Exploring how novice teachers learn to attend to students' thinking in analyzing case studies of classroom teaching and learning

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Abstract: In this paper, we explore how candidates in a science teacher preparation cohort attend to the substance of student thinking while watching classroom videos or reviewing students' written work. Our findings suggest that the teacher candidates are able to attend to specific student ideas and reasoning from the beginning of their pre-service preparation, but their practices of attending become more sophisticated over time. We also consider participation dynamics within the cohort, as participants assume different roles and begin to regulate their discussions.

Introduction

The National Research Council (NRC) (2007) characterizes students' science learning in terms of knowledge and use of conceptual content, reasoning abilities, epistemological understandings, and participation in scientific practices. In line with the NRC's conceptualization of science education reform, it is suggested that "proximal formative assessment" (Erickson, 2007), as it refers to teachers' ongoing, everyday attention to the substance of students' ideas, plays an important role in shaping teachers' instructional moves and supporting students' science learning across these strands (Atkin & Coffey, 2003). We believe that an important focus for science teacher education is thus to help novice science teachers learn to attend to the substance of student thinking, interpreting the meaning students are trying to convey.

This paper is our effort to document what happens in our science pedagogy program, which takes as a specific aim the development of teacher candidates' practices of attending to the substance of student thinking while examining records of classroom practice. We report results from the first two semesters in the science pedagogy course sequence, focusing our inquiry on three questions:

- What do our teacher candidates attend to when discussing records of classroom practice?
- How do our candidates attend to student thinking?
- How do practices of attending to student thinking develop over time within the cohort?

What teachers notice in records of classroom practice

We refer to practices of "attending" to student thinking, but our work is similar to a body of literature primarily in mathematics education that uses the term "noticing." The noticing literature is explicitly focused on the substance of student thinking, responding to reform documents in both mathematics and science education (NCTM, 2000; NRC, 2007) that call for teachers to "base their instruction on the lesson as it unfolds in the classroom, paying particular attention to the ideas that their students raise" (van Es & Sherin, 2008, p. 244). Several scholars (Hammer & Schifter, 2001; Jacobs, et al., 2007) argue that professional development and teacher education aimed at focusing teachers' attention on the substance of student thinking is crucial for teacher learning; it is assumed that helping teachers notice students' ideas when exploring records of practice like classroom videos (e.g., van Es & Sherin, 2008) and samples of student work (e.g. Kazemi & Franke, 2004) will amplify teachers' tendencies to do so in their own classrooms. For the purposes of this paper, we are focusing on the teacher education setting, but we take up the issue of connections between teacher education and teachers' classroom practices in our discussion.

Little research has been conducted on pre-service teachers' practices of attending to student thinking, but Carter et al. (1988) suggest that novice teachers' abilities to notice student thinking are poorer than experienced teachers' abilities. Theoretically, lacking any experience in classrooms, new teachers have more difficulty hearing and interpreting student ideas in the classroom than experienced teachers do. However, in a more recent study in a pre-service secondary mathematics teacher education course, Star and Strickland (2008) found that teacher candidates generally did not enter the course with well-developed observation skills, but the course led to significant increases in these skills, particularly novice teachers' abilities to notice features of the classroom, mathematical content, and student thinking. Sherin and van Es (2005) have also shown that pre-service teachers can learn to attend to student thinking fairly quickly. Our current study contributes to the noticing literature and literature on pre-service teacher education by exploring what happens in a pre-service science teacher pedagogy course sequence focused on attending to the substance of student thinking.

A framework for learning to attend to the substance of student thinking

Drawing on the noticing literature, and based on our iterative coding for this project (see the section on data analysis below), we describe in this section what we take as evidence of attending to the substance of student thinking. We also draw from other genres of literature, including physics education (diSessa, 1993; Hammer, Elby, Scherr, & Redish, 2005), cognitive science (Minsky, 1985), sociolinguistics (Goffman, 1974; Tannen, 1993), and anthropology (Lave & Wenger, 1991) to understand what it means to learn to attend to the substance of student thinking.

Attending to the substance of student thinking

Three aspects of attending to student thinking are prevalent in the noticing literature; we have identified these aspects in this study as well, and we consider them to provide varying degrees of evidence of attending to student thinking. These three aspects include identifying students' ideas and reasoning, interpreting the meaning students are trying to convey, and evaluating the ideas and reasoning inferred from students.

Goodwin (1994) describes "highlighting" or identifying ideas as an important part of what practitioners in a field do. Identifying important ideas helps to "divide a domain of scrutiny in a figure and ground, so that events relevant to the activity of the moment stand out" (Goodwin, p. 610). We consider identifying important ideas to be a necessary precursor to attending to the substance of those ideas.

Once teachers identify important student ideas, Crespo (2000) distinguishes between teachers' comments that are evaluative and focused on correctness and those that are interpretive and focused on understanding. We believe that van Es and Sherin's (2008) definition of interpreting is closest to the meaning that we ascribe to the term. As van Es and Sherin state, "… we want to emphasize the importance of interpreting classroom events. Thus, how individuals reason about what they notice is as important as the particular events they notice" (p. 247). We speak of attending to the substance of student thinking in this strict sense – interpreting the meaning students are trying to convey, without simply evaluating the ideas. Thus, we take interpretive statements to be the best evidence that a teacher is attending to the substance of student thinking. Furthermore, we believe that interpretive statements are the most productive in professional development contexts or teacher education courses – when teachers identify and interpret specific student ideas in collaboration with others, they have the opportunity to argue about their interpretations of the ideas, which leads to better-warranted evaluations and proposed instructional responses.

It is important to note that we view these aspects of attending to student thinking as analytical tools that help us make sense of how candidates are attending to students' ideas and reasoning. We are not making claims that these are separate cognitive processes within teachers' minds. Our purpose in describing these components is simply to examine those aspects of attending to student thinking that the candidates make explicit.

Learning to attend to the substance of student thinking

Our perspective for understanding how teachers learn to attend to the substance of student thinking draws from research on learning in physics. Hammer (2000) argues that students do not draw on nascent fully formed theories to reason in physics but rather that students employ small-grained, context-sensitive *resources* to do so. Hammer's framework builds on diSessa's (1993) description of phenomenological primitives or "p-prims," which are conceptual resources, based on learners' experiences with physical phenomena, which can be useful for learning physics. Hammer et al. (2005) have expanded the idea of resources to include fine-grained bits of declarative and procedural knowledge, metacognition, epistemology, and understandings of social norms that are derived from people's past experiences and activated in different situations.

Hammer et al. (2005) also suggest that in any moment, locally coherent sets of resources or *framings* are activated that are mutually consistent and reinforcing. Framing stems from a diverse history in cognitive science and sociolinguistics (Goffman, 1974; Minsky, 1985; Tannen, 1993). Here, we define framing as an individual or collective sense of "What is going on here?" Thus, framing involves an interaction between the contextual cues present in any given situation and the resources that various participants already have.

In any practice, which Wenger (1998) refers to as sustained engagement in a joint enterprise with shared tools, newcomers must learn relevant norms. Lave and Wenger (1991) describe the process by which newcomers learn these norms as "legitimate peripheral participants" (p. 29), which we take to mean that newcomers learn the framing of a particular practice through engaging and participating in that practice. We will argue that our teacher candidates draw on resources that they already have in order to participate in the practice of attending to student thinking. Additionally, by engaging and participating in this practice in various ways, the cohort establishes and reinforces a collective framing of attending to student thinking.

The language of framing has been used to understand how physics students frame what is going on in a particular context and how their framing is associated with their physics learning (Hammer et al., 2005); it has only been recently applied to secondary science pre-service teacher learning. Additionally, there has been little focus on how a framing of attending to student thinking is established and reinforced in a community of pre-service teachers. We return to our framework in our conclusion to articulate how pre-service secondary science teaching candidates learn to attend to student thinking while watching video and looking at samples of student work.

Research context and methods

Our data come from the first two courses of the three-course science pedagogy sequence in a one-year graduate-level initial teaching certification program at the University of Maryland, College Park. The course sequence is explicitly structured to draw teacher candidates' attention to the substance of student thinking, first by having them collectively examine records of classroom practice (videos and samples of student work), and then by having them collect and analyze such records from their own classrooms. During the first course (summer session), the teacher candidates identify frameworks for understanding students' science learning in the literature, interview students about science topics, engage in their own scientific inquiry, examine curricula for opportunities to draw out students' ideas and reasoning, and discuss samples of student thinking in classroom video and student work. The second pedagogy course (fall semester) continues these practices of examining and discussing samples of student thinking but goes beyond the first course in helping candidates develop instructional strategies consistent with science education reform and respond to student ideas as they arise during instruction. Candidates write lesson plans in which they anticipate what students might say or do and how they (as teachers) might respond instructionally. They then teach these lessons, collect student work or recordings of the class, and analyze the student thinking in evidence. The third course involves candidates in collecting data from their own teaching and writing case studies of the student thinking in evidence. Here, we report on data from the first two pedagogy courses – specifically on how the teacher candidates attended to the substance of student thinking in records of classroom practice.

Subjects

The first course was comprised of eleven pre-service secondary science teacher candidates. Seven of these candidates were in a one-year program to earn a Masters degree and certification. Three were post-doctoral scientists pursuing certification only, and one was a former patent attorney who was pursuing certification only. In the second course, three additional candidates joined who were participants in an integrated bachelors/Masters program for certification. They had taken the initial pedagogy course the previous year as undergraduates. For the purposes of this paper, we primarily consider the candidates as a group. We discuss some differences among candidates in terms of their participation, but an in depth discussion of other differences is beyond the scope of this paper.

Procedures

We shared eight cases of secondary science classroom work with the teacher candidates. Six cases were videos (20-45 minutes long) of secondary science classrooms with typed transcripts and/or captions. One of the videos was shown twice, as we discuss below. Two cases were collections of samples of student work. We selected all of the cases from a collection developed as part of another project (Levin, 2008); these cases will be included in a book/DVD package of teacher-authored case studies, similar to one produced for elementary teacher education (Hammer & van Zee, 2006).

As the instructor, Levin began the discussion of each case by describing the context in which the work occurred or by having the group read the introduction to the teacher's written case study. We then shared the video or student work with the group, and Levin asked, "What do you notice in the students' ideas and reasoning?" Levin facilitated the discussion to draw specific attention to the substance of students' ideas and reasoning. For example, if candidates made a general statement such as, "It seems like the students get it," Levin would say, "Can you point to something someone said or did that makes you think they get it?" Similarly, if candidates directed attention to the action of the teacher by suggesting what the teacher should do or describing problems with the teacher's approach, Levin would ask what they saw in the students' reasoning that led them to make that claim about the teacher.

Data collection

We videotaped the candidates' discussions of student thinking in each of the cases. The discussions were each approximately 30-45 minutes in length. Due to the great variability among the cases, it was difficult to compare the cases in order to explore how the cohort's practices of attending to the substance of student thinking changed over time by looking at the progression throughout the cases. Thus, we showed the case we had shown at the beginning of the summer session again at the end of the fall semester in order to look at differences in how the candidates attended to the substance of student thinking at the beginning of the first course and at the end of the second.

Data analysis

To explore our first question ("What do our teacher candidates attend to when discussing records of classroom practice?"), we drew on a coding scheme to categorize each speech turn, which was developed by inductive coding (Miles & Huberman, 1994) in a similar project with practicing teachers (Levin, 2008). We then developed our codes further through an iterative process of coding a sample of the discussions, discussing our codes, and expanding or collapsing codes as appropriate. In doing so, we developed a scheme that organized what candidates attended to into eight categories: specific student thinking, general student thinking, the actions of the teacher, the nature of the activity, the science content, student attributes, student engagement, and "other." We provide a detailed description of how we defined each of the codes in another paper (Levin & Richards, 2009), but the most important categories for our purposes in this paper are specific student thinking and general student thinking. We identify candidates' comments about specific student ideas or reasoning as attending to specific student thinking; for instance, we would code a statement like, "Maybe he's saying that they are practice for hunting – the snakes are just practice" as attending to specific student thinking. Alternately, we identify candidates' comments about the general understanding or reasoning of students in the class as attending to general student thinking (e.g. "I think most of them get it"). Levin coded all of the transcripts. Richards coded one third of the transcripts, and we compared our coding to arrive at an inter-rater reliability of 83%. We then discussed each disagreement until we reached consensus on the remaining codes.

To explore our second question ("How do our candidates attend to student thinking?"), we conducted another round of iterative coding, focusing only on the comments we had coded as attending to specific student thinking. As we previously described, we saw that candidates made three kinds of comments that we coded as attending to specific student thinking. At times, candidates 1) simply identified students' ideas, which we took as evidence that the candidates noticed the ideas, but we could not tell whether they attended to the meaning that the students were trying to convey. Candidates also 2) made evaluative statements in reference to students' ideas, which again indicated that the candidates were attending to the ideas that were present and perhaps making tacit interpretations of these ideas, but their interpretations (if present) were not made public. Finally, candidates sometimes 3) attempted to interpret what students were saying, which we took as the strongest evidence that they were attending to the substance of students' ideas. We did not take frequency counts of this coding because many utterances included overlapping codes at this level of analysis; instead, we considered how the three kinds of comments seemed to be related in candidates' statements. We explore the occurrences and relationships of these codes qualitatively in our data analysis.

To explore our third question ("How do practices of attending to student thinking develop over time within the cohort?"), we showed candidates the same case twice – once at the beginning of the summer session and again at the end of the fall semester. This case, hereafter referred to as the "Owls and Snakes," showed a teacher and students discussing a strange relationship between a species of owl and a species of blind snake that lives in the owls' nests undisturbed. We compared the initial coding of the first showing with the coding of the second showing. The discussions were slightly different in length, so we normalized the results by converting them to the frequency of codes uttered per 30 minutes of discussion. Both of us scored both transcripts completely, and we had 84% inter-rater agreement. Again, we resolved differences in coding by meeting and agreeing on the disputed codes.

We also looked across all of the case study discussions for patterns in the nature of the conversations and how participation in the norms and practices of attending to student thinking developed over time within the cohort. Specifically, we looked at who participated and how they did so over the course of the two semesters, how candidates drew each other's attention to specific student ideas, and how the role of the facilitator changed.

Data and analysis

In this section, we present the results of our coding, followed by our analysis of the data and a discussion of the cohort's practices over time.

Results and analysis of coding

We collected 995 coded passages over the course of nine discussions, including discussions of the eight cases plus the repeat of the first case. We coded 43% of utterances as specific attention to student thinking, 6% as general attention to student thinking, 18% as attention to teacher action, 9% as attention to the activity, 11% as attention to science content, 3% as attention to student attributes, 1% as attention to student engagement, and 6% as "other."

As we discussed above, it was difficult to make any claims about changes in what candidates attended to because of differences in the content of the cases. To look at changes, we led a discussion of the same case study at the end of the second course that we had discussed at the beginning of the first course and compared the changes in the frequencies of our coding. We only saw notable changes in the relative frequencies of attending to "specific" and "general" student thinking – the percentage of specific comments about student thinking (per

30 minutes) increased from 36% to 48%, while the percentage of general comments about student thinking decreased from 7% to 2%.

Thus, we can make two assertions related to our research questions at this point. First, our secondary science teacher candidates were able to attend to the substance of student thinking from the beginning of the pedagogy course sequence. Second, our candidates focused more on specific student ideas relative to general student ideas over time.

We saw that candidates consistently attended to the substance of student thinking from the beginning of the first pedagogy course. We coded almost half of all comments throughout the cases as "attending to specific student thinking," and our coding varied little across the cases in this respect. In terms of how candidates attended to student thinking, we saw that candidates routinely identified, interpreted, and evaluated students' ideas. At times, candidates made comments simply identifying a student's idea, and Levin followed up to ask what the candidates thought the student meant and what the candidates thought of the idea. Frequently, however, candidates specifically interpreted the student's meaning without prompting. These specific interpretations frequently led to sophisticated evaluations of students' conceptual understanding, reasoning, epistemological stances, and participation in scientific practices. Specific interpretations often occurred during long stretches of conversation that were about students' ideas and reasoning. For example, during an early case discussion in which candidates were discussing whether the students understood the relationships among force, mass, and acceleration when considering gravitational motion, Sarah, who was often one of the quieter students, identified an idea on a student's worksheet that she did not understand:

> Sarah: "I was confused by what she meant about inertia canceling out, like for, on page 2, when they talked about how... and not falling at the same time because their inertia's different?"
>
> Jack: "Well again I think that just mass, or heavier mass is less acceleration because they were just going back to that and less mass is higher acceleration."
>
> Alex: "It's interesting because on question 3 she -- at first the student states the right answer, they've got the concept that they land at the same time, and she understands that things that fall land at the same time, but then has trouble explaining why... she has this idea of the inertias canceling each other out, which indicates that she doesn't really have an understanding of what inertia is or how it applies in the case of falling objects."
>
> Jack: "Well again I think that goes back to their thinking the forces are the same, because she's saying 'the higher the mass the lower acceleration' versus 'a lower mass and a faster acceleration,' they are going to equal the same thing, so that's what she means, 'canceling out' -- they're gonna equal the same thing."

Here, Alex offered an interpretation of the student's thinking that she "has this idea of the inertias canceling each other out" and evaluated that she "doesn't really have an understanding of what inertia is or how it applies in the case of falling objects." Jack interpreted the student's idea more specifically, suggesting why the student might be thinking about "canceling out," which had not been obvious to everyone. As the conversation continued, Mark suggested another possible interpretation for what the student was thinking, and Elsa, Sarah, Ryan, and Alex debated Mark's interpretation, all drawing on the student's responses to other problems to debate what she might mean by "canceling out." This conversation about one specific student's thinking was followed by a discussion about how to teach the F = ma formula more generally, including how to help students recognize different situations (e.g. when acceleration is constant versus when force is constant).

However, candidates often made general comments about student thinking early in the first semester. In the first discussion of the "Owls and Snakes" case, for example, we heard many general claims about what students understood or how they were reasoning. Candidates made declarative statements like "They were thinking out loud, and thinking logically;" "They're asking the right questions;" and "They're doing good stuff, they're reasoning, they're connecting their prior knowledge" without including interpretations of students' specific ideas to warrant their statements.

Candidates also made general comments about student thinking after long discussions of particular students' ideas. For example, in the "Owls and Snakes" case, the teacher presents the students with some data, which leads to an interesting argument about whether or not the data fits students' hypothesized relationship between the owls and snakes. During the first viewing of the case, candidates had a long discussion about particular students' ideas during this segment (including a number of comments we coded as "specific" student thinking), at the end of which Ryan made the following general claim:

> "I can see the students are, uh, doing something that I agree with, which is not assuming that just because there's data that indicates something, that that means that [the owls and snakes are] getting something out of it."

Here, we see an example of a general statement about student thinking, which is an evaluation that the students are doing something with which Ryan agrees. It differs from the other general statements above in that, following a conversation about specific student ideas and reasoning, it is grounded in the interpretations that candidates provided during the preceding conversation. Ryan was therefore able to specify what he liked about the students' argument – they did not assume that the data supported a particular answer.

When we looked at candidates' general comments in the second discussion of the "Owls and Snakes" case, we found that there were fewer general comments relative to specific comments. Also, the general comments were all of the kind that followed interpretations of specific student ideas and reasoning; none were the blanket evaluations we had seen in the first discussion. This kind of general claim about student thinking draws on specific interpretations of students' ideas and reasoning and can therefore provide novel and productive warrants for the evaluation of student thinking.

Developing practices of attending to student thinking

In addition to exploring the content of what candidates attended to, we looked at how their participation in the conversations changed over time. In the earliest discussions, four candidates spoke the most in the discussions: Alex (the patent attorney), Brian and Elsa (post-doctoral scientists), and Ryan (an engineer by training). Alex in particular seemed to understand that the central aspect of the practice of attending to student thinking was to make claims about students' meaning by identifying specific things that students said. As we discussed above, Levin actively modeled this practice by asking candidates for specific examples. In the exchange below from the first "Owls and Snakes" discussion, we see Alex jumping in with an example even before Levin has finished asking for it:

> Ryan: "I thought it was a really impressive class."
>
> Levin (instructor): "Say more about that, why?"
>
> Ryan: "Because, uh, they were thinking out loud, and thinking logically, and the teacher was doing a great job of getting them to use reasoning."
>
> Levin: "So let's see if we can find – " (overlapping with Alex)
>
> Alex: (overlapping) "I like that distinction of that there's the good, the good maid and the bad maid, because the students are told there's a distinction, right, some snakes are eaten and some snakes aren't, there's eighty-nine percent that are alive and eleven percent that are dead, although they're not really told that they're eaten. Only one seems to be half eaten. So they're trying to immediately come up with a reason about why there are these two groups, why some snakes are alive and some snakes are dead and the reason that they come up with, well some are good at burrowing and cleaning up the nest and some are bad at this job and so they're eaten by the owls. At least that's an interesting reaction to being told there's two groups and they immediately come up with some mechanism, some reason, some logical reason to explain why there are two groups, why there are alive and dead snakes."

Throughout the case study discussions, Alex continued to identify examples of student thinking himself and to provide interpretations of others' examples to support evaluations. In some cases, he asked other candidates to support their statements with references to the transcripts or student work, asking several times "Where is that?" or "Where do you see that?" Alex appeared particularly comfortable with practices of interpreting students' meaning. Both in and outside of the pedagogy classes, Alex explained that his work as a lawyer helped him to focus on what people were saying.

Although Alex and some others dominated the conversations at the beginning, others began to participate within the first few case study discussions. By the second viewing of the "Owls and Snakes" case in the second pedagogy course, multiple candidates were participating in long conversations about student thinking without prompting from Levin. For example, Jack brought attention to a situation in the video in which a student, responding to a question from the teacher, said that a particular piece of data could be "used to evaluate" the students' hypotheses about the relationship between the owls and snakes. Jack thought that the student was just choosing one of the options the teacher had given him (can or cannot be used to evaluate the hypotheses) without thinking about it. Other candidates were not so sure. When the teacher asked the student, "What does it add that will help us answer the question?" the student replied:

> *"Uh, it could enter the nest on its own. The snakes are capable of climb, climbing up trees, and they can get to the nests on their own… and, if owls and snakes ever turn against each other, they could use that as an advantage for like, uhhh, battle and stuff."*
>
> Kay: "He's saying that the snakes are making the choice to go there. Like I…"
>
> Mark: "Right, that's what I read here."
>
> Kay: "Right, and then that's what's important about it to him…"
>
> Jack: "Right, so right. I see where that is important but I don't know if [he] understands that… he says, 'Yeah, they can climb trees'… but then line 23 I don't understand what he was meaning there because [he's] like, 'If they ever turn against each other they can use that to their advantage.'"
>
> Maria: "He probably means they could just climb back down to escape."

Kay interpreted the importance the student was placing on choice, but Jack questioned whether the student understood why it was an important idea. Maria interpreted the student's idea about why climbing trees was advantageous to the snake. The point of this snippet is not to definitively interpret and evaluate the student's idea. The point is that the candidates were focused on trying to understand the student's unconventional idea and truly attending to his meaning -- with little scaffolding from Levin nor the participation of Alex and other participants who had dominated the earlier conversations about student thinking.

Conclusions and future study

This work contributes to a growing understanding of novice teachers' abilities to attend to the substance of student thinking and provides insight into how their practices of doing so develop and change over time. We show evidence that novice teachers can identify, interpret, and evaluate the substance of student thinking when they participate in pedagogy courses designed to draw attention to this topic. Additionally, the candidates in our pedagogy courses became more adept at drawing specific interpretations of student thinking and using these interpretations to warrant general claims and evaluations of student understanding.

However, a particularly important aspect of our data is that the cohort of teacher candidates attended to student thinking from the very beginning of the pedagogy course sequence. We believe that this finding has important implications in terms of how to best conceptualize learning to attend to the substance of student thinking. The predominant assumption in the noticing literature is that noticing is a "skill" (e.g. Jacobs et al., 2007; van Es & Sherin, 2008). We challenge the use of the term "skill," which typically implies something that teachers do not know how to do until they have been taught. Even if the use of the term "skill" in the noticing literature is not intended in this manner, we argue that conversations about learning should always be explicitly connected to a strong theoretical base, and we do not believe that the term "skill" accurately captures what is learned or how learning occurs.

Our data from this study support the presence of resources that teachers have to attend to the substance of student thinking. To us, the existence of these resources is important because it suggests that teachers do not learn a new skill in professional development or teacher education contexts, but that these contexts instead activate resources that teachers already have. That is, focusing on the substance of student thinking is not something developed de novo, but rather an activation of the resources that all people have for listening to the meaning that another person is trying to convey. Thus, an important task for teacher education is to help pre-service candidates draw upon these resources to support a framing of teaching in terms of attending to student thinking.

We suggest that the framing of teaching in terms of attending to student thinking was not simply put in place by Levin, the instructor, but was supported collectively through interaction among the participants in the group. Alex and some other candidates, perhaps because of prior experiences in similar settings, entered into the conversations very quickly and helped to support the framing that Levin was trying to establish. Over time, Levin's voice became less prominent as candidates pushed each other to articulate the specific evidence in student thinking that warranted claims of students' reasoning and understanding. The spirit of these exchanges over case studies continued into the third semester of the program, where candidates presented case studies from their own classrooms.

Our findings also suggest productive avenues for further research. As we noted, there were differences in the ways that individual candidates attended to student thinking. Some, like Alex, offered substantive interpretations of students' ideas from the very beginning. Others had difficulty doing this at first and seemed to become better at it as they engaged more with the group and saw the practices modeled by other candidates. We are pursuing more in-depth case studies of particular candidates in order to address these distinctions.

We are also examining candidates' practices of attending to the substance of student thinking while they are teaching in their own classrooms, where they must listen to student ideas in real time while trying to manage other facets of the classroom and the curriculum. We have followed several candidates into the classroom, and we plan to continue following them through induction and the early years of their teaching careers in order to better understand how and when teachers attend and respond to the substance of student thinking while teaching science.

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