Making Space to Sensemake: Epistemic Distancing in Small Group Physics Discussions

Luke D. Conlin
Salem State University
Rachel E. Scherr
Seattle Pacific University

Author Note

Luke D. Conlin, Department of Chemistry and Physics, Salem State University; Rachel E. Scherr, Department of Physics, Seattle Pacific University.

This work was funded by the National Science Foundation (Grant #0440113). The authors would like to thank David Hammer for guidance in this work, Ayush Gupta for assistance with analysis and insightful discussions, as well as Megan Luce, Eric Kuo, and Dan Schwartz for helpful comments and suggestions on earlier drafts.

Correspondence concerning this article should be addressed to Luke D. Conlin, Department of Chemistry and Physics, Salem State University, Salem, MA 01970.
Email: luke.conlin@gmail.com

This is an Accepted Manuscript of an article published by Taylor & Francis in COGNITION AND INSTRUCTION on October 1, 2018, available at http://www.tandfonline.com/10.1080/07370008.2018.1496918

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Abstract

Students in inquiry science classrooms face an essential tension between sharing new ideas and critically evaluating those ideas. This tension poses affective risks that can discourage further discussion, such as the embarrassment of having an idea rejected. This paper presents a close discourse analysis of three groups of undergraduate physics students in their first discussions of the semester, detailing how they navigate these tensions to create a safe space to make sense of physics together. We identify a discursive resource – epistemic distancing – which can protect students' affect while they share their own ideas and critique each other's ideas in productive ways. We find the groups differ in how soon, how often, and how deeply they engage in figuring out mechanisms together, and these differences can be explained, in part, by differences in how they epistemically distance themselves from their claims. Implications for research include the importance of considering the coupled dynamics of epistemology and affect in collaborative sensemaking discussions. Implications for instruction include novel ways of encouraging classroom discussion.

Keywords: discourse, physics, motivation and engagement, social context, qualitative methodology, science education

Making Space to Sensemake: Epistemic Distancing in Small Group Physics Discussions

Science is driven by an essential tension between two sorts of processes: generative processes of coming up with ideas and communicating them to others, and critical processes of evaluating those ideas and pruning them (T.S. Kuhn, 1977; Popper, 2005). This tension arises in science classrooms, particularly during collaborative scientific sensemaking discussions in which students come up with ideas to explain physical phenomena, share these ideas with others, and critically evaluate each other's ideas (Ford, 2008). Students in these discussions must continually make repairs of each other's understanding, and so must find ways to manage the affective risk of disagreeing if they are to prevent the discussion from shutting down. On the one hand, too much disagreement could discourage further contributions to the discussion. On the other, too *little* disagreement can mean that students are avoiding conflict at the expense of sensemaking together.

Previous research on inquiry-based science classrooms has focused on the conditions that can support students in learning through sensemaking discussions (e.g., Roseberry, Warren, Conant, & Hudicourt-Barnes, 1992; Scherr & Hammer, 2009), even charged discussions in which they manage affective risks (Duschl, 2008; Engle & Conant, 2002). This research lacks a detailed account of how students in inquiry-based classrooms first manage to construct a safe space to sensemake together. Of particular interest is how students overcome the affective risks of both contributing their own ideas as well as evaluating one another's ideas in their sensemaking discussions. In this paper we provide evidence of an important type of discourse move we call *epistemic distancing*, which students and teachers alike rely on in managing these affective risks as they make a safe space to sensemake. Epistemic distancing moves include hedging, quoting, joking, and other ways by which students reduce commitment to their ideas. We will describe these moves in greater detail below.

This paper presents an analysis of the early discussions of three groups of undergraduate students working together in introductory physics tutorials, with the goal of understanding how the groups construct a safe space to sensemake. The tutorials are weekly discussion sessions where students meet in groups of four for 50 minutes of worksheet-guided inquiry, as part of their introductory algebra-based physics course. Tutorials are meant to support students in collaboratively making sense of topics in physics that research has shown are particularly challenging for students (Shaffer & McDermott, 1992).

To understand how groups co-create a safe space to share and critique their ideas, it helps to first examine what it looks like once they have established such a space. Two groups' contrasting approaches to the same physics problem helps to illustrate the nature of a safe space to sensemake. The problem comes from the 9th week of tutorial, in which the students are exploring the physics of how a roller coaster cart can make it all the way around a vertical loop in the track. Students are asked to draw a diagram showing all the forces acting on a roller coaster cart when it is upside-down at the top of the loop (Figure 1, Point B). The correct answer is that there are two forces: the gravitational force exerted on the cart by the Earth, and the

contact force exerted on the cart by the track. When the cart is at point B, both of these forces point vertically downward.

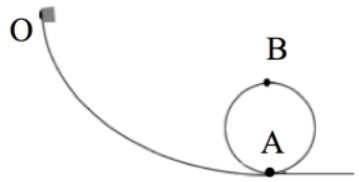

Figure 1. Diagram of roller-coaster track in tutorial problem. Students are asked, "A cart is released at point O, goes down a hill, and goes around a vertical loop in the track. What forces act on the cart when it is at point B?"

The students in the Green group contribute their ideas about which forces act on the cart, agreeing that gravity is pulling down on the cart. As seen in the following transcript[1], they also agree that the track exerts a force on the cart, but they disagree on its direction:

CARMELLE: I mean you have the force of the track pressing it down,
BREE: The force of the track pushing down.
DEIRDRE: But wouldn't it-
AMANDA: Going down.
DEIRDRE: Would it be going up or would it be going like, *(draws an arrow that points up at an angle)* like that?
BREE: What?
DEIRDRE: The force of the track.
BREE: Nah, it's going down.
CARMELLE: 'Cause it's pressing down on it, it's at- it's at the top part it's that top part of it is what's pushing down *(gesture: one hand representing track on top of other representing car, and pushing it down)*
BREE: *(overlapping with Carmelle)* Pushing down, cause that's what's holding it in *(gesture: pointing index fingers in towards body)* from like being shot like way out *(gesture: pointing away from body with index finger, shooting hand away)*

Carmelle, Bree, and Amanda state that the force on the cart by the track should point downward, but Deirdre contributes the conflicting idea that it should be pointed up, or at an angle. Carmelle and Bree both offer ideas that justify their stance that the force should be downwards. Carmelle explains in terms of the configuration of the car and the track: The track is on top so it must be "pressing down" on the car. Bree explains in terms of competing influences: If the track is "holding [the cart] in" from "being shot like way out," then the track must be pushing the cart inwards (toward the center of the loop). Both explanations are based on the

[1] All names are psuedonyms. See Appendix A for transcript conventions.

students' sense of mechanism (Russ, Scherr, Hammer, & Mikeska, 2008) of how the track interacts with the cart. Overall, the members of the Green group are willing to contribute their own ideas, and to critically evaluate each other's ideas, about the physical scenario. In other words, they have made a safe space for collaborative scientific sensemaking.

In discussing the same question, the Red group also disagrees on the direction of the force from the track. Britte has written "N – mg", while Devin has written "mg – N" ("N" stands for "normal force," which is the contact force perpendicular to the surface of contact between the track and the car; "mg" stands for the weight of the cart). In contrast to the Green Group, they do not explicitly share their ideas about which forces are acting on the cart to settle their disagreement. Instead, they have their lecture notes out and are trying to recreate the diagram the lecturer had drawn on the board. Britte realizes that her "N – mg" refers to the point at the bottom of the track (Point A), while Devin notes "I have 'mg – N = mv^2/r' at the top" (Point B). This apparently resolves the disagreement. An instructor later finds that they have drawn the force of the track in the wrong direction, and have drawn gravity pointed up. The Red group has evidently not made a safe space to make sense of this physical scenario, deferring to their lecture notes rather than discussing their ideas about the mechanism of the cart-track interaction.

Why do these groups take such different approaches to the same problem? To answer this question requires an examination of each group's broader history of interactions. Prior research indicates that the groups' different approaches are established very early on in the semester; the tone is set within their first few discussions (Conlin, 2012). This paper presents a close analysis of the discourse of three tutorial groups' early discussions, to address two research questions:

1. How do groups in introductory physics tutorials first construct a safe space to sensemake together?
2. What accounts for variability across groups in how soon and how stably they sensemake?

In our long-term observations of student groups in inquiry-based physics tutorials (see Scherr, 2009), we have noticed students frequently reducing their commitment to their ideas by hedging, quoting, questioning, and joking. Synthesizing literature on conversation and interaction analysis (Goffman, 1979; Kärkkäinen, 2006; Goodwin, 2007), we use the term *epistemic distancing* to describe these conversational moves by which speakers soften their stance. By epistemically distancing themselves from their claims, speakers can introduce their ideas and critiques while mitigating the affective risks of doing so. Their reduced commitment offers plausible deniability ("I was just kidding"; Pinker, Nowak, & Lee, 2008), thus leaving room to evaluate the ideas rather than the person coming up with them. We hypothesize that this discursive resource can play a pivotal role in groups co-constructing a safe space for sensemaking, where the generation and critique of ideas are welcomed, rather than discouraged.

In our analysis of three tutorial groups' first discussions, we pay special attention to students' use of epistemic distancing and its effect on the sensemaking dynamics. The next section characterizes the construct of epistemic distancing by reviewing research on stancetaking

in conversation, with a focus on how participants in scientific sensemaking discussions can manage the affective risks involved in productive conflict.

Managing Conflict through Epistemic Distancing

Managing affective risk is essential to authentic disciplinary engagement. Critique and skepticism are necessary for building reliable explanations in science (Ford, 2008; Osborne, 2010), but when scientists' ideas are rejected it can do damage to their reputation within the scientific community.[2] In active engagement classrooms where students must resolve conflicts amongst competing ideas face-to-face, these affective risks become even more immediate. Disagreements are by their nature face-threatening acts (Brown & Levinson, 1987; Goffman, 1955, 1956), and as such can lead to frustration, embarrassment, and loss of face. Students experiencing frustration or embarrassment in collaborative group work may become reluctant to contribute more ideas. If groups are to collaborate in scientific argumentation, they must find a way to manage these affective tensions, in addition to the conceptual and epistemic dynamics (Leander & Brown, 1999; Duschl, 2008).

Research on small group work in science classrooms has begun to examine the discursive processes by which students successfully navigate these tensions. Earlier work identified discourse practices that facilitated consensus building, but tended to focus on a single aspect of the tension, e.g., conceptual *or* epistemic. For example, Roschelle (1992) analyzed how two learners using a computer-based physics simulation co-constructed a shared conceptual understanding of an acceleration vector. Their meanings converged incrementally, through a series of conversational repairs and corrections of each other's ideas. The affective repercussions of these corrections were left unexamined.

Subsequent studies of small group discourse have begun to reveal the importance of other dynamics besides conceptual, including social, epistemic, and affective dimensions. Leander and Brown (1999) analyze a classroom through several of these lenses, in turn. They make note of a case where the teacher's authoritative discourse momentarily shuts down a student's engagement – highlighting the "dance" between epistemic and affective dynamics. Barron (2003) found evidence of how the social and cognitive aspects of small group work contributed to different outcomes for 6th graders working on a math problem solving activity. The task performance of the groups was not associated with their average math score, but rather with how they engaged with each other's ideas, i.e., the successful groups at least discussed the correct proposals rather than rejecting them outright. Barron (2003) as well as Hogan & Corey (2000) found social and affective factors to present major barriers to collaborative sensemaking, such as students being overly concerned with being the one who comes up with the right answer.

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[2] This was the case for Dan Shechtman, recipient of the 2011 Nobel Prize in chemistry for the discovery of quasicrystals. When his idea was originally rejected, Shechtman's career was all but ruined. He was expelled by his research group and ridiculed by leading chemists such as Linus Pauling, who quipped: "There is no such thing as quasicrystals, only quasi-scientists."

More research is needed to understand not just the barriers to collaborative scientific sensemaking, but how student groups manage to overcome these barriers in co-constructing a safe space to sensemake. Berland and Lee (2012) is one example of an analysis of how students build consensus in light of social and affective challenges, such as saving face while working with ideas counter to their own. They identified a discursive resource – legitimization of opposing ideas – which 5th and 6th graders used in ways that supported their productive engagement in consensus building. One student, Cassie, legitimized a classmate Natalie's contrasting idea by conceding that it *might* be right: "We think, kind of like your point they [the invader] might eat rabbits, but mostly they eat grass" (p. 23). After this concession, Natalie shifted her engagement in the activity and began to engage more with Cassie's evidence.

The studies reviewed above highlight the conceptual, social, and affective tensions students must navigate to create a safe space to sensemake. However, none of them examine how students begin share their ideas in the first place, or critique each other's ideas, given the affective risks of doing so. Cassie's concession provides one hint of a way this could happen – through softening stances to allow for multiple viewpoints. The modification of stance in conversation, and its affordance for mitigating conflict, has been explored in research on discourse in interaction (Johnstone, 2008; Schiffrin, Tannen, & Hamilton, 2001). In what follows, we draw from this literature to characterize one resource – epistemic distancing – by which students and instructors alike may manage affective risk in constructing a safe space for collaborative sensemaking.

Stance-Taking in Conversation

Students engaged in scientific sensemaking discussions continually make claims, display attitudes, and express evaluations, all of which discourse analysts have described broadly as taking *stances* in conversation (Kärkkäinen, 2006; Kirkham, West, & Street, 2011). Participants can take stances toward the conceptual substance of what they are discussing, i.e., that the force is directed down. They can also take stances toward the source and reliability of the knowledge being expressed, i.e., what discourse analysts have described as *epistemic stance* (Biber, 1989, 2006; Kiesling, 2009). Often, these co-occur. For instance, when Deirdre asks about the force on the cart from the track, "Wouldn't it- Would it be going up…?" she is simultaneously conveying an idea about the direction of the force while conveying uncertainty in this idea by phrasing it as a question. (Her groupmates may also understand her as sending other messages, e.g., about whether she is a capable knower, which carries added risk as a woman in a science learning context [Steele, 1997; Lakoff, 2004; Fricker, 2007]).

Speakers can upgrade or downgrade their epistemic stance through various discourse moves, for instance by *deferring* (e.g., "research has proven…") or by *hedging* (e.g., "I guess…") (Clift, 2006; Kärkkäinen, 2007). Any discourse move that either strengthens or weakens a speaker's stance are described as shifts in a speaker's *footing* (Goffman, 1979; Clift, 2006). Footing shifts can be accomplished through explicit hedging using phrases such as "I think" (Kärkkäinen, 2003; Holmes, 1990), but can be conveyed through paralinguistic channels as well. These include the use of a fall-rise intonation to express uncertainty (Ward &

Hirschberg, 1985), adoption of sing-song prosody to convey irony (Clift, 1999), or the shift of body posture to broadcast resistance to an idea (Goodwin, 2007a, 2007b). In each case, the function of a discourse move is complex and must be weighed in context to determine whether it upgrades or downgrades an epistemic stance.[3]

Discourse analysts have highlighted how people index their stance in conversation to manage conflicts (Bonito & Sanders, 2002; Heisterkamp, 2006; Jacobs, 2002; Kärkkäinen, 2003, 2006; Sharma, 2011). By using the phrase "I think" to soften their stance, speakers can avoid the threat to face that comes with bringing up a controversial topic (Kärkkäinen, 2006). Bonito and Sanders (2002) found that by deferring to each other when disagreements arose, students engaged in a collaborative writing task used footing shifts in ways that allowed them to express contrary positions without escalating the conflict.

Epistemic Distancing

Footing shifts that soften a speaker's stance can play such a critical role in managing face-to-face conflict that it is worth distinguishing them with their own term. In the literature on footing and stance-taking in conversation, the term "distance" is often used to characterize such footing shifts. However, the meaning of "distance" is ambiguous. Sometimes conversational analysts take it to be the distance between the speaker, who serves as the "animator" of a claim, and its author. For example, a quotation introduces distance in this sense (Goffman, 1977). At other times analysts have taken the distance to be between the speaker and their avowal of a claim, as when a claim is meant to be taken in jest (Goffman, 1974, p. 512). Often, these separate meanings of "distance" amount to the same thing; an overall disavowal of a claim. But at times these meanings of distance can be in tension. For this reason, in our work we draw a distinction between *rhetorical* distance (between speaker and authorship of the claim) and *epistemic* distance (between speaker and their avowal of the claim). For example, an appeal to authority tends to increase rhetorical distance ("Studies have shown…") as a means to *decrease* epistemic distance (i.e., the speaker is getting behind the claim).

We introduce a new term to describe discourse moves that soften a speaker's stance – *epistemic distancing*.[4] We use epistemic distancing to refer to any footing shift that lowers a

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[3] The phrase "I think" is not necessarily a hedge; it can serve many different purposes depending on context and emphasis (Kärkkäinen, 2003). "I *think*" can convey uncertainty, while "*I* think" can convey certainty and discourage disagreement.

[4] A related term, 'epistemic distance' has been in use by both linguists (e.g., Mortelmans, 2000) and philosophical theologians (e.g., Hick, 1973) to assess how privileged the positions are from which we make truth claims. For example, I have a more privileged position than you (i.e., less epistemic distance) for assessing whether or not I believe in God, but not for assessing whether God exists at all. Linguists debate whether the term should be reserved for indicating a speaker's level of certainty or the directness of evidence from which they draw their conclusion. We use the term to refer to both, although in practice speakers more often index their level of certainty

speaker's commitment to their utterance or otherwise downgrades their epistemic stance, for example by hedging, quoting, or joking. Epistemic distancing is "epistemic" in that it concerns the speaker's commitment to the truth of what they are saying. It is "distancing" in that it creates distance between the speaker and what they are saying (Goffman, 1979).

We hypothesize that epistemic distancing can serve an important role in the process as physics students make a safe space to sensemake. The discourse analysis literature suggests a mechanism by which distancing moves could protect students' affect while they begin to introduce their ideas and critique each other's ideas. In the event that their idea gets evaluated negatively, a speaker's reduced commitment can help them save face, mitigating the associated ego threat and embarrassment that can discourage further contributions (Goffman, 1967, p. 228). It can also prevent loss of face if their idea is evaluated *positively* and it contradicts someone else's idea (Goffman, 1956). Epistemic distancing could also protect students against embarrassment of taking the tutorial "too seriously", for instance, by making fun of their own serious response.

For a brief illustrative example, consider how one student in the Green group responds to the very first tutorial question: "What do you think are the benefits of discussing your mistakes in physics? Discuss your answers." After an uncomfortable silence, the group decides to read their answers aloud. Bree goes first, reading what she wrote dramatically, with exaggerated pitch variations, gestures, and facial expressions (Figure 2).

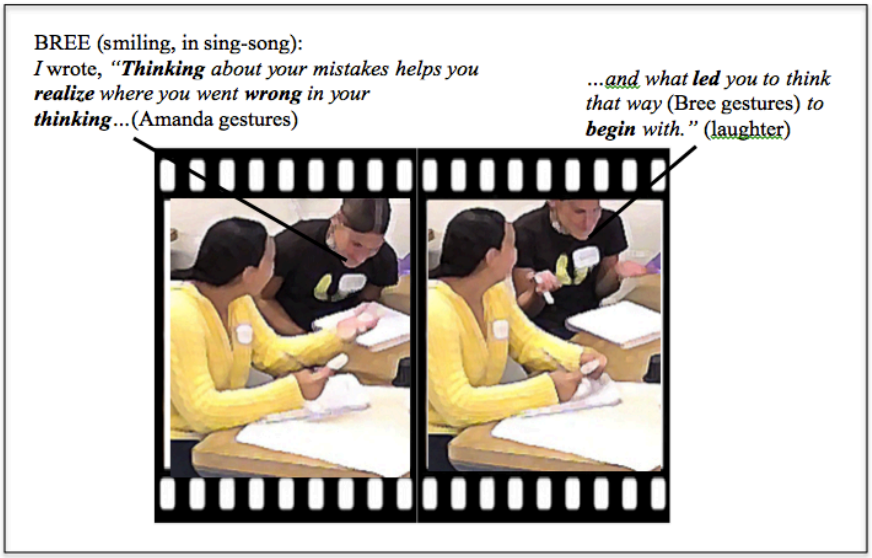

Figure 2. Bree reads her response to the first tutorial question. She softens the stance implied in her written words via an ironic shift in footing, using sing-song prosody and performative gestures (Clift, 2006).

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than their sources of evidence. We also prefer the gerund "distancing" because it highlights the active nature of the process by which speakers manage their epistemic commitments.

Bree is epistemically distancing herself from what she says in two ways. She adds one layer of distance by reading what she wrote, instead of saying what she thinks. She adds a second layer of distance by performing her response (rather than straightforwardly reading it). This move constitutes an ironic shift of footing (Clift, 1999) that further downgrades the stance taken in her written response, signaling that she does not take her response too seriously. In the words of Goffman, (1974, p. 512):

> When a speaker employs conventional brackets to warn us that what [s]he is saying is meant to be taken in jest, or as mere repeating of words by someone else, then it is clear that [s]he means to stand in a relation of reduced personal responsibility for what [s]he is saying. [S]he splits [her]self off from the content of the words by expressing that their speaker is not [s]he [her]self or not [s]he [her]self in a serious way.

By expressing her view, but not taking it too seriously, Bree downgrades her epistemic stance in a way that softens any impending conflict that might arise from someone expressing a different view about the value of discussing one's physics mistakes. It also protects her from embarrassment from taking the task "too seriously." Beyond protecting Bree's affect, her epistemic distancing move can make others more comfortable with sharing their perspective. As detailed below, Bree's epistemic distancing helps her group shift away from reading what they wrote and toward saying what they think, an important step on the way to collaborative sensemaking.

This is not to say that more epistemic distancing would necessarily be better for collaborative sensemaking discussions. Students who distance themselves too much from their ideas about physics or how to learn physics might end up avoiding conflict completely (Ayduk & Kross, 2010), or else come across as so dismissive of the activity that they discourage further contributions from the group. In what follows, we present a close discourse analysis of three tutorial groups' first discussions of the semester, noting when epistemic distancing is happening (or not) and tracking its effect on the dynamics of collaborative sensemaking.

Methods

Instructional Setting

The *Tutorials in Physics Sensemaking* are worksheet-guided discussion sections designed to support inquiry into various topics as part of an introductory algebra-based physics course. At the University of Maryland, where these tutorials were developed and where this study was conducted, students in the algebra-based physics course are primarily life science majors in their junior year. Tutorial groups meet once a week for a 50-minute session of collaborative work. Six teams of four students each are supported by one or two Teaching Assistants (TAs). The worksheets are not collected or graded. The students often do not know each other when they sit down together on their first day. They may sit wherever they like, but they generally stay with the same groups throughout the semester.

Data Collection

During each tutorial session, the activity at two of the tables was recorded by a pair of small stationary cameras, placed on the periphery of the room. The two tables were equipped with embedded microphones. Seating was not assigned, but since the students tended to keep the same seating arrangements we were able to follow intact groups throughout the semester. Three groups were selected for comparison across a range in levels of engagement with the tutorials, based on the frequency and durations of their discussions (via methods described below). The groups are referred to in this paper as the Green, Blue, and Red groups. The Green and Blue groups were in the same year and same course section, and so were in same room during the time of recording. The Red group was recorded two years later but were using the same curriculum.

Episode Selection

The video data comes from a large corpus (~2,000 hours) of videotaped tutorial sessions at the University of Maryland, recorded as part of a larger study of students' reasoning during tutorials (see Scherr, 2009). To pinpoint group discussions out of the many hours of video records, we used the behavioral coding method outlined in Scherr and Hammer (2009). Specifically, we identified episodes in which the groups collectively shifted their postures and gestures, signaling their transition in activity from, say, *completing the worksheet* (e.g., hunched over, eyes down, hands writing) to *having a discussion* (sitting up, making eye contact, hands gesturing). This method aligns with the criteria for an ethnographically adequate description of concerted activities (McDermott, Gospodinoff, & Aron, 1978), including the observation that small-group members tend to collectively organize their postures in ways that signal the context for their activity, especially around points of transition (p. 249-250).

To investigate how student groups initially engage in collaborative scientific sensemaking, our analysis focuses on the groups' first few discussions of the semester. In those initial discussions, each group faces two related challenges: (1) establishing a discussion space, and (2) using that discussion space to discuss their own physics ideas. We split our Data Analysis section into Parts I and II to focus on each challenge in turn.

First, we used group-level shifts in body positioning to identify the very first time each group orients to a discussion space (McDermott, Gospodinoff, & Aron, 1978; Scherr & Hammer, 2009). For all three groups this happens in response to the very first tutorial question of the semester. We examine how each group gets into this first discussion in Part I below. Next, we located the first *collaborative sensemaking* discussion of each group. This was the first discussion in which we found evidence of the students' reasoning mechanistically about physics, which we established using the mechanistic reasoning coding scheme described in Russ et al. (2008). For each group, this happens in response to a different tutorial question. We examine how each group gets into their first collaborative sensemaking discussion in Part II.

Analytic Methods

This research emerged out of a larger project with an established corpus of video data. Following the guidelines for video analysis articulated in Derry et al. (2010), we began with a

guiding question: What precipitated tutorial groups' transitions into sensemaking discussions, as observed by Scherr and Hammer (2009)? In pursuing this question, we behaviorally coded a whole semester's worth of three tutorial groups (10 tutorials for each group), then selected clips of transitions into and out of discussions for further analysis. In concert with individual and collaborative viewings, we developed narrative summaries of the sequences of events that led to the transitions. This process revealed an unanticipated phenomenon: Many of the transitions seemed to be precipitated by students laughing at their own ideas. Through further iterations of viewings and refinement of narrative descriptions, we arrived at a more general phenomenon – epistemic distancing – of which the self-joking is one example.

Informed by the literature on footing shifts and epistemic stance-taking, we compiled a list of exemplars of what we call epistemic distancing – hedging, quoting, and other discourse moves that downgrade epistemic stance through shifts of footing (Table 1). These moves encompass both verbal and nonverbal channels of communication, often simultaneously. Verbal channels include explicit substance of speech as well as tone of voice (prosody), while nonverbal channels include posture, gesture, body positioning, and facial expressions. In conjunction with our narrative descriptions, we developed transcripts as a reliable record of what we view to be the most important aspects of communication during the tutorial groups' transitions into and out of group discussions.

Armed with our definition of epistemic distancing and exemplars of students both increasing and decreasing epistemic distance, we honed our narrative summaries into detailed descriptions that focus on instances of epistemic distancing and their influence on each group's discussion. We noted discourse moves that modified students' epistemic stance and in each case weighed whether these moves increased or decreased epistemic distance. Finally, we noted the effect of these moves on the conversation, specifically, whether they had the effect of encouraging or discouraging other students' contributions of (physics) ideas. In doing so, we took into account the local context of the conversation, as evidenced by what the students themselves oriented to (McDermott, Gospodinoff, & Aron, 1978). We also developed alternative interpretations to check against our own.

Table 1

Exemplar Discourse Moves That Indicated Increased or Decreased Epistemic Distance

Discourse Move	**Occurrence**	**Example**	**Increase/Decrease in epistemic distance**
Hedging Sing-song prosody	Green group's 1st discussion	"I guess we should… discuss our answers"	Increase
Phrasing as a question	Green group's Loop-the-loop discussion	"Would it be going up?"	Increase
Body positioning	Red group's 1st sensemaking discussion	((Britte leans back away from table)) "Are we, um, allowed to discuss our answers?"	Increase

Deferring to authority	Red group's 1st discussion	"It's been proven that you learn from your mistakes."	Decrease
Dismissal	Blue group's 1st sensemaking discussion	"What were those two jumps? Whatever…next"	Increase

Data Analysis

In presenting our analyses, we draw a distinction between two related explanatory goals. In Part I (1st discussions), we attempt to explain how tutorial groups first established a shared discussion space. In Part II (1st collaborative sensemaking discussions), we explain how each groups' discussions first came to focus on the students' ideas about physics.

Part I – 1st Discussions

All three groups get into their first discussion of the semester in response to the instructions of the first tutorial question, which asks them how thinking about their mistakes may help them learn physics (Figure 3). Groups vary in how they take up this discussion. Epistemic distancing helps explain this variability.

Since reflecting on the purpose of an activity can help you get more out of it, let's start with this:

A. (*Answer individually*) What do you see as potential benefits of explicitly thinking and talking about the mistakes you make while working through these activities? If you think dwelling on your mistakes won't be particularly helpful, explain why not.

B. Discuss your answers with your group. If anyone gave part of an answer significantly different from yours, write a one-sentence-summary of that opinion here.

Figure 3. Part A of Question 1 in Tutorial 1 asks students to reflect on the potential benefits of thinking and talking about mistakes they make. Part B asks them to discuss their responses with their group.

The Green group's 1st discussion—"I guess we should…'discussss our answersss'"

After the TA's introduction to the tutorials, the Green group starts the tutorial silently focused on their worksheets. After a few minutes, the group suddenly transitions to discussing their responses to the first tutorial question (Figure 4).

Figure 4. The Green group's gaze shifts during their first transition from completing the worksheet to having a discussion. Clockwise from front left, the members of the Green group are: Amanda, Bree, Carmelle, and Deirdre.

Behaviorally, each student orients to the group space one at a time over a span of about thirty seconds. Deirdre transitions first. As she finishes Part A she sits back, lifts her hands away from her tutorial worksheet, and looks up. This constitutes an example of what Scherr and Hammer (2009) call a *bid* for a change in activity. After the last student orients to the group space, Deirdre speaks up first and a discussion ensues:

DEIRDRE: I guess we should...what did we have to do?
BREE: *(in a mocking tone)* "*Discusssss our answersss...*"
AMANDA: I'm sure we all wrote the same thing *(laughs)*
DEIRDRE: We could just **read** it to each other, I dunno, to see...
BREE: Well...
AMANDA: What'd you write, Bree?
BREE: *(smiling, in a mocking tone)* I wrote, "***Thinking*** *about your mistakes helps you realize where you went* ***wrong*** *in your* ***thinking*** *and what* ***led*** *you to think that way (Bree gestures with open palms) to* ***begin*** *with.*" *(laughter)*
AMANDA: *(laughing)* I wrote exactly the same thing.

Deirdre starts off by asking what they are supposed to do. Bree answers Deirdre's question by reading the instructions from the worksheet, but with elaborated enunciation: "*Discussss our answersssss.*" Bree's mocking tone signals an ironic shift of footing (Clift, 1999) that allows her to express the instructions while epistemically distancing herself from the commitment to following them. Amanda adds, "I'm sure we all wrote the same thing." On the one hand, this could be seen as a sign of solidarity with the group. On the other hand, it could be taken as resistance to discussion since it would obviate the instructions of the tutorial to discuss and write down any differences in their ideas. Deirdre offers a compromise, "We could just **read** it to each other I dunno, to see…" Deirdre's suggestion is delivered with epistemic distancing ("I dunno"). Reading their responses also constitutes a shift in footing away from discussing their answers. This an epistemic distancing move that allows the students to minimally follow

the tutorial instructions while also distancing themselves from their responses. In this way, the Green group establishes a precedent of taking the tutorial seriously, but not *too* seriously.

Bree reads her response first, but performs her reading of it with a smirk, and with exaggerated pronunciation, prosody, and gesture. She is apparently poking fun at what she wrote by playing as if she is "teaching" it to the others, an ironic shift in footing that allows Bree to express her idea about learning from mistakes, while at the same time epistemically distancing herself from what she has written. While Bree is reading, Amanda laughs and plays along, expressing agreement with two open palms (Fig. 2) before replying, "I wrote exactly the same thing" in a similar register and laughing. After Bree's turn, Carmelle starts to read her response:

CARMELLE: I just put that it um,
BREE: ...silly.
CARMELLE: Oh, you still goin' I'm sorry
BREE: Oh nonono I'm done
CARMELLE: I was just gonna say it comforts others in knowing that they too may have made the same mistakes, so you don't feel like you're alone, *(Bree nods)* and um, I also said it kind of fosters better reasoning because *(looks up)* if you can reason through you mistakes then you can-
TA ROSSLYN: *(off camera)* Real quick, guys, I 'm sorry to inter- I need to explain to you about how to do the experiment for this one...

Carmelle starts reading her response with a bit of epistemic distancing, prefacing with "just" in "I just put..." and "I was just gonna say…" She reads her response in earnest, without a mocking tone. When she introduces the idea that discussing mistakes can be comforting in that "you don't feel like you're alone," Bree nods in agreement. By the end of her turn (before the TA interrupts with instructions for the class), Carmelle is looking up and has shifted from reading her response to saying what she thinks.

In summary, the members of the Green group use epistemic distancing in ways that help them take the tutorial question seriously, without taking it *too* seriously. At first, the students are epistemically distancing themselves from the task, i.e., from their ideas about how to approach learning physics together in this moment. Deirdre makes a bid to engage with the tutorial, but softens her bid first by hedging ("I guess we should") and then by turning it into a question ("What is it we have to do?"). Bree answers Deirdre's question ("Discussss our answersss") with exaggerated pronunciation, distancing herself from the content of her suggestion to discuss their answers. Deirdre distances them further from the task by suggesting they read their responses. Reading their responses allows the students to epistemically distance themselves from their ideas, while still expressing them. Bree reads her response ironically, and Carmelle begins with a hedge.

The epistemic distancing in the Green group seems to fade over the course of the discussion. By the time Carmelle takes her turn, she is "epistemically close" to the idea she expresses: she expresses it as her own idea, without hedging, joking, or an altered tone. It could be that epistemic distancing helped them ease into discussing their ideas, and becomes less

necessary once they get started. For instance, it could be that Bree making fun of her own response made Carmelle comfortable enough to say what she thinks. Alternatively, it could be a difference in the students' personality. Either way, descriptively the Green group uses epistemic distancing in ways that helped them discuss their ideas. This an important step towards having collaborative sensemaking discussions about physics, as will be discussed in Part II.

The Blue group's 1st discussion—"Whatever…next!" Like the Green group, the Blue group starts the tutorial by reading the worksheet, then transitions together into behaviorally orienting to a discussion space (Figure 5). The entire transition takes thirty seconds.

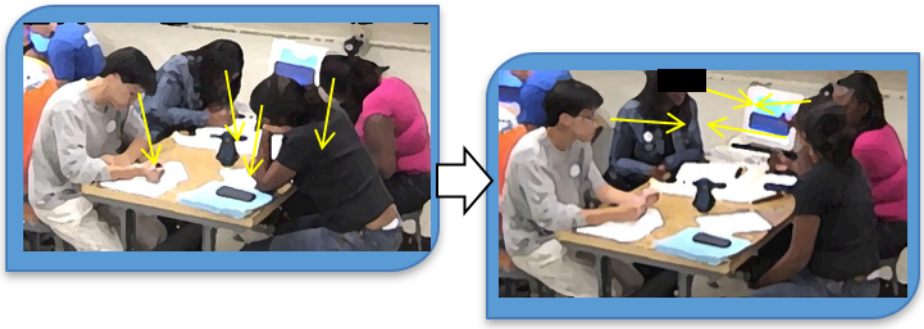

Figure 5. The Blue group's gaze shifts during their first transition from completing the worksheet to having a discussion. Clockwise from front left, the members of the Blue group are: Alan, Brandi, Chrissie, and Daria.

Their discussion of the first question is much more brief than the Green group's. Daria is the first to speak, but instead of reading her response, she speaks in generalities:

CHRISSIE: *(laughs)*
DARIA: So...okay...we talked about how you can learn from your mistakes pretty much yeah
ALAN: Yeah I think everyone said "learning from your mistakes," right?
DARIA: Yeah
BRANDI: Right
CHRISSIE: *(laughs)*
DARIA: pretty much okay
ALAN: Whatever...next!

Daria offered the idea "you can learn from your mistakes", but epistemically distances herself from her contribution in multiple ways. Instead of discussing her idea specifically, she keeps it general. Her use of the pronoun "we" instead of "I" constitutes a shift of footing that locates the idea in the group, instead of in herself. Her contribution, "you can learn from your mistakes" is punctuated with a hedge, "pretty much yeah." Alan endorses the generality of her contribution, also attributing it to the whole group ("I think everyone said [that], right?"), along with a hedge and a question, rather than sharing his own thoughts. By speaking for everyone, Alan could be signaling solidarity with the group. On the other hand this move can discourage further discussion it two ways: It gives anyone else who does not want to discuss their idea an

"out"; It also increases the conversational risk of sharing any ideas that are different. Chrissie laughs and Alan closes the brief discussion with a dismissal: "Whatever…next!"

The Blue group engages with the substance of the question much more superficially than does the Green group. Nobody in the Blue group actually reads their response, or takes personal responsibility for a contribution to the discussion. In this case, the Blue group uses "too much" epistemic distancing, in that they use it ways that discourage further discussion (as exemplified by Alan's "Whatever…next!"). At this point, the group could be in danger of aligning against the tutorial's goals of collaborative sensemaking. They continue in this direction until an instructor intervenes (to be discussed in Part II).

The Red group's 1st discussion—"It's been proven that you learn from your mistakes." Like the Green group and the Blue group, the Red group orients to the group space after an extended period of focusing on their individual worksheets (Figure 6).

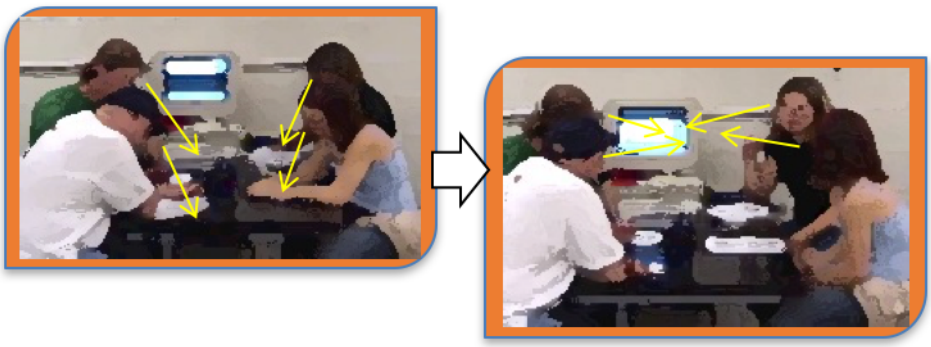

Figure 6. The Red group's gaze shifts during their first transition from completing the worksheet to having a discussion. Clockwise from front left, the members of the Red group are: Alan, Brad, Cathy, and Devin.

Adam is the first to transition in his behaviors when he puts his pen down and looks up at the computer screen. He apparently finishes responding to the tutorial question about a minute before anyone else. Towards the end of this minute, Brad makes a disparaging comment on the tutorial question right before Cathy looks up and starts the discussion.

BRAD: PShshss this is very...condescending
CATHY: What were...your reasons?
DEVIN: So just allows you to better understand...the way you thought about it=
CATHY: I said...if you
DEVIN: =versus the correct way, so you can sorta be able to assess the situation better next time.
CATHY: Yeah, if you- can catch your mistakes you might notice like a pattern of what you- like, what topic you're not understanding
ADAM: It's been proven that you learn from your mistakes.
BRAD: M'yah.

Despite Brad's disparaging comment, the group enters the discussion by following the instructions. While Cathy and Devin each share their ideas about how discussing mistakes can help them learn, Adam states matter-of-factly: "It's been proven that you learn from your mistakes." Adam uses a passive construction ("it's been proven…") that increases the rhetorical distance between him as speaker and the author of the claim. However, this has the effect of *decreasing* the distance between Adam and his avowal of the claim, and so is an example of decreased epistemic distance. It is a footing shift that strengthens his epistemic stance by deferring to authoritative findings (Clift, 2006). Adam gets behind the claim without hedging, while simultaneously deferring responsibility for the claim to someone else (presumably, experts who have "proven" it). Perhaps as a result, this statement leaves very little room for disagreement. This allows Brad, who had already expressed displeasure with the activity, to simply agree with a "M'yah" without sharing his own ideas. Alternatively, it could be that Brad would have avoided sharing his idea no matter what Adam said. Either way, Adam's forceful appeal to authority gave Brad an "out". In this case, a lack of epistemic distancing seems to discourage further contributions, in essence shutting down the conversation.

Summary of Part I – Making space for discussion. Part I examined each tutorial group's very first discussion, bracketed by their behavioral orientation to the group space. There is variability in how deeply the groups engage in discussing their ideas about the first tutorial question, which asks what they think the benefits are of discussing their mistakes. Differences in the groups' use of epistemic distancing help explain this variability (Table 2). The Red group's discussion was cut short by a statement with very little epistemic distancing. In contrast, the Blue group's discussion was preempted by so much distancing ("Whatever…next!") that further contributions were discouraged. The Green Group used epistemic distancing to make fun of the tutorial and even their own answers, allowing them to ease from *reading what they wrote* into *saying what they think*.

Table 2

Summary of Each Group's Epistemic Distancing Moves During Their First Discussion.

Tutorial Group	Statements that *increased* epistemic distancing	Statements that *decreased* epistemic distancing	Comments
Green Group	"I guess we should… …discussss our answerssss" "I'm sure we all wrote the same thing" ((laughs)) "We could just read it to each other, I dunno"	"I was just gonna say it comforts others in knowing that they too may have made the same mistakes, so you don't feel like you're alone"	Student suggests an activity in a mocking tone; this helps them do the activity
Blue Group	"We talked about how you can learn from your mistakes pretty much yeah" "Yeah I think everyone said 'learning from your mistakes', right?" ((laughs))		Students distance themselves from personal responses, while mocking the tutorial

Red Group		"It's been proven that you learn from your mistakes"	Student's appeal to authority seems to shut down the discussion

These contrasting cases reveal that epistemic distancing is not unilaterally beneficial to opening up space for discussion; there can be "too much" distancing. This is not to suggest there is an absolute "right amount" of epistemic distancing, only that it can be used in ways that encourage or discourage further discussion. We determine whether or not epistemic distancing is productive for each group on a case-by-case basis, attending to the local context of the discussion as well as the group's history. The analysis of Part I illustrates the critical role of epistemic distancing in these groups' construction of a discussion space. This is an important step towards collaborative scientific sensemaking, which will be the focus of the analysis in Part II.

Part II – 1st collaborative sensemaking discussions

In this second analysis, we identify the dynamics by which each group first succeeds in making space to collaboratively sensemake. The analysis focuses on each group's first discussion that includes evidence of students contributing and evaluating ideas about physical mechanisms (Russ, Scherr, Hammer, & Mikeska, 2008). For each group, this happens at different times, in response to different tutorial questions (Table 3). In each case, however, the students' and instructors' use of epistemic distancing plays a critical role.

Table 3

Variability in How Soon Each Group Enters Into A Collaborative Scientific Sensemaking Discussion

Tutorial Group	# of discussions until evidence of sensemaking	Elapsed time until evidence of sensemaking	Tutorial question where sensemaking occurred
Green group	3	13:15	Tutorial 1, Question II.B.1
Blue group	3	12:30	Tutorial 1, Question II.A.4
Red group	4	52:46	Tutorial 2, Question 1.A.I

The Green group's 1st collaborative sensemaking discussion. The Green group started making sense of mechanisms soon into the first tutorial. Their third discussion contained evidence of collaborative scientific sensemaking, in response to the third tutorial question. The previous question had asked students to stand 0.5 meters away from a motion detector and walk slowly away as it makes a plot of their distance from the detector as a function of time. The third question asks them to predict what the graph would look like if they started at one meter away and walk away faster, individually recording their predictions by drawing a dotted line on their graph then discussing to come to a consensus graph. Carmelle expresses confusion over the "dotted line thing", and they discuss:

CARMELLE: Darn it! Why am I not doing this dotted line thing?
BREE: So it'd just be like a steeper slope *(gestures straight line with pen)*
AMANDA: Right, okay.

DEIRDRE: Steeper slope, that's what- okay.
AMANDA: And not starting at the origin
DEIRDRE: Yeah a little bit higher
AMANDA: Yeah
DEIRDRE: *(reading)* and then, same thing *(starts to write)*
CARMELLE: But you know what...*(they all look at her)* Okay. Okay. Okay right cause the steeper slope would represent=
AMANDA: *(over Carmelle)* Going faster
DEIRDRE: *(over Carmelle)* A shorter
CARMELLE: =a farther distance in shorter time *(Amanda and Bree say "shorter time" in unison with her)* Okay
AMANDA: Right.
CARMELLE: Okay. *(nods)*

In collaboratively predicting what the graph will look like, the Green group contributes ideas to explain why it will look like that, and critically evaluates those ideas. Bree suggests the slope of the graph will be steeper; Amanda and Deirdre agree. Carmelle seems poised to disagree ("But you know what…") but then immediately softens her stance and finds agreement with the idea. In resolving her potential disagreement, she offers a conceptual justification for the idea: "the steeper slope would represent a farther distance in a shorter time." Amanda confirms with a "Right" and the group agrees on their graph. From this point on, the Green group continues to collaboratively make sense of mechanisms regularly throughout the semester.

Compared to the Green group's first discussion (Part I), there is very little epistemic distancing in this discussion. It could be that the "right amount" of epistemic distancing can evolve over time for each group. The Green group has already made a safe space to discuss their ideas (Part I), using epistemic distancing. Perhaps now they feel comfortable enough to discuss their physics ideas without epistemic distancing.

The Blue group's 1st collaborative sensemaking discussion. The Blue group's initially dismissive approach continues for the group's subsequent discussions, until later in Tutorial 1 when an instructor (TA Joey) overhears them dismissing what he thinks is a good question. They are working on second section of the first tutorial, which asks a student to walk slowly and steadily away from a motion detector, making a graph of the student's distance from the detector as a function of time. The students in the Blue group have all predicted a straight line with a positive slope, depicting the walker's distance from the detector steadily increasing with time.

Alan is the walker for this experiment. He walks slowly and steadily backward, holding a book out in front of him as a target for the motion detector. As he is returning to the table after making the graph, he notices two "jumps" in the graph that deviate from the straight line:

ALAN: Wh- what are those two jumps?
DARIA: *(laughing)* Heh- I don't know.
ALAN: Whatever. *(Sits down)*
CHRISSIE: Okay, *(reading out loud and trailing off)* "Sketch the result"...

DARIA: *(trailing off)* You wanna try it again?
CHRISSIE: *(reading out loud and trailing off)* "Sketch the result"...

The instructor overhears Alan's question and dismissal and joins their discussion, saying, "So wait a second, that's a- that's a good question. What are those two jumps?" (Figure 7)

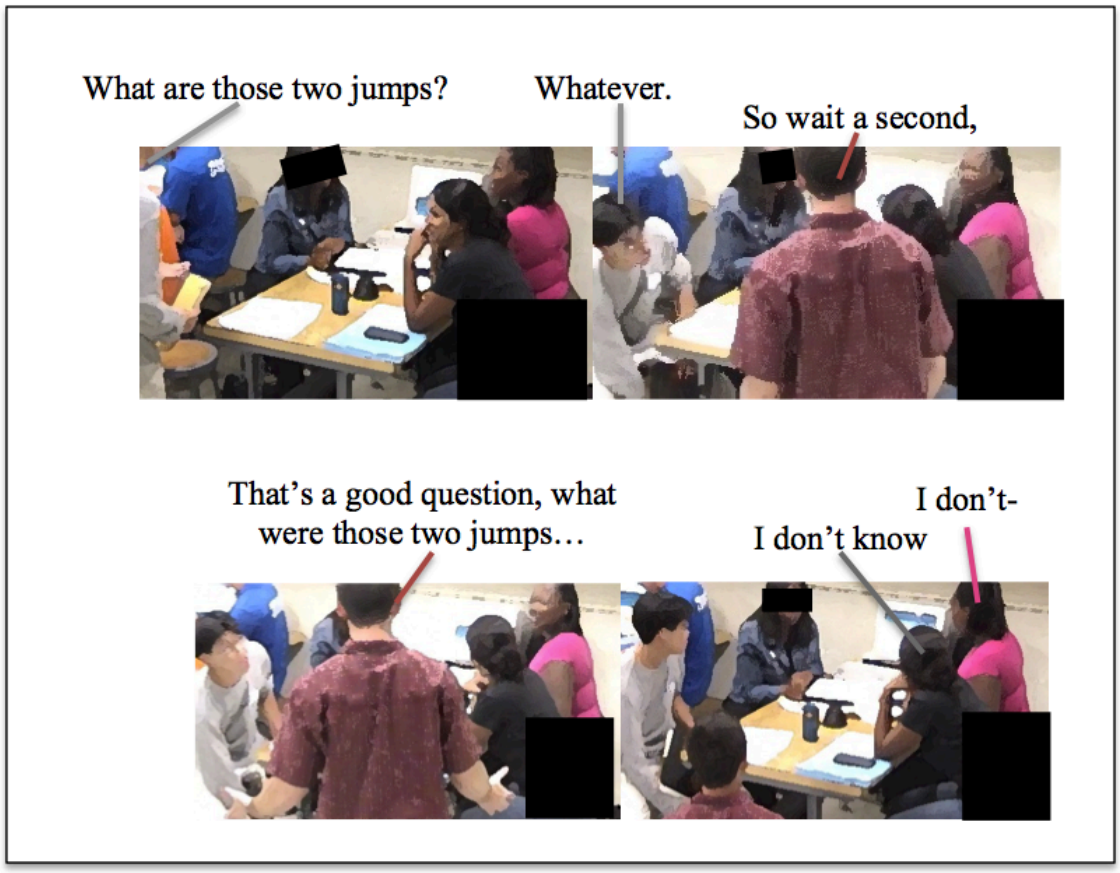

Figure 7. TA Joey overhears the group dismissing a good question and joins in to help the Blue group make sense of the graphs.

When nobody responds, TA Joey kneels down and asks the question again, but in a way that encourages epistemic distancing (Figure 8).

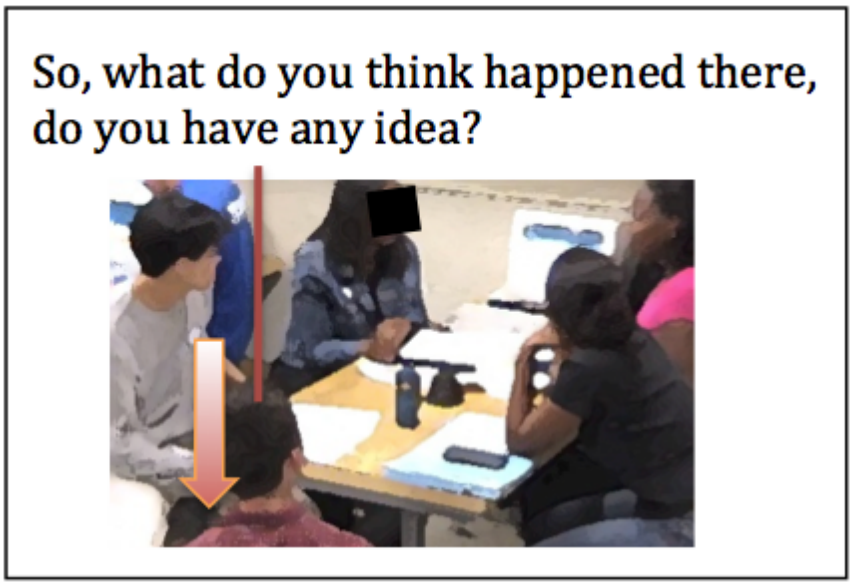

Figure 8. TA Joey encourages epistemic distancing, when he kneels down and asks about what they *think* happened there.

The instructor uses both linguistic and paralinguistic channels in phrasing his question to encourage students' use of epistemic distancing. Instead of asking "What happened there," this time he asks "What do you *think* happened there, *any idea*?" (emphasis added). By asking what they *think* he introduces a hedge that lowers the stakes for contributing ideas they are uncertain about, as does his move to ask if they have *any idea*. His rephrasing of the question invites students to offer ideas even if they do not *know* what happened there. The instructor also introduces a rising intonation to his question, conveying more uncertainty than before. Finally, he kneels down as he asks the question, bringing him from an authoritative "hovering" stance to a position in which he is below the students, looking up at them. All of these subtle moves contribute to creating a space in which the Blue group is willing to share their ideas to explain the jumps in the graph:

TA JOEY: What do you think happened there, do you have any idea?
ALAN: Ahhh...
TA JOEY: Because your- It looks like everyone's prediction was a straight line
DARIA: Right
TA JOEY: Right? And then, it's mostly a straight line *(gestures out the shape of straight line with two hands)*, but, not exactly. So what's-
DARIA: Something wrong must've happened.
ALAN: I dunno. Maybe, this was weird?
DARIA: Hehehe
TA JOEY: Maybe it was weird.
ALAN: Yeah, or
TA JOEY: What do you mean by 'mayb-' "Weird" could mean a lot of things.
DARIA: Maybe it's just getting started up or something.

CHRISSIE: HaHAha!
TA JOEY: It was getting started up, so like if we did it again *(rolling hand motion)*, like now it's warmed up almost
DARIA: Mayyybe
ALAN: Maybe
CHRISSIE: I think we should do a second trial, to see
BRANDI: M'yah, maybe he wasn't walkin' that steady
CHRISSIE: Right. At a steady pace,
DARIA: Oh that could be
TA JOEY: So this is the sort of thing we want you to investigate. You know, like this MOSTly fits with your prediction, but there's some discrepancies, and what are they, can you explain why, or maybe, like you were sayin' "We wanna try it again." Well, inVEStigate those things, don't just say, "Oh, it's exactly what we thought." Because it's NOT, quite.
BRANDI: Right.
ALAN: Okay.
DARIA: Okay.

Here the instructor is engaging the Blue group in a sensemaking discussion about what might be causing the jumps in the graph. The students offer competing suggestions, such as an unsteady walking pace and an inadvertent movement of the book they were using as target for the motion detector. The Blue group is using considerable epistemic distancing as they introduce their ideas, with hedges such as "maybe" and "I think." They are also laughing as the ideas are introduced, hinting that they may be half-joking. Alan suggests, "Maybe it was weird," to which Daria laughs, but the instructor takes his idea seriously and presses him to clarify. Daria offers that "Maybe it's just getting started up or something," to which Chrissie laughs, but the instructor again takes the idea seriously and considers a consequence of the idea "so if we did it again…". Finally, Chrissie declares "I think we should do a second trial, to see" and Brandi offers another reason why a second trial would help ("Maybe he wasn't walkin' that steady").

At this point the instructor comments on their sensemaking discussion in order to make an explicit point about what it is the group should be doing in tutorial (Figure 9).

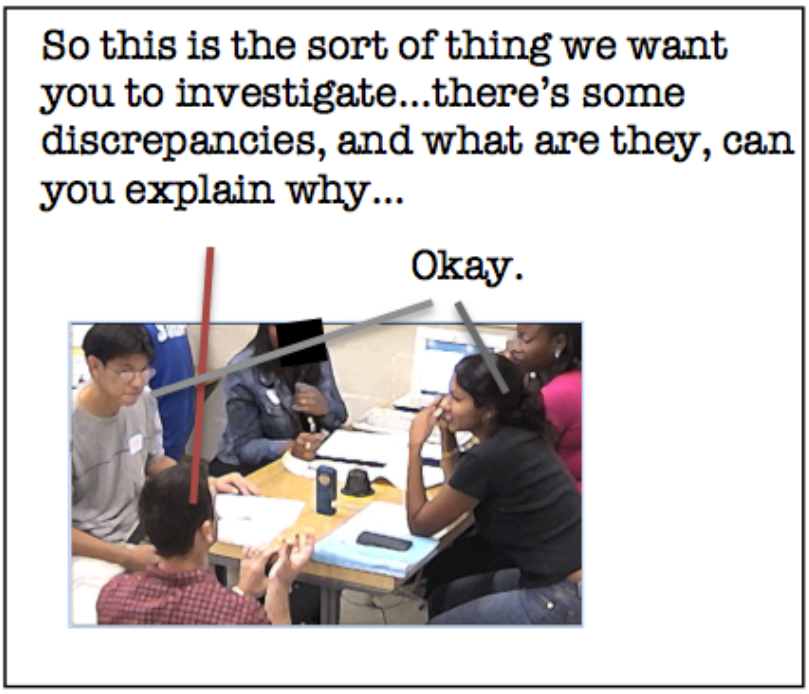

Figure 9. TA Joey uses this sensemaking discussion as an opportunity to repair the Blue group's understanding of what they should be doing in tutorial.

After the instructor leaves, the Blue group does not go back to their dismissive approach to the tutorial. Instead, they continue to sensemake about the causes of the jumps in the graph. First, they follow Chrissie's suggestion and do another trial:

DARIA: D'you wanna try again?
ALAN: You wanna try it again?
CHRISSIE: Yeah
DARIA: Yeah I just wanna try
BRANDI: *(looking at computer screen)* How did...
DARIA: Hold on,
CHRISSIE: You gotta stand in front of it...ready?
ALAN: Yep *(walks slowly away with book in hand)*
DARIA: *(looking at the new graph)* THERE you gooooo!
CHRISSIE: Ahhhh, okay!
BRANDI & DARIA: *(laughing)*
DARIA: Okay it worked out.

After trying it again and finding a straight line with no jumps in it, the Blue group celebrates with smiles and laughter, saying "Okay it worked out." Even though it seems there is resolution and they can move on, the Blue group continues their sensemaking discussion as they try to resolve the discrepancy between the first and second trial:

CHRISSIE: So maybe you weren't walkin' at a steady pace at one point,
ALAN: Probably, I probably like moved the book or something like that
DARIA: Did you? Yeah maybe

ALAN: Yeah.
DARIA: Wait did you do something different the first time?
ALAN: No.
DARIA: Like, while you were walking back?
ALAN: I was- I prob'ly...I donno either=
BRANDI: Sometimes you do things subconsciously
ALAN: =moved the book down or, you know, yeah.
CHRISSIE: So where do you, you write that where? Oh. B.

Even without the TA present, the Blue group is discussing their ideas to make sense of the "jumps" in the graph – they have made a safe space to sensemake. This was facilitated by the instructor, who encouraged students to discuss ideas they are unsure of, in part through epistemic distancing. In Part I, the Blue group had used "too much" epistemic distancing to encourage further discussion, and were about to do so again ("Whatever, next"). In Part II, the TA's initial question ("What happened there?") is using "too little" – they are reluctant to offer ideas beyond saying "I don't know". By rephrasing the question ("What do you *think* happened, *any idea*?") the instructor encouraged the students to use epistemic distancing in a more productive way: to discuss their uncertain ideas, rather than avoiding discussion. The students respond by using epistemic distancing as they offer ideas half-jokingly, and the instructor legitimizes their ideas (Berland & Lee, 2012) by taking them seriously.

Another interpretation is that the instructor's influence was not via his use of epistemic distance but through his use of authority – in effect, he told them to discuss their ideas and they did. It is difficult to square this interpretation with the fact that after the group does not offer ideas upon his initial request, the instructor's subsequent moves were ones that apparently *relinquish* authority. He softens the phrasing of his question ("What happened there" to "What do you *think* happened there"), while physically moving from a hovering stance to kneeling down to below the students' eye level. Only after these moves do students offer ideas, and they do so with epistemic distancing.

Overall, the Blue group illustrates learning that the "jumps" in the graph are entities they should point out and try to understand by discussing their own ideas. The instructor's interaction helps repair the Blue group's tutorial participation. Their subsequent discussion after he leaves provides evidence that the instructor's intervention has a lasting effect on the their understanding of their activity, at least on a short timescale.[5]

The Red group's 1st collaborative sensemaking discussion. Part I demonstrated that the Red group's first discussion contains some of the precursors of collaborative sensemaking.

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[5] In fact, the Blue group continue to sensemaking about their motion graphs, so much so that later in the tutorial they sensemake about bumps in their graphs even when the tutorial worksheet tells them to just "smooth out the bumps."

For instance, Cathy and Devin each describe some of the mechanisms by which talking about your mistakes could help them learn. But Adam's comment, "It's been proven that you learn from your mistakes" seems to shut down the conversation. The Red group's discussions contain little evidence of collaborative sensemaking for the rest of the first tutorial.

It is not until the beginning of the second tutorial that the group has a collaborative sensemaking discussion. Cathy is absent and a new member, Britte, is present, who did not participate in this group's dismissive discussions during the first tutorial. The second tutorial, like the first, asks the students to predict and then create motion graphs, but of *velocity* versus time instead of position versus time. The Red group starts by predicting a velocity vs. time graph for someone walking slowly away from the detector. They are focused silently on their worksheets for several minutes, before Brad suggests they get to the experiment:

BRAD: Should we let it rip?
BRITTE: Are we um, allowed to discuss now?
DEVIN: Yes.
BRITTE: Mmkay...let's see...

Brad suggests they get started with the experiment. Britte, who is new to the group, makes a bid to discuss by using considerable epistemic distancing: "Are we, um allowed to discuss now?" Devin answers in the affirmative, and this prompts them to show each other their graphs and to discuss their predictions:

BRAD: *(holds his tutorial worksheet up, silently, for others to see)*
DEVIN: Wait... *(places her worksheet in the middle of the table)*
BRITTE: *(looks at Devin's worksheet, holds hers up)* I have the opposite of you aheh...Why?
DEVIN: *(looks at Brad's worksheet)* So, I guess my thinking was the um...velocity's gonna increase *(gestures path of cart down the ramp with hand, down & to the right)* AS it's going down?
ADAM: But since it's a constant acceleration wouldn't it be a *(gestures a line up and to the right)*
BRAD: Well, velocity's gonna increase *(gestures straight line up and to the right)* because, it's just FALLing *(repeats gesture up and to the right)*...slower, so things...increase steadily in speed when they fall. And they fall at constant acceleration *(repeats gesture again)*.
ADAM: Constant acceleration but shouldn't the velocity...curve...
BRAD: Yeah so velocity is positive...
ADAM: *(gestures curve with fingers slightly curled)* be a curve as opposed to a straight line *(straightens fingers)*?
DEVIN: Right right.
ADAM: 'Cuz the velocity's going to *(traces a curve in the air that flattens out)*
DEVIN: Level off *(mirrors Adam's gesture)*
BRITTE: You sure it's not the opposite? Why am I thinking it's the opposite?
ADAM: But you don't change your velocity though. 'Cuz accelera- 'cuz

it's constant acceleration, should have a change in velocity.
BRAD: *Should have*, or shouldn't.
ADAM: It *should*.
BRAD: It's constant acceleration, velocity should- yeah it'd just be a straight line.
ADAM: Oh it's a straight line? *(pauses, then nods)*
BRAD: Should we- Should we drop it and try it and see what we got?
ADAM: *(nods again)*

In this discussion, the Red group is collaboratively making sense of a phenomenon. They notice inconsistencies in their predicted graphs and seek to resolve them by reasoning about how the physical motions connect with features of the graph. Britte seems to have drawn a graph that represents the physical path of the cart down the ramp, rather than the increasing values of its velocity; Adam and Brad both think the graph should go up, but disagree on whether it should be a straight line or curved. By the second time Brad suggests they try it out, they have a legitimate controversy to settle. If they had tried it out the first time Brad suggested it, they might never have noticed their disagreement, let alone discussed it.

There is evidence that the Red group's sensemaking here is facilitated in part through the use of epistemic distancing. When Britte challenged Brad's initial move to try it out by suggesting that they discuss their predictions, she did so with considerable epistemic distancing. First, she phrased her request as seeking permission ("Are we, um, allowed to discuss now?"). Her pitch rose significantly by the end of her question, denoting uncertainty (Ward & Hirschberg, 1985). And as she asked her question she pushed her body away from the table, physically distancing herself from the group (Figure 10).

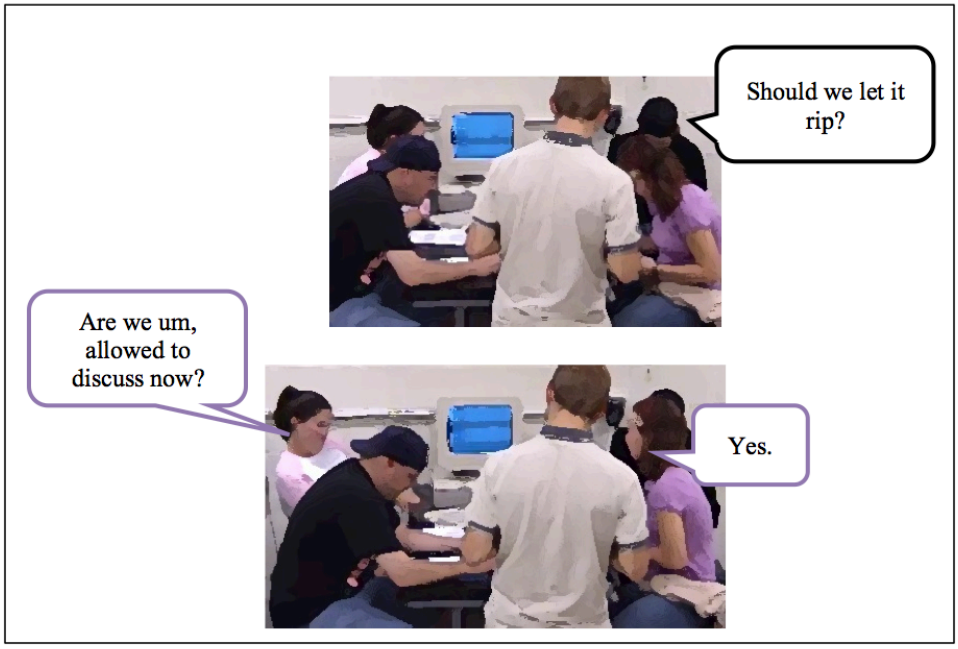

Figure 10. Brad bids to start the experiment, while Britte suggests that they discuss their predictions, with considerable epistemic distancing.

Phrasing her question in this way created an opening for Devin to confirm her request to discuss, after which the group proceeded to discuss their ideas rather than jumping right to the experiment as Brad had suggested. When Britte asked why they have opposite graphs, Devin used epistemic distancing by hedging her idea ("I guess") and explaining what she was thinking ("my thinking was") rather than presenting it as something she *knows*. Adam disagreed with her, but used epistemic distancing by phrasing his disagreement as a question ("but since it's constant acceleration wouldn't it be a") before gesturing a line going up to the right, instead of Devin's line going down. Thus, during the second tutorial of the semester, we have evidence that the group has made a safe space to sensemake, i.e., to share their ideas even if they disagree with others. Once again, the group's establishment of this space to sensemake depended sensitively on the use of epistemic distancing. The Red group continues to have sensemaking discussions throughout the rest of the semester, though not as frequently as the two other groups. The Red group's discussions also tend to be less mechanistic in nature than the other groups', a contrast exemplified in the comparison of the Green Group's and Red group's loop-the-loop discussions in the Introduction.

Summary of Part II – Making space for sensemaking. Part II explored the dynamics leading to each group's first collaborative scientific sensemaking discussion, finding that in each case epistemic distancing played a critical role (Table 4). The Green group made a safe space for sensemaking, at first using epistemic distancing in ways that helped them introduce their own ideas and evaluate them, then seeming to fade out their use of epistemic distancing over time. In contrast, the Blue group initially seemed to be aligning against the goals of the tutorial, until a TA supported their collaborative sensemaking. By incrementally adding epistemic distancing to his questions, the TA encouraged students to use epistemic distancing more productively, i.e., to engage with their uncertain ideas rather than avoid them. Finally, the Red group did not collaboratively sensemake until a student asked a question with enough epistemic distance ("Are we um, allowed to discuss now?") to encourage the group to share and evaluate each other's ideas. In all three groups, epistemic distancing played an important role in the groups' finding a safe space to sensemake.

Table 4

Summary of Each Group's Epistemic Distancing Moves During Their First Collaborative Scientific Sensemaking Discussion.

Tutorial Group	Statements that indicate *increased* epistemic distancing	Statements that indicate *decreased* epistemic distancing	Comments
Green Group	"But you know what? Okay…because a steeper slope would represent…"	"So it'd just be like a steeper slope…And not starting at the origin."	Student starts to challenge with a question, but soften stance to make sense of others' idea
Blue Group	"What do you think happened there, any idea?" "I dunno, maybe this (detector) was weird?"	"It was just getting started up, so like if	Instructor encourages epistemic distance

	"Maybe it's just getting started up or something"	we did it again…"	with his question
Red Group	"Are we, um, allowed to discuss now?"	"Yes." "So velocity's gonna increase…because, it's just FALLing"	New group member challenges norms of the group

Conclusion

In science, there is an essential tension between the generation of new ideas and the critical evaluation of those ideas (T.S. Kuhn, 1977). This tension is present in active engagement science classrooms that focus on learning through authentic scientific practices (Ford, 2008). This paper demonstrates how three student groups in introductory physics tutorials navigate this essential tension in making a safe space to sensemake. They do so, in part, through the use of epistemic distancing – softening their stances through hedging, joking, quoting, and other shifts of footing. One of the possible functions of this distancing is for students to protect themselves from the affective risks of evaluating each other's ideas and having their own ideas critically evaluated. This allows them to have productive scientific discussions in which they contribute and critique their ideas to build a shared understanding of the mechanisms behind phenomena.

We analyzed three tutorial groups' first discussions, and found evidence that epistemic distancing played a critical role in each group's process of making a safe space to sensemake. The Green group was able to make a safe space to sensemake by making fun of their own responses as they shifted from reading what they wrote to saying what they think. Their use of epistemic distancing seemed to fade over time, as they grew more comfortable sharing their ideas and collaboratively evaluating them. The other groups either distanced themselves too much (the Blue group) or too little (the Red group) to share much of their thinking at first. In each case, an outsider challenged the developing norms of the group by using epistemic distancing in a way that encouraged sensemaking. For the Blue group, it was a nearby instructor engaged the group in a discussion, encouraging students' use of epistemic distancing in sharing their uncertain ideas. The Red group started sensemaking when a new member asked the group, "Are we um, allowed to discuss now?"

While all of the groups eventually managed to create safe space to sensemake together, it took some groups longer than others to do so. Part of this variability can be explained by differences in the groups' uses of epistemic distancing. The Green group started off using epistemic distancing in ways that allowed them to discuss their ideas, while maintaining a safe distance (e.g. reading what they wrote, making fun of their own answers). They were collaboratively sensemaking very soon into the first tutorial. The Blue group started off distancing themselves so much ("Whatever…next!") that further discussion was discouraged. They did not sensemake together until near the end of the first tutorial. The Red group's first discussion ceased after a statement with very little distancing ("It's been proven that you learn from your mistakes"). It is not until the second tutorial when they first engage in a collaborative sensemaking discussion.

Despite their critical role in making a safe space to sensemake, epistemic distancing moves do not always lead to sensemaking; more epistemic distancing is not necessarily better. And while we appeal to an intuitive sense of "too much" or "too little" epistemic distancing, this is not to suggest that there is an absolute "right amount". What amounts to a productive use of epistemic distancing depends on the local context, as well as the group's history. Our analysis suggests each group's productive use of epistemic distance may evolve over time. For instance, the Green group's use of epistemic distancing seems to fade once they initially establish a safe space to discuss their ideas. These longer-term dynamics should be pursued in future research.

Implications for Research

This work builds on research into how students in active engagement science classrooms come to understand the epistemological nature of their activity, i.e., their epistemological framing (Berland & Hammer, 2012; Conlin, Gupta, Scherr, & Hammer, 2007; Hammer, Elby, Scherr & Redish, 2005; Redish, 2004; Scherr & Hammer, 2009). Specifically, it demonstrates how groups come to frame their activity as an opportunity to have collaborative scientific sensemaking discussions, despite the effort of exertion or the risk of embarrassment that comes with sharing and evaluating each other's ideas.

While research on learning science through inquiry has demonstrated the importance of argumentation and critique (Berland & Hammer, 2012; Kuhn & Pease, 2008; Osborne, 2010), very little research has attended to the affective dynamics of argumentative discussion. The present work highlights that for these tutorial groups their productive sensemaking is not a matter of purely conceptual or epistemological dynamics of the group: There is a potential affective risk in sharing an idea. An idea can be conceptual (as in Deirdre's idea about the normal force) or epistemological (as in Britte's "Are we, um, allowed to discuss now?"). Either way, the embarrassment of having one's idea rejected –- or the avoidance of that embarrassment—can shut down collaborative sensemaking. So can the risk of embarrassment of taking the tutorial "too seriously" relative to the other group members. The groups in this study use epistemic distancing to navigate these conceptual, epistemological, and affective dynamics all at once. By hedging, joking, or other means of softening their stance, speakers can create a buffer between the person and the idea, so that the idea can be evaluated rather than the person.

Finally, the results presented here demonstrate how the nature of epistemic distancing, and its effect on sensemaking dynamics, depends sensitively on the context. Subtle shifts in emphasis, tone of voice, or body positioning can easily upgrade or downgrade a speaker's epistemic stance. This is to be expected given the theoretical backdrop of framing. Framing, i.e., a person's moment-to-moment sense of 'what is going on' (Goffman, 1974), is in essence a set of shared expectations highly influenced by context (Tannen, 1993).

There may be other contextual factors that influence the use of epistemic distancing and its effect on students' framing. For instance, individuals likely have different perceptions of hedging moves and different preferences for using them - and this may interact with gender and cultural background. Some researchers have argued that women's use of hedging can perpetuate gender stereotypes and problematic power dynamics, and thus should be avoided (e.g. Lakoff,

2004). We did not focus our analysis on how gender might be influencing students' use and perception of epistemic distancing moves, but this is an important question that should be considered in future research. At the very least, we have found evidence that hedging can play a very powerful and productive role in scientific sensemaking discussions, even in mixed gender groups. This pushes against claims of hedging as "weak" language to be avoided.

Implications for Instruction

The context-dependent nature of epistemic distancing and its effect on framing has an important instructional implication: small moves can make a big difference. The data presented above illustrate how a subtle shift in how an instructor words a question, from "What happened there?" to "What do you *think* happened there? Any idea?" can have immediate consequences on students' willingness to share their ideas. So can a subtle shift in how a student proposes to engage in an activity. Deirdre's suggestion for the Green group to start with reading what they wrote rather than jumping right into discuss their ideas may have ultimately made them more willing to discuss their ideas. In some instances, a single epistemic distancing move seemed to be enough to shift a group into their first collaborative sensemaking discussion, as when Britte challenged the group norms by asking, "Are we, um, allowed to discuss now?"

Pedagogical moves that encourage epistemic distancing could prove useful to instructors and curriculum designers looking to support students' collaborative scientific sensemaking. These kinds of moves could easily be adopted by an instructor or even a curriculum developer interested in supporting students' sensemaking[6]. Before moving from observation to prescription, however, we emphasize that more epistemic distancing is not necessarily better. Successful instructional moves like TA Joey's and Deirdre's were constructed on the spot *in response to* the ongoing activity. Such in-the-moment instructional moves require attending and responding to the students' affect, especially their comfort with sharing ideas.

Discussion – Degrees of Belief in Science

To close, we address one essential tension that has gone unmentioned: Is the use of epistemic distancing consistent with doing "good science"? In science, a hypothesis must take risks (Godfrey-Smith, 2003, p. 58). It must "stick its neck out" so that the scientific community can put it to a stringent test, and only accept it once it has "proved its mettle" (Popper, 2005, p. 32). If science favors bold claims, perhaps epistemic distancing should be avoided in science, and therefore in science classrooms. However, such a view becomes untenable when taken to the extreme. In the history of science, ideas that once proved their mettle are later rejected, and once-rejected theories can make a comeback, such as the corpuscular theory of light (Lakatos, 1980). Ideas deemed impossible by accepted theory need to be at least considered in order to make progress, as was the case when Einstein considered what it would be like to ride on a beam

[6] *The Tutorials in Physics Sensemaking* are open source, so instructors may adjust them to meet their particular needs, say, by adding epistemic distancing into the worksheet questions.

of light (Isaacson, 2007). Professional scientists have a varied repertoire of stances towards ideas: not only acceptance or rejection, but also pursuing an idea without necessarily believing in it (Laudan, 1981; Whitt, 1990).

Failure to appropriately manage epistemic distance can pose risks to scientists' careers. When physicists reported the detection of faster-than-light neutrinos at CERN in 2011, they did not boldly claim that they had overthrown the theory of relativity. Instead they noticed the discrepancy with relativity and asked for other teams to attempt a replication (Cho, 2011). Through this process, the cause was found: a mundane case of faulty wiring. Had these scientists made a bolder claim, they would have been risking their credibility. Instead, they understood that the boldness of hypotheses in science should be held in proportion to the strength of supporting evidence and their fit with established theory. The risk-taking faced by students in collaborative scientific sensemaking discussions reflects the risk-taking of cutting-edge science. In both cases, good science involves the management of epistemic distance.

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Appendix A – Transcription Conventions

Transcripts follow a variant of the Jefferson transcription system (Sacks, Schegloff, & Jefferson, 1974, pp. 731-733).

Sign	Description	Example
. , ?	Punctuation indicates pitch variation at the end of utterances, not grammar of sentences.	A: I dunno. Maybe, this was weird? D: Hehehe TA: Maybe it was weird.
Boldface	Indicates emphasis signaled by changes in pitch.	"So just helps you understand the way **you** think of it"
CAPITALS	Indicate increased volume.	"THERE you go!!"
-	A dash denotes a sudden cut-off of speech.	'Cuz accelera- 'cuz it's constant acceleration
…	Ellipses denote a significant pause in speech.	"I guess we should...what did we have to do?"
ssss	Repeated letters denote elongated pronunciation.	Discusss our answerssss
(*actions)*	• *Italics* in parentheses indicate actions, including gestures, which accompany the speech.	*(points to worksheet)*
Contiguous= =talk	An equals sign is used to indicate "latching"; there is no interval between the end of a prior unit and the start of a next piece of talk.	D: the way **you** thought about it= C: I put...if you D: =versus the correct way