ATTENDING TO AFFECT IN STUDENT INQUIRY

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Abstract. This paper explores dynamics of attending and responding to affect as integral to, rather than separate from, attending to the substance of students' ideas. I examine the relationship between *responsiveness to affect* and *the disciplinary substance of student thinking*. The questions I consider are: how does a teacher attend and respond to affect as integral to the substance of student reasoning and ideas in the science class? And how do these acts of attending and responding become consequential to student engagement? Using a case study of a fifth grade teacher's interactions with a student struggling to communicate an idea, I illustrate how the teacher's attention and responsiveness to affect was an act of attending to the student's reasoning and persistence. Moreover, I show how intending for his student to struggle at the intellectual level was an act of caring for him as an intellectual agent. In this way, I show how caring can be connected to and in service of student disciplinary engagement and epistemic agency. More broadly, I highlight the need to examine affect as inherent to the discipline in conversations on responsive teaching and I discuss implications on instruction and teacher education.

Introduction

It was the first day of the water cycle module when a group of fifth graders were grappling to explain what happens to rain water that evaporates from a puddle. Various ideas were brought to the table. However it was not clear how all these ideas cohered and related to each other. At one point, Cody, one of the students, was having a side conversation with other students at his table. He looked frustrated, and made intense facial expressions and emphatic statements with regards to some of the ideas being discussed in class. Noticing these behaviors, Mr. Myers, the teacher, invited Cody to share his thinking with the class. Cody expressed being confused about the connections between the different ideas, and as Mr. Myers asked him to clarify his thinking, Cody became anxious and struggled to communicate his idea which concerned water from the puddle "steaming" and "rising up" causing the puddle's water level to decrease. As Mr. Myers pressed him to clarify his reasoning, Cody became more and more hesitant and showed signs of discomfort and frustration.

What should Mr. Myers do at this point? Should he press for more or should he just move on to another student? On the one hand, it is clear that Cody was in distress and

perhaps, Mr. Myers might be thinking, he could save Cody the trouble and pain of experiencing this intellectually uncomfortable space by simply calling on another student. Mr. Myers might also be wondering if he should give Cody a hint or two to alleviate his discomfort and make him feel better about himself in this moment of struggle. But how about pushing Cody to persist in the struggle and encourage him to work through his frustration to articulate an idea? This way, Mr. Myers might be reasoning, Cody and the whole class might come to see this challenge as part of the work of science, and more specifically in this moment, Cody might get to see himself as a valuable contributor of ideas to the intellectual discourse in class. But would that come at the risk of Cody feeling vulnerable and left to struggle alone in this interaction?

I anticipate that the scenario presented here resonates with many who often find themselves in similar situations in teaching, and might similarly wonder how to manage the tension between our desire to relieve students' frustration while also supporting their engagement in disciplinary practices and the feelings that come along with them. This tension, the literature shows, is widespread among educators. Teachers often report a challenge in being responsive to students' feelings and well-being while at the same time addressing disciplinary learning goals, a challenge that often leads them to compromise one goal over the other.

I first report on these findings from the literature to illustrate how this tension is expressed and manifested in teachers' instructional decisions as they juggle the demands of attending to the cognitive facets of the discipline and to students' emotional needs. Then I make connections to distinct research accounts that stress on one hand the need to attend to students' emotional well-being and, on the other, to the substance of their reasoning and

disciplinary engagement. I posit that by rethinking the role of affect in student engagement in science, we can come to bridge these two expectations by attending and responding to feelings in ways that are grounded in the discipline. For instance, rather than trying to avoid anxiety and intellectual discomfort, we can see these moments as opportunities to encourage students to cope with and appreciate emotional complexity in science. This perspective motivates my orienting questions:

- How can a teacher attend and respond to student affect as integral to disciplinary learning in the science class?
- How do these acts of attending and responding become consequential to student engagement?

I explore these questions more specifically in the context of the scenario presented at the outset of the paper of Mr. Myers' and Cody's interaction, to illustrate how the teacher's attention and responsiveness to Cody's affect was in essence an act of attending to the dynamics of Cody's reasoning and agency in science. This, I argue, motivates attending to affect *as intimately intertwined with, rather than divorced from,* attending to the conceptual and epistemological substance of student thinking. Before I revisit the scenario, I turn to the literature to report on the aforementioned tension in teachers' expectations and instructional practices.

Affect versus substance – A tension in teaching

In their exploratory study interviewing eight experienced teachers on the ways in which they managed emotional events in the classroom, Williams-Johnson, Cross, Hong, Aultman, Osbon, and Schutz (2008) showed that teachers often felt like they had to choose between paying attention and responding to emotions or repressing them, as they juggled to maintain good emotional climate and navigate their daily instruction agendas. On one hand,

teachers who attended to students' emotions seemed to center their pedagogical choices on creating warm and sensitive environments, embracing students' individuality, fostering team spirit and collaboration, and participating in extracurricular activities to display a caring attitude. On the other hand, some teachers chose to limit or suppress emotional transactions as they worried about burdening or sabotaging their learning objectives and/or negatively impacting the learning environment. For instance, one science teacher explained that he "managed to silence his students' expression of emotion by asking them to push the emotions to the side" (p. 1600). Williams-Johnson et al. (2008) pointed that they

> noticed a disconnect between what many of the teachers described as the desire to create a comfortable learning environment, and an unwillingness to discuss an individual student's emotions during instructional time. Although the teachers acknowledged these instances and the emotional impact of building relationships with the individual student, some felt that it was of great importance to continue instruction and asked the student to push the emotions aside and approach the situation at a later time. (p. 1601)

While these findings do not unpack how teachers respond to the different affective needs and emotional states of the students, they underline a tension between attending to affect and attending to learning goals. Looking across a set of studies, we find that this tension plays out differently in elementary and secondary schools.

In secondary classrooms, affect seems to be pushed further to the background: teachers tend to view themselves mostly as responsible for the conceptual and epistemological facets of the discipline they teach rather than as catering to students' emotional needs. Hargreaves (2000) observed that by and large in secondary classrooms, "emotions are normalized or neutralized to make the pedagogical process as smooth and easy as possible" (p. 822). Emotions are addressed only when they seem to intrude or threaten to disturb the order of the classroom. When asked about situations where "positive

emotions like exhilaration and enjoyment" were promoted, teachers in Hargreaves' study mentioned events that "took place outside the core processes of teaching and learning" (p. 823) such as dances, competitions, school-wide awards, ceremonies, or the cafeteria. Hargreaves concluded that for these teachers, "classrooms are seen as arenas where students' emotions are managed and responded to, not as places that can, do or should actively generate particular kinds of student emotion (either positive or negative) in and of themselves" (p. 823).

Elementary classrooms, on the other hand, are primarily seen as spaces that cater to students' emotional growth and well-being, at times at the expense of the conceptual and epistemological learning goals. In his study on pre-service elementary teachers' views on teaching mathematics, Gellert (2000) found that their concern with creating a "safe space" seemed to shift teachers' attention away from student substantive engagement as they attempted to "relieve" (p. 251) students from the anxiety often associated with mathematics. For instance, one teacher stated that "mathematics should be wrapped up in a way that students do not become aware of the fact that mathematics is taught" (p. 259) which indicates, as the author argued, that the teacher conceived mathematics as something frightening to children. Other teachers attempted to make mathematics less "deadly serious and rigorous" (p. 264) by having appealing pictures in the classroom or by using games and competitions to teach math in playful ways. The author argued that in their efforts to protect children from feeling bored, anxious, or frustrated, teachers often felt the need to compromise the disciplinary substance of learning activities: "Instead of confronting the pupils with – sometimes trying – mathematical tasks, they wanted to shelter them from a mathematical shock" (p. 266).

In the context of elementary science teaching, Zembylas' (2005) findings shed light on yet another tension by illustrating how the emotional ecologies at the school level and more specifically conventions, expectations, and policies about "appropriate" (p. 474) discourse impact teachers' attention in the classroom. In his case study of Catherine, an elementary science teacher, the author showed how norms around emotions or what he termed the institutionalized "emotional regime" (p. 474) in the school clashed with the teacher's competing views on students' right to experience and express emotions in and about science. Catherine's tension was of trying to find a fit between her own approach to emotions and the school emotional norms, a tension that often influenced, and at times restrained, the teacher's pedagogical decisions. Catherine, whose case will be revisited later in this paper, saw excitement and frustration as resources to capitalize on as she guided students' scientific explorations. However, she often felt pressured by the school culture to tune down emotional transactions in her classroom. Varelas, Becker, Luster, and Wenzel (2002) voice a related concern that permeates science classrooms with regards to the emotional and epistemological expectations pertaining to disagreeing and arguing over ideas in science. The authors note that such practices often create dilemmas for teachers who struggle to equitably integrate students' preferences, particularly girls, for agreement and integration rather than negotiation and argumentation.

Of particular relevance to this paper is that these findings point to a tension, widespread among educators, between attending and responding to affect on the one hand and to learning goals and disciplinary norms on the other. These two goals are often perceived as in friction, or at best as isolated from each other. In order to envision ways in which these goals might overlap and possibly act as one dynamic in science teaching, it is

important to examine the underlying reasons behind this tension. In particular, it is important to look at how the literature reinforces particular portrayals of teachers as "carers" and of teachers as accountable to student conceptual and epistemological disciplinary learning. I argue that by reconsidering how teachers could care for their students, essentially by orienting to affect within the discipline, we can conceive of ways for bridging these two goals by grounding and connecting caring to the discipline.

Teachers as "carers"

In educational psychology, school counseling, and elementary education research, much emphasis is placed on the importance of teachers' responsibilities to foster a culture of care, warmth, and affection toward children (e.g., Burgess & Carter, 1992; Nias, 1989, 1999; Noddings, 1984). In this sense, teaching entails a commitment to enacting caring attitudes by attending and responding to students' emotional, interpersonal, and cultural needs, with explicit attention to affective transactions in the classroom. Research in this area is often disciplinary-general as the focus is less on the learning within a particular discipline and more on the social and psychological well-being and growth of learners. For instance, Noddings (2005) asserts that as "carers," teachers should be educators first and teachers of particular subject-matters second. Noddings (1984, 2005) articulated her notions of caring relations as centered on being engrossed in students' experiences and responding to their needs to help them expand their worlds. In these ways, caring is an act of responsiveness to students' self-realization as valued members of a community. Noddings' caring theory has been applied to study teaching practices in a variety of contexts, including teacher education programs and pre-service elementary teachers in their field placement experiences (e.g., Cassidy & Bates, 2005; Goldstein & Lake, 2000; Rogers & Webb, 1991, Wentzel, 1997). Findings reveal that an ethics of caring often frames the

nature of interactions in elementary science classes where much of teachers' attention is on creating positive trusting environments that exhibit sensitivity to students' emotional and social needs (e.g., Beck & Kooser, 2004; Nias, 1999; Noddings, 1984; Rogers & Webb, 1991).

In these considerations, caring for students and for their feelings is occurring outside the discipline. Affect in these accounts is primarily addressed as separate from the discipline, reinforcing the tension between attending to affect and to disciplinary goals.

Teachers as accountable for student disciplinary learning

Current efforts in science education have focused on promoting student engagement in the practices and norms of the discipline (e.g., Driver, Newton, & Osborne, 2000; Engle & Conant, 2002; Ford, 2008; Hammer, 2004; Lehrer, 2009; Minstrell & van Zee, 2000; NRC, 2011). This entails creating spaces for students to experience science in ways that are consistent with the discipline, to help them develop a sense of science as about a pursuit of understanding through the generation of questions, refinement of ideas, and formulation of coherent explanatory accounts. Correspondingly, a central aspect of teaching is to carefully attend to - elicit, listen to, and interpret - the substance of student reasoning to identify the merits and disciplinary beginnings in their ideas and to adapt instructional objectives in response to student-generated ideas and questions (Coffey, Hammer, Levin, Grant, 2011; Hammer, 1997; Hammer, Goldberg, & Farguson, 2011; Levin, Hammer, Elby, & Coffey, 2012; Rosebery, Ogonowski, DiSchino, & Warren, 2010). Hammer (1997) elaborately illustrated this process in action in the context of his physics teaching, where his "discovery teaching" developed in response to students' emergent ideas in the classroom. Likewise, Rosebery et al. (2010) describe how Mary, an elementary school teacher, responded to students' language use and meaning-making in ways that enabled her third and fourth

graders to engage ideas related to heat transfer and the particulate nature of matter through a series of planned and unplanned encounters. Engle and Conant (2002) and Chin and Osborne (2010) offer additional evidence of the role of responsive instructional design in opening up spaces for learners to pursue their own lines of inquiry and promote their engagement in disciplinary practices. In these spaces, students get to experience what it means to reason like a scientist; they get to see themselves as creators and critics of knowledge claims (Coffey, et al. 2011; Ford, 2008).

While this body of work provides evidence for the importance of attending and responding to students' ideas and meaning-making efforts, it also shows that research on disciplinary learning primarily centers on conceptual and epistemological dynamics of student reasoning. Less focus is on the affective dynamics that emerge in these inquiry spaces and on how to navigate and respond to them. Some of these affective dynamics pertain to tensions within argumentation, anxiety in formulating new and uncertain ideas, frustration for not having a clear explanation, feistiness and enthusiasm for arguing over ideas, etc. As we have seen in the literature findings at the beginning of the paper, such affectively charged experiences might be perceived as a disruption to the flow of the classroom, or as a threat to safe spaces, especially when teachers themselves do not feel comfortable in these inquiry spaces.

In sum, this brief review outlines two widespread perspectives on the role of teachers: teachers as "carers" and teachers as accountable to disciplinary learning. When it comes to affective issues, the corresponding literatures do not seem to make contact with each other: while the first line of work on teachers as "carers" construes caring as outside the discipline, the second one does not pay enough explicit attention to the role of feelings

and emotions in the doing of science and to how teachers can cater to students' affect in science. I propose that, by reconsidering the role of affect *within* the discipline, we can alleviate the aforementioned pedagogical tension and bridge these two valuable goals of caring for student feelings and for the discipline. In what follows, I present a perspective on *disciplinary affect* that invites attending to feelings and emotions *within* science as inherent to student reasoning and engagement in the discipline.

Affect as integral to the discipline

As reviewed earlier in the paper, research on teacher attention and responsiveness has largely engaged the conceptual and epistemological dimensions of the discipline. While I align with this orientation to disciplinary learning, I argue that a richer understanding of disciplinary engagement involves an appreciation and an awareness of what it means to *feel* like a scientist.

Elsewhere, I elaborate this perspective on *disciplinary affect* (Jaber & Hammer, in preparation) by building on accounts from scientists and learners engaging in science. As we point out, findings from biographical and ethnographic accounts of scientists (e.g., Gruber, 1974; Keller, 1983; Lorimer, 2008), in addition to research work of psychologists and philosophers of science (e.g., Osbeck, Nersessian, Malone, Newsletter, 2011; Thagard, 2008) and work of creativity scholars (e.g., Aldous, 2006, 2007) depict the centrality of affect in scientists' investment in their pursuits and in the creative process of reasoning and problem-solving. Evidence from these accounts point to a variety of ways in which affect plays a role in scientists' work including taking pleasure in phenomena, empathizing with the object of inquiry, developing intuitive feelings for ideas, and experiencing challenges as thrilling. As Varelas et al. (2002) succinctly note, "There is a continuous sense of engagement, intensity, commitment, dedication, disappointment, and satisfaction as

scientists pursue their practice" (p. 582). In brief, these reviews support a synergistic account of affect and cognition and call attention to affect not as "add-on" but as inherent in the intellectual work of science.

Similarly, as they generate questions, negotiate ideas, and examine the fit between theory and data, learners experience various feelings such as *drive to reconcile inconsistencies, frustration at incomplete explanations, tensions within argumentation, curiosity for phenomena, irritation at discrepancies, enjoyment of challenges, etc.* (Jaber & Hammer, under review). These feelings and emotions are populated with substantive meanings and they are often cues about one's reasoning; for instance, they might signal the lack of a coherent explanation or tacitly hint at the presence of a burgeoning idea hence motivating its pursuit. Thus we refer to these feelings as disciplinary; hence the notion of *disciplinary affect* as pertaining to the affective dynamics that one experiences in the doing of science and in reasoning about scientific phenomena, i.e., the feelings and emotions that infuse intellectual scientific pursuits.

Disciplinary affect thus involves feeling like a scientist, and recognizing these feelings as part of the disciplinary experience, as markers of being in a disciplinary space of ideas. Part of learning science, I contend, involves the refinement of affective intuitions and the nurturance of disciplinary drives and motivations as students raise questions, suggest explanations, confirm and verify ideas.

This perspective on *disciplinary affect* motivates careful and explicit attention to feelings and emotions in attending and responding to student thinking. In other words, it implies that *part of attending to the substance of student thinking involves attending to their affect as they engage in inquiry*. To support this claim, I first review some research

initiatives from mathematics and science education that begin to examine teachers' attention to affect as integral to student disciplinary experiences. I then revisit the initial case of the interaction between Mr. Myers and Cody, to illustrate how the teacher's attention to Cody's affect was an act of attending to the substance of his thinking and persistence in the pursuit. This, I argue, entails a more nuanced understanding of disciplinary engagement that involves an appreciation of the inherent role of affect in the scientific pursuit.

Attending and responding to affect as integral to the discipline: some burgeoning efforts

Lately, there is growing interest in science and mathematics education to understand the nature of the interaction between affect and cognition. In this section, I present some work in math and science education that begins to integrate affect in accounts of teacher attention to learning in the classroom. This work, I contend, offers some promising evidence on the importance of attending to affect as an act of attending to student reasoning and engagement in the discipline.

Building on Noddings' (2002) caring relations, Hackenberg (2005, 2010) explored the development of "mathematical caring relations" (or MCRs) as an evolving interaction "that conjoins affective and cognitive realms in the process of aiming for mathematical learning" (p. 237). Hackenberg (2005) explains:

> I conceive of establishing care in mathematical interaction as inseparable from engendering mathematical learning. Mathematics teachers may act as carers in general, but they start to act as mathematical carers when they hold their work of orchestrating mathematical learning for their students together with an orientation to monitor and balance feelings of stimulation and depletion that may accompany student-teacher interactions. (p. 47)

To explore this idea, Hackenberg (2010) provided students with mathematical tasks that either aligned with or challenged students' current levels of understanding. The goal was to

strike the right "balance between depletion and enhancement" (p. 244) of students' "subjective vitality" (Ryan & Frederick, 1999; as cited in Hackenberd, 2010) which refers to the "level of positive energy that a person experiences as available to the self" (p. 236). Grounding her instructional decisions in students' cognitive and affective responses, the teacher made "in-the-moment interpretations" (p. 242) of her interactions with students by responsively monitoring, and using as cues, their mathematical thinking and energetic reactions to the activity.

> If the level of subjective vitality is sufficient, the student's interest in or curiosity about a situation may prolong mathematical activity and open new opportunities for learning. If, over time, subjective vitality is enhanced, even though there may be periods of depletion, the student may feel mathematically cared for. (p. 241)

This work highlights the need to orchestrate affective and cognitive dynamics in teachers' responses as a way for students to feel cared for mathematically. It also implies that student emotions, including their excitement, joy, frustration, etc., can be used as cues about the nature and substance of their engagement.

In science education, recent research studies point to the coupled dynamics in teachers' attention to students' emotions and to disciplinary learning goals, suggesting the importance of caring for students' affect in disciplinary-specific ways (e.g., Milne & Otieno, 2007; Richards, 2013; Olitsky, 2007; Zembylas, 2004). For instance, Zembylas (2004, 2005) conducted an ethnographic study to explore the role of emotions in the teacher's acts and instructional decisions, in the classroom of Catherine, the elementary science teacher whom I introduced earlier in the paper. Zembylas (2005) recounts how "[s]eeing the children being excited about their learning affected Catherine's emotional style as well as her decisions and actions" (p. 478). Catherine "built on how children felt to

endorse and sustain feelings of excitement" (p. 478) and to nurture their curiosity about phenomena, which in turn nurtured similar feelings for her. She explained:

> One of the things that to me is really important is that children get a chance to experience and to feel the world around us. That just seems to be really important to give kids a chance to fool around with it and share how they feel for what they are doing. I encourage them to experience and feel science. (p. 479)

Catherine wished for her students to experience the feelings that come along with exploring natural phenomena and with "messing about" in science (Hawkins, 1965). In addition, Zembylas describes, the teacher saw that reflecting openly on her and her students' feelings in the science class was a way to promote their cognitive and emotional engagement with the world. Analyzing the emotional acts that students performed in Catherine's class and the teacher's reactions to them, Zembylas (2004) shows evidence of the coupled reflexive dynamic between talking science and talking about feelings in science. This dynamic was at the basis of "Catherine's ability to create *affective alliances* with her students and with what was being studied" (2005, p. 479, emphasis in original). This dynamic, in many ways, resonates with Hackenberg's MCRs rendering possible, and perhaps indispensible, the integration of affect and cognition in teacher responsiveness to foster students' disciplinary engagement and meaningful connection with the discipline.

In sum, these burgeoning efforts, though limited and scarce, provide promising evidence in support of an interdependent dynamic of attending to affect and to disciplinary substance and motivate further research in this direction. In an attempt to contribute to these efforts, I now turn to my empirical case study to illustrate dynamics of teacher attention to affect as substantive to, rather than separate from, attending to student thinking. Below, I situate the case within the context of a learning progressions project and I present my methods for data analysis.

Context and analysis methods:

The data is from a three-year project on learning progressions for scientific inquiry that aims to promote practices of "responsive teaching," centered on recognizing, interpreting, and responding to the substance of student thinking. As part of the program, participant teachers implemented responsive teaching "modules" designed to elicit rich student thinking and help learners experience science as a pursuit by focusing on their own lines of inquiry. Throughout the project, we collected videotapes from teachers' classrooms, meetings, interviews, and debriefs. Here, I use qualitative video analysis (Derry, et al., 2010) recruiting tools from discourse and interaction analysis (Jordan & Henderson, 1995) to explore moment-to-moment the teacher-student interaction and to Cody's affect as it relates to conceptual and epistemological dynamics. I adopt a multi-modal approach (Sidnell & Stivers, 2005) to identify affective markers as enacted and expressed within the flow of activity. These include explicit discursive markers as well as paralinguistic markers including prosody, intonation, hedging, body positioning, gestures, and facial expressions. I also draw on data from a stimulated recall interview with Mr. Myers where, after watching the clip, the teacher reflected on his moves in this local episode in light of his broader sense of Cody as a student.

Situating the Episode

The episode I analyze is from the first day of the water cycle module. It begins around thirty-five minutes into the class discussion. At the beginning of class, Mr. Myers posed the following question: "One night it rains. When you arrive at school, you notice that there are puddles in the parking lot. When you go home, the puddles are gone. What happened to the rainwater?" Students grappled with the question, suggesting multiple possibilities, including that water goes into clouds, turns into vapor, and the sun evaporates it.

Students used various examples to illustrate their ideas such as water evaporating from a cup, swimming pool, and sauce drying up and leaving a stain, diverging from the launching question to pursue emergent ideas, other questions, and lines of reasoning. The role of the sun in evaporation and whether water can evaporate in the absence of sunlight became a point of contention. One student, James, provided an example of an instance when he left a glass of water in his kitchen at night and saw that the water level was lower in the morning; this, he claimed, was in support of the idea that water can evaporate in the absence of sun. Dane questioned whether James' dog could have drunk the water, but Dillon challenged this possibility saying that in this case the dog would have dripped and left behind some evidence. Students then discussed stain formation on different surfaces after the water evaporates from various liquids, forming sticky residues.

A salient feature of the discussion was the use of particular terms, such as "sink down" and "rise up," without students being specific about what the terms referred to. For instance, while some students used them to denote the sun rising and setting, others used them to describe water vapor rising, and others to signal that the level of the water in a puddle increases or decreases. These terms were used throughout the conversation across different topics, which created confusion, leading students to press for clarity on the terms' use and meanings as evident for example in this exchange[1]:

1.	Dane:	It has to be sun, because if it's the afternoon, the water will just sink down.
2.	Dillon:	What do you mean by 'sink down'?
3.	Dane:	In the morning, the water rises. Then in the afternoon, it stays there.
4.	Mr. Myers:	(writes something on board) What water, what water stays there?
5.	Dane:	Let's say you're watering your plants. The water will quickly rise up in the morning. Then if you're watering it in the afternoon, it'll stay there, stay in the ground.

[1] Transcript notation: Capitalized words refer to emphasis or stress in the speech; Two open brackets [on different turns refers to overlapping speech; [text] refers to inaudible meanings or words; (text) describes paralinguistic aspects of the interaction.

6. Mr. Myers: Why?
7. Dane: Because the sun's not as strong as it is in the morning.
8. Student: What?
9. Mr. Myers: So Trevor, what do you want to add, and I'll come back to you, don't worry (addressing another student).
10. Trevor: I wanted to ask Dane what he means by 'rises'?
11. Mr. Myers: I did, too, I like that question, great job of coming up with that, what do you mean by 'rise'? That's a great question, Trevor.

While Dane was using the terms "sinking down" and "rising up" to refer to the water level in the garden, other students seemed unclear about what he meant, as evidenced by Dillon's and Trevor's explicit requests for clarification on lines 2 and 10. The teacher acknowledged the importance of this push for clarity on line 11 and further commented that "we need to be sort of in agreement in figuring out the sort of idea behind" these terms. This confusion around use and meaning of terms, and the students' and the teacher's emphasis on clarity, will be relevant to the subsequent interactions between Cody and Mr. Myers.

Prelude- "How are all these things connected?"

In what follows, I summarize an exchange between Mr. Myers and Cody that occurred almost fifteen minutes after the above exchange, as a prelude to the main episode that I focus on later in the paper. Here, to set the ground for what will come next, I briefly recount some of the interaction between Cody and the teacher, including some illustrative transcript excerpts.

Students were offering different ideas and examples related to water evaporation, in particular related to how water evaporates from a liquid leaving behind a stain. In the midst of this classroom discussion, Cody and other students at his table seemed to engage in a side conversation looking around with confused faces and displaying signs of frustration (Fig.1). Cody seemed the most expressive, hitting his hands together to emphasize certain

points he was making. Mr. Myers explicitly directed the classroom's attention to Cody and his tablemates by inviting Cody to share the table's conversation with the rest of the class:

Fig1. Cody, on the right, and his tablemates.

> Mr. Myers: Cody, I'm hearing you guys having a little bit of a conversation. Can you share with us what you guys are thinking about? You've been sitting here real quiet, and I've heard you a couple of times, I've seen a couple of times a facial expression from you (Cody nods). Share with me what it is you've beer thinking about when you hear them talk.

Attending to Cody's facial expressions and emotional displays, Mr. Myers inferred that Cody might have something to contribute and might be struggling to make sense of this conversation. This is supported with evidence from a stimulated recall interview with Mr. Myers who, without any probing on my behalf, volunteered the following:

> *I did see in his face that sort of like- I call it a scrunchy face, and I try to bring that up with all of my students about the fact that "hey scrunchy face is a good thing because if you have scrunchy face I know you're thinking about and you have been listening to what other people were saying so you're trying to, you know, figure out in your own head, what is it that you're hearing happening in the room or what is it that you wanna understand better." So scrunchy face to me is that sort of like "I don't get it" type of a thing or, you know, I- I'm thinking really really, you know deeply about what is it that I wanna understand better.*[2]

Interpreting Cody's emotional expressions as a sign of struggle, Mr. Myers invited Cody to share his thinking in order to make it visible to the rest of the class. Cody responded animatedly with an assertive tone and with pronounced displays of emotions, hitting his hands and frowning (Fig.2):

[2] Interview excerpts are italicized to distinguish them from classroom transcripts.

Cody: Well, I'm kind of confused, like, you know, we were talking about the puddles (hits hands), and then the pool (hits hands), and then the glass of water (hits hands), and then the floor stain (gestures to floor confused (Fig.2)).

Fig2. Mentioning the floor stain.

Mr. Myers: What's confusing?
Keith: How did they get the floor stain?
Students: (Overlapping talk)
Mr. Myers: You tell me.
Cody: I don't know (shrugs), something –
Mr. Myers: I want to hear, I want to hear what Cody has to say.

Cody expressed confusion about the nature and flow of the conversation: he seemed frustrated that the class was not staying on any one topic as indicated by his emphasis as he enumerated the various topics; his frustration might also be related to the fact that he was not following the logic and connectedness between the different ideas.

While Cody originally raised a concern about the lack of coherence in the conversation, Mr. Myers pushed Cody to articulate what specifically was confusing and continued to ask him for an account of how the different ideas could be connected. Mr. Myers revoiced Cody's initial concern in different ways (O'Connor & Michaels, 1993), checking to see if he understood Cody's query ("How are they related I think is what you're asking, right?"), and pushing Cody further to reason for himself about his question:

Mr. Myers: With everything that you've been hearing them talk about (Cody nods), what keeps coming back up in your mind? That connection piece. How are they related I think is what you're asking, right? (Cody nods) How are they related? Do you see a connection? And if so, where do you see it, what sort of thing do you see in how we got to different places?

Being asked, on the spot, to formulate an idea which was not clearly formed for him at that moment, Cody became more and more hesitant and frustrated. Rather than taking up Mr. Myers' persistent invitation to contribute, Cody responded with a brief "Um, I don't really know." As Mr. Myers probed him one more time for additional explanation, Cody began to express a muddled idea concerning the water rising and sinking:

> Cody**:** I think it's, you know, like, the puddle, then, you know how it, like, evaporates? (Moves hands in circular motion) And then, you know, like, the next morning, it comes up higher? (Raises one hand up higher) And then it's like a big pool or something? (shrugs and spreads hands)

However, as Mr. Myers pressed Cody to clarify what he meant by "comes up higher," he became increasingly hesitant and flustered as he attempted to answer. He sent multiple behavioral and discursive cues, including hedging ("I don't remember, maybe" and "I think"), hesitant speech (unsure tone and low voice), contorted facial expressions, bodily movement (shaking his head, hunching over, restless shifts in posture, and avoiding eye contact. etc.), and various overt affective expressions (e.g., "Oh my God!", "I'm confused"). Ultimately, covering his eyes and face with his hand (Fig.3), Cody stopped trying and disengaged.

Fig3. Cody getting frustrated.

Noticing Cody's heightened affect, Mr. Myers, made a move to transition to another student, explicitly praising Cody for his participation:

Mr. Myers: Trevor, I saw your hand go up as soon as I said 'how are all of these things connected?' Cody, you're doing a great job of participating (Cody smiles), paying attention, and giving us some ideas to think about. Keep it up. (Cody nods)

To Mr. Myers' praise, Cody responded positively, looking up and smiling (Fig.4). Reflecting on Cody's emotional display, Mr. Myers explained:

> *I think his anxiety had gotten up to that point where you know he'd been called upon, you know he tried to give an answer and his anxiety was starting to get the better of him […], so I think that he had just, he had reached his saturation point in a sense on how much, how much I can push back and get from him.*

Fig4. Listening to Mr. Myers' praise.

In this interview excerpt and throughout this initial exchange, we have evidence that Mr. Myers was responding to Cody's affect, monitoring Cody's energetic responses to make decisions about the ways in which to respond to Cody and support his struggle. When he saw that Cody reached his saturation point, Mr. Myers moved to another student while praising Cody precisely for his substantive engagement (attending to ideas, sharing his confusion, and contributing to the conversation). He also encouraged Cody to "keep it up" marking as such, for Cody and for other students, the value of his intellectual struggle, and as he noted in the interview, helping Cody to be "a little bit more self confident in participating more in class there." By highlighting disciplinary aspects of Cody's contribution , Mr. Myers' praise was at once an affective repair and an epistemological move to reaffirm a sense of what is valued in this conversation, asserting particular norms and expectations, namely with regards to offering ideas and persisting in the pursuit. While

this exchange might sound less promising in terms of disciplinary progress than what we might have hoped for, we will soon realize that it was indeed a productive tension that seeded what came next.

Cody's episode- “It would be steaming and the water might be sinking down”

Right after Mr. Myers directed the conversation to Trevor, various students complained about the flow of the conversation and questioned the coherence among the different ideas. This lack of coherence was experienced with intense feelings, leading to a heated debate between students about the use of different examples and how they connect to the phenomenon of water evaporation they were trying to explain. Almost five minutes after the exchange above between Cody and Mr. Myers, Cody raised his hand to contribute an idea and Mr. Myers called on him (Fig.5).

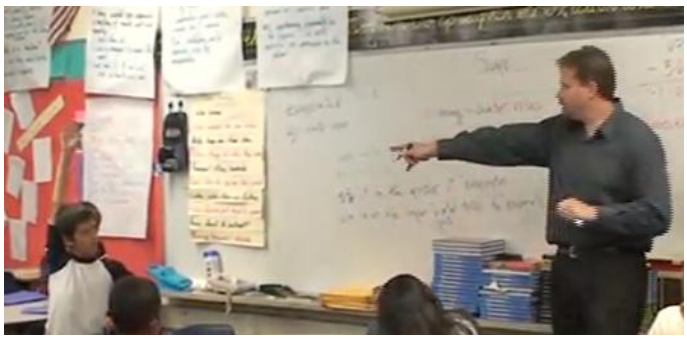


Fig5. Cody raising his hand and Mr. Myers calling on him.

1. Mr. Myers: Cody, did you get some help?
2. Cody: No, but I was thinking, I thought water, the sun, it hits the water. You know how it boils, if it’s 300 degrees, and then the water sinks down. And then it turns, it’s all bubbly and then it sinks down until it completely [inaud] (looking serious and assertive, and making gestures as he explained his thinking (Fig.6)).

"the sun…" "…it hits the water…" "…it's all bubbly…" "…and then it sinks down…"

Fig6. Cody explaining his idea about the water being heated by the sun and sinking down.

Unsure about how to interpret what Cody meant by the water "sinks down," and possibly given the contention that had already developed in class around the use of this term, Mr. Myers asked Cody a few probing questions to clarify the substance of his idea. Walking to the front of the classroom, Mr. Myers offered a few possible interpretations of Cody's idea (lines 3, 5, and 7), asking Cody for verification. Cody responded "No" to each interpretation (lines 4, 6, and 8):

3.	Mr. Myers:	The water sinks down, what do you mean by 'the water sinks down'? The water that I have up here [in reference to the puddle] sinks down?
4.	Cody:	No, but if you have it 300 degrees, you know how it boils? And then you know how it stops boiling, the water sinks down?
5.	Mr. Myers:	So where does the water, so the water sinks here?
6.	Cody:	No, but.
7.	Mr. Myers:	In Zack's stove, the water sinks down? [referring to an idea brought up earlier by Zack]
8.	Cody:	No.

With Mr. Myers' attempts to clarify what Cody meant by "sinks down" proving unsuccessful, Cody tried once again to explain his idea with an example:

9.	Cody:	But I just thought of it, and I've done it once. I just put some water, you know how you put eggs and you boil it, or something like that. But I just put water in it, and then I just turn it on for 300 degrees, and then when it's boiling, I just turn it off. I just watch it sinks down, until it's all used up completely (trails off).
10.	Mr. Myers:	What sinks down?
11.	Cody:	The heat.
12.	Mr. Myers:	The heat sinks down?

13.	Cody:	If it's 300 degrees.
14.	Mr. Myers:	The water stays the same though?
15.	Cody:	No.
16.	Mr. Myers:	What happens?
17.	Cody:	It's gone completely, not completely but just a little bit.
18.	Mr. Myers	So the water, when you say 'sinks down,' I want to make sure that I'm real clear on what you mean by the water 'sinks down.' What do you mean by that?
19.	Cody	Like, um- like- (silence, and gestures in search for words (Fig.7))

In essence, Cody's example concerns boiling water and noticing that the water level becomes lower after water boils. However, Cody had trouble stating his idea clearly and Mr. Myers up to this point did not understand it, but was working closely and patiently with Cody to make sense of his reasoning. Mr. Myers pushed Cody again to clarify what he meant by "sinking down" (lines 10, 12, and 18). Just like in the first exchange, Cody was having difficulties communicating his idea and making it visible to others. However, unlike the first exchange, Cody remained engaged in this prolonged period of unsuccessful communication, without showing signs of anxiety like he had before. Here, we see him more confident and determined, and comfortable in his attempts to articulate his idea, as evidenced by his assertive tone, serious look, and eye-contact with Mr. Myers. But there were indicators that this might change soon: After Mr. Myers asked him one last time "What do you mean by that?" on line 18, Cody was at a loss for words. Not finding the right words, Cody became silent and more fidgety, scratching his ear with his left hand (Fig.7, 1st frame) which he then flung back down, and moving his hands and gesturing as if he were looking for words (Fig.7, 2nd frame). It was at this point that Mr. Myers proposed an alternative medium for Cody to convey what he meant by suggesting that he draw his idea on the Smart Board (line 20, Fig.7, 3rd frame):

"It's like…" "um…like…" "could you draw me a picture of it?"

Fig7. Cody at a loss of words and Mr. Myers inviting him to draw his idea on the board.

20.	Mr. Myers:	Could you draw me a picture of it? (approaching Cody and handing him the Smart Board pen (Fig.7, 3rd frame))
21.	Cody:	I could (taking the pen from Mr. Myers and preparing to walk to the board).
22.	Mr. Myers:	Try it. See if you can draw me a picture of what you mean by 'sinks down'? Remember how to change the page? It's that arrow at the very top? So show me what you mean by 'sinks down'?
23.	Cody:	Here's a cup of water, right? (draws cup of water) This is how much it has. So if something's 300 degrees Fahrenheit, it might boil or something like that or something (draws wiggled lines on top of water). And then the water just sinks down, like right here (draws arrow on outside of cup (Fig.8))
24.	Mr. Myers:	The water, so is the water on the outside?
25.	Cody:	Noooo.

Monitoring closely the level of stimulation and depletion that Cody was experiencing, Mr. Myers noticed Cody's affect shifting, and interpreted the shift as a signal that Cody might withdraw. He thus suggested another venue for Cody to express his thinking. Mr. Myers approached Cody to give him the Smart Board pen. As Cody moved to the board in front of the class, Mr. Myers moved to the back, which symbolically might signal a deferral of authority to Cody as the epistemic authority in that moment. Cody was responsive to this invitation as evident in his response on line 21, and this was Mr. Myers' impression as well who noted later in the interview:

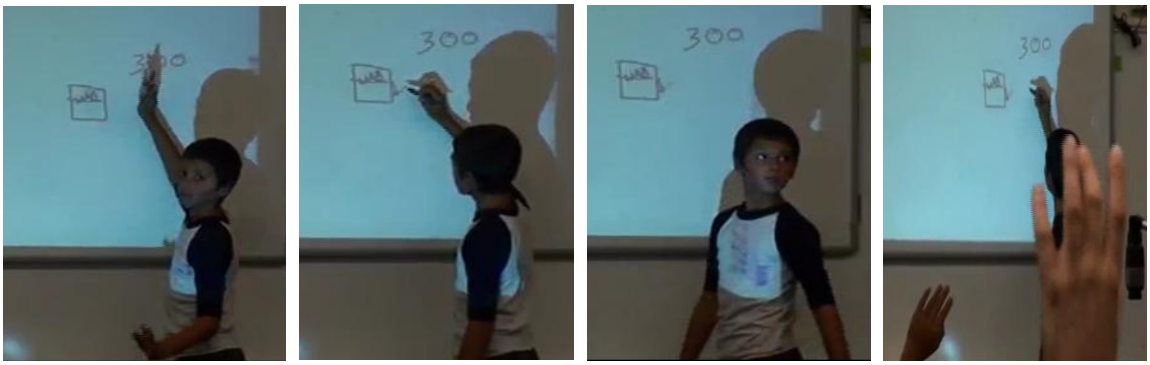
> *It didn't seem as though he had as much anxiety about drawing it as he's had in other times, um, so but you know having him come forward to do that I thin- um, was was something he wanted to do [...] he did seem like he was more interested in doing it.*

One might wonder whether Mr. Myers' focus on the meaning of the word "sink down" reflects merely his concern with correct terminology rather than his attention to Cody's sense-making. I argue that here, Mr. Myers' focus on the clarity of terms is in fact connected to and in service of Cody's reasoning and engagement in scientific practices: On the one hand, part of Cody's challenge in this instance is to articulate a clear idea and make it visible to others. This is an essential, and often a challenging part of scientific reasoning and argumentation. Students therefore need opportunities to grapple with this difficulty as part of their training to participate in scientific discourse and the co-construction of knowledge. On the other hand, when we examine this interaction as situated within a history of events and a larger web of meanings, we realize, as I have shown earlier with examples from Dillon and Trevor, that the meaning and use of words including "sink down" became a point of contention in this class. Meanings were not "taken-as-shared" (Yackel & Cobb, 1996) and were contested by the students themselves. Thus following along with students' press for clarity was an act of responsiveness on the part of Mr. Myers to support students' sense-making and engagement.

This point concerning word use and scientific reasoning calls to mind the muddled and reflexive interplay between symbols (e.g., words, notations, drawing) and meaning-making efforts (Sfard, 2000). Cody is navigating a "semantic space" (Sfard, 2000) in which he is using the term "sink down" and creating shifting meanings for it at the same time that he is using it. By pressing him on what exactly he means, Mr. Myers is encouraging these shifts and helping Cody gain greater clarity in his reasoning and argument.

Going back to our case, when Cody reached the board, he started drawing a cup of water, and added a wiggled line to show that the water is boiling, and an arrow on the

outside of the cup pointing down to indicate that the water is "sinking down" (line 23, Fig.8, 2nd frame). When done, Cody twisted around to look at Mr. Myers (Fig.8, 3rd frame), who asked him if the water was on the outside of the cup (line 24) possibly in reference to a previous discussion on condensation. Cody responded with a strongly pronounced "Noooo" which conveyed a sense of his exasperation for being misinterpreted by Mr. Myers and being unable to make his thinking visible to him. But, instead of giving up, Cody tried again- he turned to the board and immediately started a new drawing (Fig.8, 4th frame). At this point, the other students started raising their hands.



"it might boil…" "sinks down, like right here…" "So is the water on the outside?" "Noooo."

Fig8. Cody's first attempt to explain his idea with a drawing.

A visiting administrator who was not part of the research project interjected in what looked like an attempt to help Cody in this moment of struggle. She asked Cody "what happens when you boil water in a teapot, what do you see coming out of the spout?" When Cody and others answered that "it will be steaming," she continued: "so where does the steam go?" At this point, Mr. Myers approached the administrator in a side conversation (off camera):

Mr. Myers:	No you're giving him too much. Let him- let him work
Administrator:	But I, [OK, and I want him to-
Mr. Myers:	[I know I know and you gotta-
Administrator:	[But now-
Mr. Myers:	(Louder assertive tone) You gotta let him- you've got to let him work.
Administrator:	(Addressing Cody) Now, what's gonna happen?

Noticing signs of discomfort and struggle from Cody, the administrator most likely felt the need to shelter Cody from any disturbing feelings, and thus felt compelled to offer her guidance as a way to remove Cody from this space of discomfort. Conversely, Mr. Myers did not seem overwhelmed by the signs of negative affect; and rather than shying away from this challenging moment that both Cody and himself were experiencing, he acted to protect the space of Cody's agency and his right to experience the intellectual struggle to work out his ideas. In interrupting the administrator, Mr. Myers took up a strong, assertive position as evident by his use of imperative form ("let him work", "you gotta let him") and the assertive tone of voice that became louder as the exchange unfolded. The oppositional and strongly pronounced stances (as implied by the use of "no", "but") reflect the intensity of the moves that Mr. Myers made to protect Cody's right to formulate and express ideas. Mr. Myers was caring for Cody as a disciplinary agent, and caring for Cody's experience in the process and what it entails affectively in terms of encountering intellectual discomfort and building resilience.

Following the administrator's move, Mr. Myers shifted the conversation to Cody and asked him one more time to explain what he meant by "sinking down," in reference to the arrow that Cody drew on the outside of the cup.

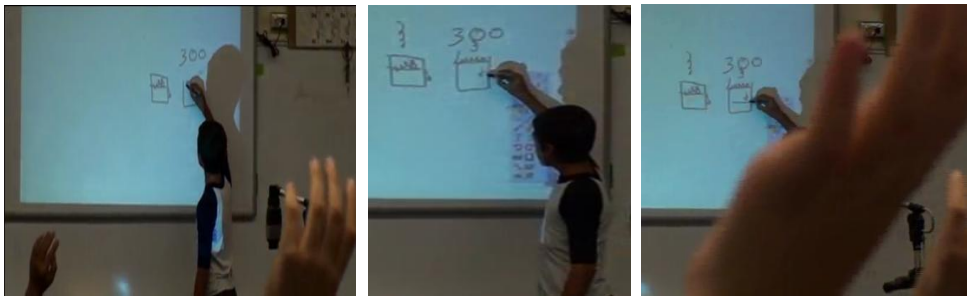
26.	Mr. Myers:	(Addressing Cody) I'm curious what you meant by 'sinking down,' that's really where I want to get to is. Can you explain for me what you mean by 'sinking down'? Because your arrow is on the outside of-
27.	Cody:	Yeah I know.
28.	Mr. Myers:	What was that again? [The cup?
29.	Cody:	[A cup. Yeah
30.	Mr. Myers:	So is the water on the outside of the cup?
31.	Cody:	No.
32.	Mr. Myers:	Okay, so explain.
33.	Cody:	Alright. If it's right here (pointing to the water level in his second drawing), and then if it's 300 degrees, it might be boiling right here (adding bubbles to his drawing (Fig.9)). And then it would

be steaming (drawing an upward wiggled line in reference to the steam going up), and after.

34. Mr. Myers: Give him a chance (here/Sarah?)

35. Cody: After 20 or half an hour, the water might be sinking down right here, and it will be right here (draws same arrow but inside the cup this time, pointing to a new water level lower down (Fig.9))

36. Mr. Myers: OOHH, oh, oh oh oh okay, wait wait wait wait. Dane, pay attention, because I want to make sure that I and- that everybody here understands. Could somebody tell me, Addison, could you tell me what he means by 'sinking down,' do you understand his word for sinking down?



"it might be boiling…" "the water might be sinking down…" "…and it will be right here"

Fig9. Cody's second attempt at the Smart Board.

On line 32, Mr. Myers made a strong move to support Cody's persistence in articulating his reasoning by directly requesting him to explain his idea ("Okay, so explain."). This move is different from the other moves Mr. Myers had made up to this point where he was either asking probing questions or revoicing what he took Cody to be saying. By asking him very directly to explain, Mr. Myers was encouraging Cody to persist and not to shy away and give into his exasperation. In response to Mr. Myers' probing, Cody completed his second diagram, this time drawing an arrow inside the cup pointing downward to a new lower level of water. As such, Cody made an adjustment to his previous representation (where the arrow was on the outside of the cup) which had been misinterpreted by Mr. Myers and possibly by other students as well. As Cody was explaining his diagram on line 33, some students tried to help him out. Mr. Myers

immediately interrupted them by asking them to "give [Cody] a chance" (line 34). In the end, Cody succeeded to explain what he meant by the water "sinks down," showing the lowered level of water and explaining that the water first boils and then it "would be steaming" (line 33) as represented by his wiggled line showing the steam rising up. The idea finally became clear to Mr. Myers who excitedly exclaimed "OOHH! Oh oh oh oh okay!" (line 36), in what looked like a brief celebratory moment.

Mr. Myers did not simply stop at this, but he additionally asked students to attend closely to what Cody meant (line 36), signaling as such the epistemic worth and value of Cody's ideas. By inviting Addison and other students to revoice the idea behind Cody's "word for sinking down," the teacher positioned Cody's idea in a public space for other students to interact with it. Students became interested in Cody's argument and asked him questions about it. The conversation continued in generative ways as students summarized and rephrased Cody's idea, and expanded on it by asking new questions and suggesting hypothetical scenarios (for instance wondering what would happen to the water level if the cup were covered with a lid or if it were placed in the microwave, and wondering whether the water level of a swimming pool decreases like that of the cup).

To sum up this episode, Cody raised his hand enthusiastically to offer an idea –that water "rises up" in the form of steam making the water level "sink down," offering as such a plausible account to understand what happened to the puddle (namely that the puddle disappearing is similar to the water disappearing when it boils). Cody struggled to communicate his idea, and after various unsuccessful attempts, he was at a loss for words. Mr. Myers, rather than being troubled by Cody's struggle, encouraged and pressed him to pursue his reasoning. He also invited him to draw his idea on the board. Using his diagram,

Cody eventually succeeded to explain his reasoning. Despite the various challenges, Cody persisted and was able to go through a prolonged period of challenges without becoming overly frustrated.

In what ways were Mr. Myers' attention and responsiveness to Cody's affect part of his attention to Cody's thinking?

Mr. Myers provided Cody with an extended period of time to formulate his idea and share his reasoning (a total of four minutes in the main episode), implicitly communicating to Cody and to his classmates that he values their ideas and agency, and that articulating an idea clearly and coherently takes time and effort. One could argue that Mr. Myers could have guessed Cody's idea as referring to water evaporating causing the water level to decrease; thus he could have easily saved precious instructional time and also could have relieved Cody from the discomfort and frustration he experienced as he was trying to articulate his thinking. However, he chose not to. And part of that, I argue, indicates his attention to and care for students as disciplinary agents who can actively participate in the pursuit of understanding and the refinement of ideas. Inherent to that attention and care were Mr. Myers' attention and responsiveness to what that pursuit affectively entails; that is, lingering in the space of uncertainty and working through confusion and frustration.

Throughout the exchange Mr. Myers was dynamically attending to Cody's energetic responses as cues about Cody's thinking, and he was reflexively making adjustments as to how he was engaging Cody and supporting his struggle. Mr. Myers as such acted to help Cody persist in formulating an idea and articulating it clearly, a challenge that can be painful and frustrating but is important for students to experience in their science learning. Expressing an idea clearly serves on one hand to communicate one's reasoning to others and on the other to make the idea more accessible and better identified

to the thinking person himself. Intending for students to struggle at the intellectual level does not mean however that Mr. Myers does not care for how students feel; on the contrary, it means that the ways in which he cares for students' feelings is connected to and in service of their engagement with the discipline and their sense of self as capable thinkers and creators of ideas in science. In these ways, Mr. Myers' attention and responsiveness to affect was integral to his attending to students' engagement and reasoning within the discipline.

Additionally, Mr. Myers was very protective of Cody's agency and did not want to take away from him the pleasure of coming up with an idea (Duckworth, 2006) and making it accessible to others. Thus, Mr. Myers gave Cody the necessary resources including ample time, tools, and physical space (Engle & Conant, 2002) to support his expression of ideas. Mr. Myers also made sure that other members (students and visiting administrator) did not take away Cody's right to experience himself as the owner of an idea. And part of protecting Cody's epistemic agency involved helping Cody experience and build up tolerance for what that agency involves affectively. By embracing Cody's frustration and making responsive moves to validate it and leverage it in productive ways, Mr. Myers' attention to affect was in support of Cody's agency and persistence in the pursuit.

In sum, I argue that Mr. Myers' dynamic attention to affect was part and parcel of his attention to Cody's thinking and served to support Cody's engagement and persistence: Mr. Myers understood Cody's affect as integral to his disciplinary engagement. By validating Cody's struggle as constructive, by allowing him to openly express how he felt, and by sitting alongside with him in his intellectual discomfort, Mr. Myers was caring for Cody in disciplinary ways. Despite the various signals that Cody sent communicating his

discomfort, Mr. Myers did not compromise the substance of the inquiry as he cared for Cody as an intellectual member with important ideas to contribute to class. On the one hand, Mr. Myers supported Cody's participation by making space for his ideas; on the other hand, Mr. Myers attended to Cody's meta-affect (deBellis & Goldin, 2006), including his awareness and regulation of feelings and emotions, such as working through frustration, capitalizing confusion as a sign of a burgeoning idea, and directing anxiety toward a productive perseverance in the pursuit. In these ways, Mr. Myers' attention and responsiveness to Cody's affect was entwined with his attention to the conceptual and epistemological aspects of Cody's experiences in science.

Conclusions and Implications

This paper argues for attending to students' affect as integral to attending to the dynamics of their reasoning in science. I set out to explore how this took place in the context of a teacher-student interaction in a fifth grade science class, and to examine how the teacher's acts of attending and responding to affect became consequential to student engagement. The empirical findings discussed in this paper illustrate how Mr. Myers' attention to Cody's feelings, rather than taking away from his focus on ideas, was grounded in his attention to Cody's thinking and engagement. Allowing room for Cody to experience and express his feelings and emotions within the intellectual challenge was consequential to Cody's participation, persistence, and agency**.** Therefore, the findings demonstrate how caring for and attending to the affect inherent in students' scientific pursuits can be connected to and in service of their disciplinary learning. It thus challenges the false dichotomy that positions teachers either as "carers" or as "accountable to disciplinary learning," promising a potentially novel approach to integrating literatures on caring and disciplinary engagement.

This perspective on attending to affect *as integral to* the discipline invites questions for teachers and teacher educators: how can we promote practices of attending and responding to affect as central to, rather than separate from, attending to student thinking? How could teachers' natural attunement to affect be leveraged to promote disciplinary feelings and emotions in science? In what ways can teachers elicit, respond to, and cultivate disciplinary motivations in the doing of science? These questions have implications for instruction and for teacher training programs.

Implications for instruction

In terms of instruction, I am suggesting that part of interpreting, recognizing, and cultivating the beginnings of science in children's thinking involves attention to their affect. Students' questions are often the result of their wonderment and curiosity; their efforts to seek coherence are often driven by their annoyance at an inconsistency and the anticipated pleasure of resolving a puzzle. Moreover, when students show interest in a question, approach a novel situation, or offer new ideas at odds with the classroom consensus, they might experience and express discomfort, uncertainty, eagerness, etc. These affective displays are not merely a reflection of engagement; they are often evidence of substantive disciplinary work, and both teachers and students need to care about and recognize them as such.

Moreover, affect should be recognized as part of what students need to learn in science. This suggests an area of meta-affective learning (deBellis & Goldin, 2006) that involves an awareness and regulation of feelings and emotions that are associated with doing science. To take up science as a pursuit, students need to develop disciplinary dispositions (Gresalfi, 2009; Lehrer, 2009) such as tolerance for disagreement, acceptance of uncertainty, inclination to seek criticism, appreciation of the tentative nature of

knowledge, a drive to work through challenges, etc. Such epistemic open-mindedness requires the navigation of the emotional complexity it entails. By encouraging students to linger in inquiry, and by helping them recognize, reflect on, and manage their feelings as part of doing science, teachers create spaces for students to come in contact with the affective experiences that permeate scientific pursuits. In these spaces, students learn to associate intellectual challenges with thrill and pleasure, and to perceive "being stuck" with a sense of motivation and perseverance.

However, as I have demonstrated at the outset of the paper, teachers, particularly at the elementary level, are very "concerned to fend off and manage negative emotion that threatens" (Hargreaves, 2000, p. 823) students' comfort and safe spaces in the classroom. As we saw in this data (with the administrator stepping in to ease Cody's discomfort), educators might be inclined to shelter students from struggles and frustration to protect their feelings, especially when they themselves are unfamiliar and uncomfortable with the emotional experiences associated with inquiry. They might feel the weight of what Swadner (1992) termed "the hegemony of nice" (as cited by Goldstein & Lake, 2000, p. 861) to fit popular expectations of elementary classrooms as warm spaces devoid of negative feelings. This raises important implications for teacher education as I discuss next, especially that affect is often understated or relegated to a minor status in teacher training programs (William-Johnson et al., 2008; Zembylas, 2007).

Implications for teacher education

I propose at least two ways in which affect could be more substantively integrated in teacher education and professional development (PD). First, teachers should be supported to experience for themselves the feelings and emotions that come up in the doing of science. This could happen in PD spaces that provide a structure for teachers to

experience science as a pursuit, where they can grapple with ideas and questions and reflect on the feelings and emotions that come up in these spaces. This way, teachers can develop for themselves a taste for what it means to feel in science. They become more familiar and comfortable with the affective and epistemological dimensions of inquiry, including the encounter of negative affect such as frustration, confusion, and tensions. By experiencing disciplinary feelings themselves, and by explicitly reflecting on them, teachers can come to appreciate and recognize their students' feelings as inextricably linked to the substance of their thinking. This point raises an interesting issue, however, concerning the alignment, or lack thereof, between teachers' and students' interests and their affective reactions with respect to a situation or a question. This calls for teachers to develop nuanced ways of attending to their own affect in addition to that of their students as they attempt to navigate and synchronize affective dynamics in the classroom to converge around a common pursuit and to gauge how and when to move from one interest to another.

Second, teacher education programs should help teachers navigate the emotional complexity of inquiry in the classroom. Teachers face tensions in making moment-to-moment decisions as they respond to affect, such as for example pressing students to persist without intimidating or shutting them down. They also face tensions when a single idea provokes opposite affective states among students in one same classroom. One way to help teachers navigate these tensions could be by engaging in collaborative discussions and reflections on artifacts of practice such as classroom videos of affectively challenging moments. For instance, teachers and PD staff could watch exchanges such as that between Mr. Myers and Cody and reflect on possible teaching moves to leverage Cody's and other

students' affect in productive ways and help students recognize the disciplinary meanings in their emotions.

Another aspect to consider as we attend and respond to affect in the classroom are personal and cultural differences in how feelings and emotions are experienced, perceived, and expressed (e.g., Briggs, 1970; Goetz, Spencer-Rodge & Peng, 2008; Shweder, Haidt, Horton, & Joseph, 2008). For instance, while some cultures normalize heightened displays of emotionality, others underscore being reserved in expressing affect. Moreover, beyond cultural attributions, individual differences play a central role in how people might engage and experience issues of affect. Even within the same household, while one person might feel stimulated by feisty and vibrant discussions, another person could be intimidated and overwhelmed in these spaces and might conversely be more prone to engage in calm and ordered settings. Such variability in how people experience and express feelings and emotions highlights the importance of teachers' awareness and sensitivity regarding nuances in affective dynamics and in the diverse emotional symbols and lexicons in the classroom.

Teaching responsively entails developing facility at orchestrating, harmonizing, and coordinating attention across various aspects of classroom dynamics at any moment in time. Teachers are constantly making in-the-moment instructional decisions and adjustments to create spaces that are conducive to generative engagement and student agency. This is complex and hard work. I do not mean to pile another layer of complexity by arguing for the need to attend to affect; I am rather pointing out that affect is inherent to those dynamics of attention and responsiveness. I am proposing to ground our attention to affect *within* the discipline; as central to rather than separate from attending to the substance of

student thinking. Increased attention to affective issues, Gresalfi (2009) warns us, can defeat its own purpose if misunderstood as a separate conversation from other aspects of disciplinary engagement. I agree, and I further caution against a view of affect as just one more item on the list of teachers' attention. Affect, I emphasize, is substantive to students' experiences in science, thus integral to the disciplinary learning goals that teachers must explicitly attend to and plan for.

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