming like a dolphin*].
159	Samantha:	so maybe you guys-
160		⌈you're saying that maybe they-
		maybe the killer whales COULD be dolphins,
161		along with all the other whales.
162	Jonelle:	[*to Ms. P*] ⌈this could go on forever
		[starts assembling her papers]
163	Brian:	actually I'M [*pointing to self*] not saying that,
164		HE [*pointing his thumb at Toscan*] said that,
165		okay?
166	Toscan:	what? [*glances at Samantha and then Brian
		with look of mock incomprehension*]
167	Brian:	I beLIEVE (..) that they (..) are not dolphins.
168	Toscan:	(I know) ⌈(that). [*inaudible-1 syllable*]
169		
170	Samantha:	⌈I believe that they ARE.
171	Brian:	basically,
172		the beLUGa whale ⌈is basically just like the killer
		whale, =
173	Jonelle:	[*to Ms. P, in disgust*] ⌈this could go on for HOURS,
174		and HOURS,
175		(upon/and) HOURS [*hits her pencil down*],
176		(and) HOURS [*hits her pencil down again*],
177		(and) HOURS [*hits pencil down once again*]. ⌉
178	Brian:	= except
		that it has a FLAT head [*brings his hand

		down in front of his face to show a flat head]
179	Toscan:	[the baleen.
180		the sperm whale!
181	Brian:	[uh uh] all the
		other-
182		the SPERM whale
183		[*pause*] [(it's just) flat [bringing hands
		in front of face again].
184	Jonelle:	[*to Ms. P*] [ours lasted-
185		we had this ARgument,
186		but it lasted for about a good HOUR.]
187	Toscan:	eXACtly.]
188	Tos&Bri:	[*slap hands*]
189	Ms. P:	that's amazing.
190		it's a good argument.
191	Toscan:	because (.) [it's like [*starts gesturing and stops*]-
192	Brian:	[*to Ms. P*] [one day in class we um-
193		(.) well ALL the whale groups meeting from like next door,
194		got together and we all had this big ol' ARgument.
195		and most EVeryone,
196		except for ME,
197		believed that the whales are DOLphins.
198		and thank you very much to me,
199		[*holds his hands up in victory and nods, smiling*],
200		that everyone CHANGED.
201	Toscan:	and then *I* changed,
202		[and then I made- I made EVERYBODY
		[*makes a sweeping arm gesture*],
203		except her [*points to Samantha*].
204	Brian:	[except for,
205		this person [*pointing to Samantha*].
206	Samantha:	no,
207		[Devonae,
208		Devonae.
209	Toscan:	[(we're a team) [*motioning with his arm around Brian*].
210	Toscan:	Devonae still thinks that they're dolphins,
211		swimming in the sea [*flapping his arms to show swimming,*
		and speaking in a high voice, mimicking Devonae].
212	Brian:	Devonae thinks,
213		whatever she thinks.
214		((because she's)) [*twirls finger at temple, gesturing*
		"that person is crazy"].
215	Toscan:	I know [*laughs*].

216		((I suppose)) [*looks at Brian*].
217	Ms. P:	anything else?
218	Samantha:	nope.
219	Jonelle:	I'm trying to make my eraser [*inaudible-1 syllable*].
220		(I think I can) fix (it).
221	Toscan:	um they're not dolphins,
222		they're not whales,
223		they're not anything,
224		they're just living in the sea,
225		having fun,
226		and leave 'em [alone.
227	Jonelle:	[*starts to get up*]
228	Students:	[*put away their things*]
229	Jonelle:	[(they're cats!)
230	Toscan:	hey
231	Jonelle:	hey cat fish
232		[[*inaudible-3 syllables*]
233		if cat fish,
234		if cat fish!
235	Ms. P:	[*to Brian*] [how long do they live?

11:10:36. [Brian doesn't answer question, conversation moves to other topics as they leave].

APPENDIX B
Quantitative Evidence From the Report to the New Student Teacher That the Students Were Especially Engaged in the Orca Question

To confirm our sense of a shift in engagement by the students at Brian's mention of the orca question, we analyzed and compared the 70 sec of Brian's report before the hypothesized shift (NST, 3/26/96, lines 1–57) with the 70 sec that followed it (lines 58–131), which includes Brian's first reference to the controversy (see Appendix A for all data referenced in this appendix). We did so using a variety of quantitative measures.

Who Spoke

To see whether more students talked about the orca topic than others in Brian's report, we first looked for differences in how often each student

TABLE B.1
Percentage of Intonation Units Presented by Each Student Before and After the Shift

	Brian	*Jonelle*	*Samantha*	*Toscan*
Before shift[a]	91%	3%	0%	6%
After shift[b]	33%	16%	16%	35%

[a]$N = 35.$ [b]$N = 55.$

spoke before and after the hypothesized shift. To quantify amount of speech, we counted how many spoken intonation units each student presented on the main topic of the conversation during the 70 sec before and after the shift. Intonation units are prosodically defined bursts of speech that are often the size of a short phrase or clause and express something like a single idea (Chafe, 1980). In the transcript in Appendix A, the relevant intonation units are student lines with numbers printed in plain text (i.e., no italics, which indicates a nonlinguistic action, or underlining, which indicates an off-topic remark or action, or a question mark, which indicates an intonation unit not sufficiently audible to code). As Table B.1 shows, before the shift Brian did almost all the talking (91% of 35 on-topic student intonation units), but afterward he shared speaking turns with the other three students, talking less often (during 33% of 55 of these intonation units, where 25% would be consistent with equal participation). This difference in the proportion of on-topic intonation units presented by Brian versus other students is statistically reliable, χ^2 (1, $N = 90$) = 30.0, $p < .00001$.[17] It is not surprising that Brian talked the most initially, given it was, after all, his report. However, what began as Brian's report, with him as the primary speaker, changed to a discussion in which he was only one of several speakers. Moreover, the students made this shift themselves, without any noticeable direction from the student teacher.

To Whom They Spoke

To see if there were any differences in how involved students were as listeners, we then looked at whether each on-topic intonation unit was addressed to the

---

[17]We recognize that technically a chi-square test is not appropriate here and in later analyses because what students do in one intonation unit is not independent of what they did in earlier ones. Despite this, we use a chi-square because it is a simple way of verifying that the differences we see before and after the shift are not likely to have occurred by chance. A more sophisticated time series analysis would have been much more difficult to explain and, given the dramatic differences in the data, would not have been likely to support different conclusions.

new student teacher (Ms. P) or to one or more of the other students, both before and after the hypothesized shift. Because the students were sitting in a line on one side of a picnic-style table with Ms. P sitting across from them, it was very easy to determine whom students were addressing by determining whether their gaze and gestures were directed across the table (therefore addressing Ms. P) or alongside it (therefore addressing other students). We found that initially almost all on-topic student talk was addressed to the student teacher (97% of the 35 intonation units). After the shift, however, the students' talk was more evenly divided between intonation units addressed to the student teacher (58% of 55 intonation units) and those addressed to other students (42% of them).[18] This was also a statistically reliable difference, $\chi^2(1, N = 90) = 16.6$, $p < .0001$. So students were also more engaged in the orca question than other parts of Brian's report in that they were more likely to serve as addressees for talk about it. Putting the first two findings together, one can say that initially Brian was presenting to the new student teacher, but afterward all four students were alternatively addressing the student teacher and each other.

Management of the Floor and Off-Task Activities

There were also differences in the ways students who did not currently have the floor behaved before and after the orca classification question was raised. We looked at both off- and on-task activities.

Before the shift, other students were engaged in quiet alternative off-task activities such as singing, yawning, shuffling unrelated papers, and remarking to others about the passage of time during 19 of the 34 intonation units before the shift (56%). In contrast, there was evidence of someone attending to an unrelated task during at most 1 of the 56 intonation units after the shift (2%). This lone exception was actually a meta-comment on the shift itself, by Jonelle, to the effect of "here we go again" (NST, 3/26/96, line 68). Not surprisingly, this difference is statistically reliable, $\chi^2(1, N = 90) = 34.1$, $p < .00001$.

After the shift, overlapping talk was usually not the result of an off-task activity, but instead was either a fight for the floor (e.g., in lines 123 and 124, Brian said "we were at Marine World" at the same time Samantha said "you guys you guys let me (just say this)") or a collaborative sentence construction such as illustrated by Toscan and Brian in lines 89 and 90:

---

[18]There were differences among student speakers, however, in to whom they addressed their talk about the orca question. All of Samantha's intonation units in the 70-sec segment after the shift were addressed to other students, whereas Toscan and especially Jonelle were more likely to address the new student teacher than other students (15 of Toscan's 19, and 7 of Jonelle's 9 intonation units were addressed to Ms. P). Brian's talk about the orca question was fairly evenly balanced, with 10 of his intonation units addressing the new student teacher and 8 addressing other students.

81	Toscan:	um they all think that (pause)-
82	Jonelle:	[*quietly*] killer whales are dolphins,
83	Toscan:	killer whales are dolphins,
84		because they have a dorsal fin,
85		just like the dolphins,

. . .

| 89 | Brian: | [BUT [*smiling broadly*] all the other whales have a dorsal fin TOO. |
| 90 | Toscan: | [BUT [*smiling broadly*] all the other whales have dorsal fins, [NST, 3/26/96] |

There were significantly more of these task-relevant spoken overlaps during the 70 sec after the shift than before (13 vs. 1), $\chi^2(1, N = 90) = 7.0, p < .01$.

Pronounced Emotional Displays of Involvement

The students' more intense involvement in the orca question is also apparent by examining their emotional displays before and after Brian's comment about killer whales. After the shift, students rolled their eyes, smiled exaggeratedly, shifted closer together, made high fives, or shook each others' hands 16 times. Before the shift, there was at most one such display, an especially exaggerated facial gesture by Toscan as he demonstrated that a whale's baleen (a series of bony plates that some species of whales use to sift plankton out of the water) is "huge" (NST, 3/26/96, line 22).

Summary

Thus, in terms of who was speaking, to whom they were talking, and how they participated, the students were more engaged in the orca classification question than in the other parts of Brian's report on features.

APPENDIX C
Analysis of Students' Use of Evidence in the Orca Controversy Discussions

The students' engagement in the orca controversy was attentive to a general scholarly norm that claims need evidence to be convincing. To support this claim, we first coded student turns discussing the controversy for whether and how evidence was used. All student turns during the orca controversy discussions made by

members of the whale groups were included in the coding except for the hallway discussion because the sound quality on the videotape was too poor to pick up much of what students were saying, other turns that were not audible or complete enough to be interpreted, and turns focused entirely on turn-taking (e.g., "I have something to say" or "wait a minute"). Turns about turn-taking were eliminated so all turns coded would be ones in which it was reasonably conceivable that a student could have chosen to use evidence (Schegloff, 1993).

We coded three aspects of the use of evidence. First, we coded whether a student provided evidence in a given turn, and if so, whether he or she had provided one piece of evidence or more than one. The following types of contributions were counted as evidence because they were recognized as being evidence in these classrooms (original data available at http://ed.stanford.edu/~ greeno/PrinciplesPaper/):

1. *Documentary evidence*: Mentioning that a particular source had made a relevant claim or otherwise using such a source to support a claim (e.g., Jonah's "it says right here that . . . dolphins are beaked whales" [BOA, 2/2/96, lines 423–424]).

2. *Anatomical evidence*: Investigating relevant anatomical features of species of dolphins, often to compare them (e.g., Liana's "and this [*pointing to a picture*] don't have no beak right here, or nose. and this [*pointing to another picture*] is one BIG OLD NO:SE" [BOA, 2/2/96, lines 493–495]).

3. *Lexical evidence*: Exploring ways in which lexical similarities or differences may relate to classificatory differences (e.g., Jonelle's "if a killer whale was a DOLphin . . . how come they're not called the 'killer DOLphins'? [NST, 3/26/96, lines 100, 102; see Appendix A]).

4. *Evidence about credibility of sources*: Examining evidence about whether particular sources (like the MW trainers) should be trusted (based on criteria like training, past knowledgeability, certainty, and the like; e.g., Brian questioning a trainer's credibility by saying, "remember when she said um a dolphin has, 44 teeth and a whale has, 88 teeth, and then she's like, 'is that RIGHT, or is this the other way around?'" [BOA, 2/2/96, lines 379–382]).

We made no attempt to judge the relative quality of the evidence because our primary purpose was to see how often the students provided evidence of any kind; in any case, making such quality judgments is difficult to do reliably. Each turn about the controversy was specifically coded as providing zero, one, or more than one piece of evidence. To count as providing more than one piece of evidence, a student had to provide more than one of the earlier types of evidence in a single turn, or provide more than one piece of evidence of the same type by, for instance, providing evidence for a piece of evidence. This occurred, for example, when one student developed an anatomical argument by arguing that killer whales are not the only whales that have dorsal fins (one piece of evidence) because the blue whale also

has one (evidence for that evidentiary claim, counted as a second piece of evidence). In cases of ambiguity, we were conservative, coding less use of evidence rather than more.

Second, we coded whether, in a given turn, the student had used connectors like "because" and "so" and related interrogatives like "why" that explicitly linked evidence with claims, as in the following examples from the BOA (claim-evidence connectors are underlined):

5.   Brian: oh, it's- it's kinda it seems like it's not true <u>because</u>, um in all the research, everything I've done on- on killer whales, [*pause*] it <u>points to</u> that they are whales. the blubber, the blowhole, the eyes, the teeth. it <u>points out</u>, that they're a whale. [BOA, 2/2/96, lines 76–82]
6.   Toscan: it has a teeny one, at the back of the fin, <u>so</u> the blue WHALE could be a dolphin. [lines 152–153]
7.   Jonelle: if- if they're dolphins <u>why</u> do they call them killer whales, <u>why</u> don't they call them (killer dolphins). [lines 193–194]

For each turn, we coded simply whether or not a connector or connectors had been used, without keeping track of the number of uses.

Finally, we coded explicit references to the concept of evidence by the students. Sometimes these occurred when students explicitly discussed evidence by nominalizing it with terms such as "evidence," "point," or "reason," as in the following example (references to evidence are underlined):

513   Brian: [*continuing*] okay. this is what happened/
514   th- there is a LOT of people that think killer whales are WHALES!
. . .
515   [*pause*] and think they have <u>EVidence</u> that they are.
516   they have <u>big E evidence</u>, that the dolphins,
517   is whales. that's not saying (it's j'same okay) [*inaudible*].
. . .
519   I rest my <u>CASE</u>.
(BOA, 2/2/96)

Explicit references to the concept of evidence also occurred when a student used verbs such as "argue," "prove," or "convince" that refer to the process of persuading or giving evidence, as in the following example (again, references to evidence are indicated with underlines):

431   Brian: [*smiles, leans forward, and looks directly at Samantha*] we're <u>conVINCED</u> him.
432   we <u>convinced</u> him, we <u>convinced</u> him, we <u>convinced</u> him.
(BOA, 2/2/96)

As with connectors, for each turn we simply coded whether such references to evidence were present or absent.

For all three codings, the two authors first independently coded roughly one fourth of the turns to establish reliability. Different fourths from each episode (e.g., the second one-fourth of turns from the BOA, but the third one-fourth of the WU reports) were randomly sampled for this purpose. The authors agreed on coding uses of evidence on 90% of these turns ($\kappa = .85$), explicit connectors on 97% of them ($\kappa = .92$), and explicit references to the concept of evidence on 90% ($\kappa = .79$). All disagreements were resolved through discussion. With sufficient reliability having been established, the second author coded the rest of the turns, referring to an earlier version of the codings done by the first author and consulting with her on potentially problematic cases. Event-by-event results for all three codings appear in Table C.1. See the section of the main text, *Use of Evidence as a Form of Scholarly Practice,* for discussion of them.

TABLE C.1
Percentage Use of Evidence per Turn in Orca Controversy Discussions

	Provide Any Evidence	*Provide Multiple Pieces of Evidence*	*Use Evidence-Claim Connectors*	*Explicitly refer to Evidence*
BOA 2/2 (n = 133)	75%	25%	28%	41%
Wrap-up sessions about BOA 2/2 (n = 11)	45%	18%	36%	55%
Ms. Kohl's group reports to parent volunteer on 2/9 (n = 10)	40%	10%	10%	20%
Disagreeing and then finding new evidence on 2/9 (n = 66)	37%	3%	2%	11%
Reanimating and reporting about argument to NST on 3/26 (n = 51)	43%	14%	20%	15%
Negotiating written report and expressing disagreement on 3/27 (n = 12)	17%	8%	50%	58%
Negotiating oral report and expressing disagreement on 4/2 (n = 22)	9%	0%	5%	0%
TOTAL (n = 308)	52%	15%	19%	27%

Note.   BOA = Big Ol' Argument.

APPENDIX D
Analysis of Students' Positioning of People in the
Orca Controversy Discussions

As shown in the previous sections, there were many ways in which the teachers and the design of the unit strongly encouraged the students to be stakeholders who were accountable to the contributions of others. However, the students could have chosen to resist the teacher's encouragement. In fact, however, there is evidence in the students' discourse that they viewed themselves as stakeholders in the controversy and also that they were accountable to the contributions of others, both inside and outside the classroom. To see this, we examined the students' discourse about the controversy to analyze how often they positioned themselves and others with respect to it.

Specifically, we coded the same set of turns used in the evidence coding—turns made by students in the whale group about the controversy that were complete enough to be interpretable and were not about turn-taking. We then coded whether in each turn a particular person or persons had been somehow associated with a controversy-relevant claim, piece of evidence, or the process of establishing them, a type of move we will call positioning (cf. O'Connor & Michaels, 1996). Positioning moves were usually of one or more of the following types:

1. *Associating a person(s) P with a belief X*: Commonly using constructions like P "believes/thinks/knows/understands/sees" X, where X could be a claim, a piece of evidence, or some statement linking them (e.g., "I don't believe they are dolphins"; "this books says that the killer whales are DOLphins"; "and I don't think whales do [have a dorsal fin] usually"; "Toscan, I don't see what you think"; and, "if it IS true, which I seriously DOUBT" [BOA, 2/2/96, lines 274, 436, 143, 226-227, and 121, respectively]).

2. *Stating a person(s) P has made or should make a point*: P's "point," P "has a point," or "why don't you say something about X?" (e.g., "my point exactly"; "Brian has a very good point;" and, "why don't you say something about what Samantha said?" [BOA, 2/2/96, lines 64, 206, and 197, respectively]).

3. *Referring to the knowledgeability of some person(s) P with respect to the controversy*: Either by asserting that they have relevant knowledge or that they are or should be correct about what they say (e.g., "they know better what they're talking about than we do"; "look, HE'S been studying whales for six months"; "how do WE know, that she was right, or she was WRONG!"; and, "Samantha, we better be right" [BOA, 2/2/96, lines 327, 359, 376, and 420, respectively]).

4. *Noting that some person(s) P did something to gain relevant knowledge Y*: P "read" or "remembered" or "studied " or "researched" or "got info" on Y, where Y relates to the controversy (e.g., "I read it in two books" [2/9/96, turn 2]; "what I remember is . . ." [BOA, 2/2/96, line 322]; "(pointing to book) it says right here

that . . ." [BOA, 2/2/96, line 423]; and, "I don't see no page with [the term 'flesh eating' dolphins]" [BOA, 2/2/96, line 475.5]).

5. *Specifically noting some person(s) P's involvement in controversy activities*: For example, noting someone had been arguing, trying to convince someone, or having a big discussion (e.g., "we all had this big 'ol argument" [NST, 3/26/96, line 194]; "we convinced him!" [BOA, 2/2/96, line 432]; "I made EVERYBODY [change], except her" [NST, 3/26/96, lines 202-203]; and, "we WON!" [BOA, 2/2/96, line 427]).

For each turn that included such positioning moves, we coded whether speakers were positioning any of the following types of people: (a) themselves; (b) other student(s); (c) themselves with other students in a group; or (d) outside sources like authors of texts, scientists, or (rarely) teachers. We determined who was positioned by identifying the nouns used as subjects, objects, or possessives in the relevant constructions. Students were coded as positioning themselves when they used first-person singular pronouns such as "I," "me," or "my." They were coded as positioning other students when they used second-person pronouns like "you" or "your," or third-person references to other student's names. Students were coded as positioning themselves in groups with other students when they used first-person plural pronouns such as "we," "us," or "our," or third-person references like "the whale group." Finally, students were coded as positioning outside sources when they pointed to texts or made third-person references to people like "trainers," "scientists," or "this book." When students used the third-person pronoun "they," it was usually clear in context whether the student was referring to other students or to outside sources. In cases of ambiguity, "they" was coded as referring to outside sources in order to be conservative in estimating the degree to which students treated themselves as stakeholders. In all cases, a particular person or persons needed to be explicitly positioned by the comment. So, for this coding, simply stating a claim or piece of evidence, no matter how vehemently (e.g., Toscan shouting "they're WHALES!"), was not sufficient to count as positioning oneself. Some of these vehement declarations, like the one just mentioned, probably did have the effect of associating the speaker with the claim or evidence he or she was stating, but because it is difficult to reliably judge what degree of vehemence is necessary to count as positioning oneself with respect to a claim (rather than merely mentioning one), we chose to be conservative and not include any cases in which a particular person or persons was not explicitly mentioned.

In many cases, a turn would include more than one positioning move, with some moves (e.g., "they know better what they're talking about than we do") positioning more than one person (in this case, both the trainers and the group of students). For each turn we simply tracked whether each of the four types of people were being positioned, not how frequently.

What does this coding mean with respect to examining whether students treated themselves as accountable stakeholders? To the extent that students

positioned themselves (whether alone or with other students), they showed that they viewed themselves as stakeholders in the controversy. To the extent that they positioned other students, they showed that they viewed other students as stakeholders, too. To the extent that students positioned both other students and outside sources, they showed that they were responding to their teachers' emphasis on accountability to others by in fact taking their contributions into account.

As was done for the evidence analysis (see Appendix C), a sample of about one fourth of the turns was coded by each author independently. Because agreement of 93% ($\kappa = .87$) for positioning students (self, others, or self with group) and 95% ($\kappa = .89$) for positioning outside sources was achieved, the rest of the coding was completed by the second author in consultation with the first.

Event-by-event results for all four positioning codings appear in Table D.1. Overall, the students positioned themselves in 18% of turns, with such positioning occurring most frequently when Brian and Samantha were negotiating their own positions with respect to the written report (42%) and the least when Ms. Kohl's whale group was reporting to the parent volunteer (10%) and Ms. Wingate's group was negotiating how to present the controversy in their oral report (9%), when many students were simply shouting positions. Positioning oneself as part of a group occurred most often when students reported their group's progress in wrap-up sessions (73% of turns) and the least often when negotiating the oral report (5%), with an overall rate of 14% of turns. Other

TABLE D.1
Percentage of Turns Students Positioned Someone With Respect to the Controversy

	Self	Other Students	Group with Self	Outside Sources
BOA 2/2 (n = 133)	22%	21%	12%	45%
Wrap-up sessions about BOA 2/2 (n = 11)	18%	64%	73%	55%
Mrs. Kohl's group reports to parent volunteer on 2/9 (n = 10)	10%	50%	20%	10%
Disagreeing and then finding new evidence on 2/9 (n = 66)	12%	15%	15%	14%
Reanimating and reporting about argument to NST on 3/26 (n = 51)	18%	28%	10%	25%
Negotiating written report and expressing disagreement on 3/27 (n = 12)	42%	58%	17%	17%
Negotiating oral report and expressing disagreement on 4/2 (n = 22)	9%	5%	5%	0%
TOTAL (n = 308)	18%	23%	14%	30%

Note. BOA = Big Ol' Argument.

students were positioned in 23% of turns, with this occurring most frequently during the wrap-up sessions (64%) and when negotiating the written report (58%) and least frequently while negotiating the oral report (5%). Putting the three codings together (positioning of self alone, of self as part of a group, and of other students), we find that students positioned students as stakeholders in 39% of their turns, with such positioning occurring most often in the wrap-up sessions (72%) and Ms. Kohl's group's report to the parent volunteer (60%) and least often when negotiating the oral report (14%). Finally, students positioned outside sources at an overall rate of 30%, with this occurring most often during the wrap-up sessions (55%) and the BOA (45%) and least often when negotiating the oral report (0%). Putting all the positioning codings together, we find that students made at least one positioning move in 56% of their turns, ranging from 14% of turns while negotiating their oral report to 91% of them when presenting about the controversy during wrap-up sessions.