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Stage-based views of teacher development hold that novice teachers are unable to attend to students' thinking until they have begun to identify themselves as teachers and mastered classroom routines, and so the first emphases in learning to teach should be on forming routines and identity. The authors challenge those views, as others have done, with evidence of novices attending to students' thinking early in their teaching and offer *framing* as an alternative perspective on whether and how teachers attend to student thinking. By this account, most teachers work in professional contexts that focus their attention on curriculum, classroom routines, and their own behavior, rather than on student thinking. An account of framing suggests an early, strong emphasis on attention to student thinking in teacher education.

Keywords: *teacher education; science education; teacher development; attention*

Introduction

Kay[1] was a novice teacher last year, working as a paid intern while she took classes toward her credential. As part of her coursework for the credential program, she videotaped and analyzed a lesson from one of her classes, paying close attention to the student thinking in evidence. Kay transcribed a clip from a lesson in which students were to diagram a cell at each phase of the cell cycle to visualize what happens during each phase. They had spent the previous class completing a "cell cycle notes sheet" together as a class.

Kay: Okay, today, as I said yesterday, you are going to be making a little wheel showing the stages of the cell cycle, including stage 1, which is?
Students: Interphase.
Kay: Stage 2?
Students: Mitosis.
Kay: Good, mitosis. And stage 3?
Students: Cytokinesis.
Kay: Now, in mitosis there are how many phases?
Students: Four.
Kay: Four. Good. What is the little acronym that we learned for the four phases yesterday?
James: P-M-A-T.
Kay: Good. PMAT. Remember, don't pee on the mat!
Students: [Giggle and laugh]
Kay: Okay, for warm-up, during what stage does the DNA replicate?
April: Interphase
Kay: Excellent! Interphase!

Given it is the first semester of Kay's first time as a teacher, how should teacher educators think about her work? The class was orderly, her students seemed engaged, and her review affirmed they retained the information from yesterday.

If she were an experienced teacher, we expect teacher educators would have concerns. The review consisted almost entirely of naming terminology, without attention to meaning. What did students think the terms *interphase*, *mitosis*, or *cytokinesis* mean? What does it mean for DNA to "replicate"? Do students realize that mitosis

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is taking place in their own bodies all the time and that mitosis is how they grow and heal?

The transcript reveals a pattern of *triadic dialogue*, a conversational routine of teacher questions, short student answers, and teacher evaluations.[2] It is common in classrooms, but here as in general, this form of participation is high in quantity but low in quality (Lemke, 1990). Kay did not notice either the nature or substance of the students' participation; she did not recognize opportunities to probe their conceptual understanding. Moreover, her carriage in class and her reflections later conveyed only satisfaction. She wrote that the diagrams and students' responses in the aforementioned exchange demonstrated that students understood the cell cycle.

By some well-subscribed accounts of teacher learning we review in the following, we should not expect a novice like Kay to attend closely to the substance of her students' thinking. Before she can do that, she needs to develop classroom routines and to establish for herself an identity as a teacher, both of which she appears to be doing admirably. Later, as these routines become second nature, she will be able to attend to student thinking. As a first-year teacher, Kay was doing quite well. Indeed, the administration at her school was delighted with her, with how quickly she was able to manage a class and make progress through the material.

Our first purpose in this article is to challenge these stage-based accounts of teacher development, contributing to arguments in the literature. To the existing empirical work we add further case study evidence of novice teachers' abilities for attending and responding to student thinking. As well, analyzing those cases, we suggest and illustrate what should constitute evidence of that attention. To the existing theoretical work, we propose *framing* as an alternative account of why teachers may or may not attend to student thinking. On this view, whether and how teachers attend and respond to student thinking largely reflects how they frame what is taking place in their classes. We argue that teachers have difficulties in part because institutional contexts inhibit their framing classroom activity as focused on student reasoning. In the final section of the article, we discuss implications of this view for teacher education and professional development.

Everyday Assessment—An Issue of Attention

Why should teacher educators care about attention? Research has begun to conceptualize assessment as an everyday classroom activity (Atkin & Coffey, 2003; Cowie & Bell, 1999; NRC, 1996, 2001), and a growing body of work points toward the strong influence that perceptive, ongoing diagnosis of student thinking has on a teacher's instructional moves and student learning (Black & Wiliam, 1998; Cowie & Bell, 1999; Hammer, 1997). Assessment that occurs moment-to-moment in classroom activities concerns, fundamentally, teachers' attention to ideas and reasoning (Ball, 1993; Sadler, 1998). There is clear consensus in the science education literature that teachers must listen and respond to the substance of student thinking (NRC, 2007). Our premise here is simply that assessment requires attention: Teachers can only assess student reasoning if they are paying attention to it.

A second reason to care about teacher attention is its effect on student attention: If a teacher is paying attention to the substance of student thinking, students are more likely to pay attention to that substance (Warren & Rosebery, 1995). For this article, we take it as a second premise that learning science involves learning to attend to—and to assess—ideas and reasoning. Thus, we care about teacher attention not only for the information it provides teachers but also for how it models a key aspect of scientific reasoning for students.

Pierson's (2008) study of mathematics teachers' "responsiveness," which she defined as "the extent to which teachers 'take up' students' thinking and focus on student ideas in their moment-to-moment interactions" (p. 25), provided evidence of its importance. She distinguished two forms of "high" responsiveness. "High I" responsiveness puts the "teacher reasoning on display": The teacher responds to the student reasoning to help bring it into alignment with the target ideas, for example to correct a misconception. "High II" responsiveness puts the "student reasoning on display": The teacher focuses on the students' meaning and logic, for the immediate purpose of understanding it on its own terms. With data from 13 teachers, Pierson found a strong, significant correlation between High II responsiveness and student learning.

Focusing Novice Teachers' Attention on Student Thinking

Science education reform emphasizes "student-centered" curriculum and instruction (NRC, 1996, 2000). At its core, this agenda involves meaningful engagement with ideas and reasoning. All students come to school with resources for understanding and using scientific knowledge, reasoning scientifically, and participating in scientific practices and discourse (NRC, 2007). Their progress in learning science depends largely on teachers' attention to those resources.

Teacher preparation, however, remains largely teacher centered. "Methods" courses focus on the things teachers

do, from instructional methods to management strategies, and programs emphasize self-reflection and identity formation (Adams & Krockover, 1997; Freese, 2006). Certainly, such courses can engage novice teachers meaningfully with ideas and reasoning, and it is important for teachers to reflect on their roles. Our argument, however, which we develop below, is that these approaches direct teachers' attention to themselves and their own actions, at the cost of attention to their students' reasoning.

Teacher-centered approaches have been influenced by accounts of developmental stages (Berliner, 1988; Fuller, 1969; Fuller & Bown, 1975; Kagan, 1992): Novices like Kay need routines that integrate classroom management and instruction *before they can attend to student learning*, and a focus on oneself is a "necessary and crucial element in the first stage of teacher development" (Kagan, 1992, p. 155).

Unitary stage-based accounts of development have been losing ground for some time in cognitive and developmental psychology to accounts of contextual variations in reasoning (Feldman, 1994; Fischer, 1980; Metz, 1995; Siegler, 1996). Recent research on teacher learning correspondingly depicts greater complexity and flexibility than stages (Loughran, 2006). Furthermore, some innovative teacher education programs use case studies to engage novices in reflection on student thinking in context (Darling-Hammond & Snyder, 2000), reflecting an understanding of contextual sensitivities in the research literature and in teacher education. Nevertheless, program design is often still predicated on the assumption that teachers' concerns about their own actions and identity must be confronted first, before teachers can attend to student thinking (Freese, 2006; Loughran, 2006; Mellado, 1998).

In the next section, we present arguments from the stage-based perspective, challenges to these arguments, and the alternative perspective of framing. In the subsequent section, we present evidence of novice teachers' attention that adds to the empirical case against stage-based accounts. We use these cases to develop the account of framing, which allows reinterpretation of the observations of novices' development. We do not dispute the evidence that novices *typically* focus on themselves and their behavior. Rather, we dispute the notion that they *must* focus on themselves before they are ready to focus on student thinking.

Research on Novice Teacher Attention

We begin with a review of the literature on developmental stages, and then we turn to a review of the challenges to those accounts.

Stage-Based Views From the Teacher Development Literature

For some time, research on teacher development has pursued a stage-based account of teacher attention (Berliner, 1988; Fuller, 1969; Fuller & Bown, 1975). This framework remains influential in the assumptions researchers make and the implications for teacher education that they infer (Dori & Herscovitz, 2005; Freese, 2006; Loughran, 2006; Mellado, 1998).

Kagan (1992) reviewed 40 naturalistic learning-to-teach studies published between 1987 and 1991 with the central goal of constructing a model to describe the professional growth of novice and beginning teachers. The resultant model described preservice and first-year teaching as belonging to a single developmental stage in which novices:

1. acquire knowledge of pupils,
2. use that knowledge to modify and reconstruct their personal images of self as teacher,
3. develop standard procedural routines that integrate classroom management and instruction (Kagan, 1992).

Thus, preservice teachers arrive with beliefs and images based on their experiences as students. As they begin to interact with students, novice teachers acquire knowledge of students, such as of the diversity in their readiness to learn, which they use to reconstruct their images of themselves as teachers. During this process, they tend to focus on their own behaviors. Once they have "resolved" an image of themselves, novice teachers can shift attention to the design of instruction and analysis of what students are learning.

The body of research shows, Kagan (1992) argued, that the initial focus on self is a "necessary and crucial element in the first stage of teacher development" (p. 155). Attempts by university faculty or supervisors to abort this period of inward focus may be counterproductive because novices need a clear image of themselves as teachers to begin the process of reconstruction. Among the studies that Kagan reviewed were several that suggested that novice teachers who fail to reconstruct their images of self as teacher may encounter frustrations that drive them out of teaching (e.g., Bullough, 1991).

This early stage of teaching is also spent developing standardized routines for integrating classroom management and instruction. Only when these routines are in place can novices begin to focus on student learning (Kagan, 1992). The notion that mastery of organizational routines is a prerequisite for attending to student learning has become conventional wisdom in teacher education

and is often assumed in published research. For example: "A teacher's career path starts when the teacher struggles to survive consistent daily routines of teaching. It continues in stages of relative stability, when the teacher is ready to introduce innovations and changes in his/her traditional teaching" (Dori & Herscovitz, 2005, p.1415).

In the time since Kagan's (1992) review, teacher development research has moved away from a rigid stage-based view of teacher development. Nevertheless, it is still argued that there is a development of issues of "concern" (i.e., issues of identity and the establishment of routines) that teacher educators must address and should "bring to the fore" rather than "waiting for them" to arise (Loughran, 2006). Teacher education programs often focus novices' attention inward, for example encouraging them to write "self-study" reflections about their teaching (e.g., Freese, 2006).

Challenges to Stage-Based Views of Teacher Development

Because of the prominence of Kagan's (1992) review, it has been a principal target of criticism. Grossman (1992) argued that Kagan's review omitted literature that demonstrated preservice secondary teachers' abilities to think about how to teach subject matter before establishing classroom routines (Grossman & Richert, 1988; Shulman, 1987; Wilson & Wineburg, 1988). While the preservice teachers in these studies did attend to issues of identity and classroom survival, "these concerns did not prevent them from reflecting deeply on issues related to the content of teaching" (Grossman, 1992, p. 174).

Davis (2006) analyzed the reflective journal entries of preservice elementary teachers as they designed and taught lessons in a school-based practicum experience prior to a practice teaching semester. Her analysis showed that the prospective teachers were able to attend to the substance of their students' thinking as they reflected back on lessons. While some have found teachers' reflections on student learning to be primarily focused on students' interest and motivation (e.g., Abell, Bryan, & Anderson, 1998), these results showed new teachers can attend to student learning in more substantive ways.

Darling-Hammond and Snyder (2000) described several teacher education programs that used case studies of students and classrooms to try to capture important attributes of teaching and reasoning about teaching in context. They argued that these assignments help beginning teachers to understand the effects of their actions and meet the needs of their students.

One line of evidence challenging the early emphasis on self-reflection and identify formation in teacher education is cited in Kagan's (1992) review. Shapiro (1991) interviewed 23 preservice secondary teachers throughout a methods course and classroom practicum and found they began to see themselves as teachers as they interacted with students. This study, and others like it, support Kagan's claim that novices reconstruct their identities. They do not, however, suggest that novices must focus inwardly in their preservice teacher education programs. In fact, they suggest the opposite; it is precisely by focusing on student learning that preservice teachers reconstruct their identities.

Further challenges to stage theories focus on what happens with experience. Stage models imply that having developed classroom routines that work, experienced teachers will flexibly adjust their routines when they appear not to be working (e.g., Berliner, 1988). Evidence shows otherwise: Teachers often become satisfied with their teaching and less likely to question their chosen routines as their careers progress (Grossman, 1992).

Finally, stage theories take little account of institutional systems. A number of researchers have argued that teacher attention is largely organized by aspects of educational institutions, including reform priorities, standards and assessments, local professional communities and their tools, and institutionalized norms of student and teacher relationships (Coburn, 2004; Cohen, 1990; Herbst, 2003; Jenkins, 2000; McLaughlin & Talbert, 2001; Rop, 2002; Settlage & Meadows, 2002; Siskin, 1990).

Our first purpose in this study is to contribute to the empirical and theoretical arguments challenging stage theories of teacher development. In the following, we suggest criteria for evidence of teacher attention to student thinking, and we analyze several examples to show how that evidence obtains in novices' classrooms. Where previous work has focused on identifying novice teachers' attention in their reflections, we analyze classroom episodes to show novice teachers attending to student thinking *during instruction*. Later we consider examples, as well, of novices having difficulties.

Our second purpose is to propose a different perspective for understanding the dynamics of teacher attention; we turn to that now, before proceeding to the case studies.

An Alternative Perspective: Framing

Our perspective for understanding teacher attention draws from research on learning in physics, which has shown how student reasoning can settle into different patterns in different situations, patterns that can be quite stable (Redish, 2004; Rosenberg, Hammer, & Phelan, 2006). For one example, consider Sherry, a graduate student in an elementary credential program (Hammer,

Elby, Scherr, & Redish, 2005), who was thinking about how tall a mirror you would need to see your full body reflected. Another student thought the mirror would only need to be half your height, based on a diagram she had drawn showing light rays bouncing from the mirror's surface. Sherry disagreed and argued forcefully that the mirror had to be as tall as the person, for the clear reason that the mirror needs to be full height for the full image to fit in it. The next week she came to class with an awkward admission: She has a half-length mirror in her bedroom, and she sees her full reflection in it every day.

There were, evidently, two different stable patterns in Sherry's thinking about mirrors. In class, she was persistent in her contention that the mirror had to be full length; at home, she knew her half-length mirror showed her full reflection. The important point here is that people are capable of multiple patterns of reasoning. How an individual thinks and experiences in one setting is not necessarily the same and may be sharply inconsistent with how that individual thinks and experiences in another setting.

Hammer et al. (2005) described Sherry's thinking in terms of framing, adapting a concept with a diverse history from anthropology, linguistics, sociology, and computer science (see reviews in MacLachlan & Reid, 1994; Tannen, 1993). We take up that use here: *Framing* is an individual's or group's forming a sense of "what is going on here?" Thus, Sherry framed what was happening in the two situations differently. Framing one activity as something like "analyzing light and mirrors," she attended to the mechanism of how an image is reflected; framing the other as, perhaps, "choosing an outfit," she attended to her appearance in the mirror.

Sherry's framing varied from one setting to another, separate in space and time (for a richly documented example, see Lising & Elby, 2005). An individual's or group's sense of what is going on can also shift dynamically within a given setting, such as when a friendly conversation turns into an argument (for examples in physics learning, see Scherr & Hammer, in press).

Lau (in press) applied a notion of framing to analyze the dynamics of teacher attention during class discussions. Heidi, for example, was teaching a lesson on sound in her third-grade class. She asked the students to talk about what they already knew about sound and hearing, and her student Marcus spoke up to say that "most of your sound" can go through your head. Heidi was puzzled by his comment and asked him to explain, "What do you mean by that, 'most of your sound'?" Marcus explained that he had learned from his doctor that "if you can't hear anything in your ear, then the sounds can go through your head," indicating the top of his head. Heidi expressed interest and said that she would write his idea on the chart paper she was using to record student thinking. Before she did that, she checked once more with him on what he was saying, asking, "It goes through the top of your head? The sound?" This time Marcus said "Yeah, and it vibrates." Lau documented how Heidi's tone and demeanor shifted in response: "*Vibrations*, I love it." What Heidi ended up writing on the board was the word *vibrations*, which was one of the vocabulary words in the objectives for the curriculum.

Lau (in press) interpreted this as a shift in Heidi's framing. Marcus's idea caught her by surprise, and for a moment she focused on understanding what he was saying. That is, she framed what was happening as something like "figuring out what he means," and that framing had her attending closely to his words and gestures. In that framing, she formed a sense of his meaning and was getting ready to write it on the chart paper. When he said the word *vibrates* however, she recognized a target vocabulary word, and that shifted her attention back to her lesson plan, with its objectives to cover terminology.

On this view, whether and how novice teachers attend to student thinking depends significantly on how they frame what is taking place. As Sherry had everyday experience of mirrors she did not apply at first in class, novice teachers have everyday experience in conversations of attending to others' reasoning. They may not apply those abilities in class, but there is no need to treat that as a developmental limitation. In Heidi's case, there is evidence of her ability to attend to a student's meaning and evidence that her framing of what is taking place can pull her attention elsewhere.

Heidi's case is evidence of how the school setting can influence framing: That she shifted from trying to understand what Marcus meant to recording the mention of a target concept in her lesson plan reflects the institutional context of their interaction. Within that context, teachers are held accountable to objectives, and the idea of (and term) *vibration* was part of the school curriculum. Levin's (2008) analysis centered on how teachers' framing is embedded within institutional and social contexts. He showed how professional communities within the school tended to focus in-service teachers' attention toward instructional strategies and curricular objectives. He also showed how another community, of the same teachers collaborating with university researchers, supported a framing of teaching as attending to student thinking.

We now turn to case studies, beginning with examples of novices attending to student thinking, in real time during class, followed by examples of novice teachers who have difficulty with that. We then argue that these novices' attention reflects how they framed what was taking place

in their classes, and we discuss how that framing may be influenced by the institutional contexts of their schools. In the closing section of the article, we discuss implications for teacher education.

Novices' Attention to Student Thinking

There is evidence in the literature that novices can attend to student thinking when examining records of practice outside of class (Darling-Hammond & Snyder, 2000; Davis, 2006). We have collected such evidence as well (Levin, 2008).

Advocates of a developmental perspective could argue, however, that their account concerns what takes place during instruction. Our primary purpose here is to present evidence of novices' attention to student thinking in real time, during their teaching. We then turn to case studies of interns who struggled or failed to attend to student thinking, and we offer an alternative account of their difficulties.

Research Context and Data Collection

The data for the study are from the fall and spring semesters of 2006-2007, in the graduate masters certification program at the University of Maryland, College Park. Most candidates in the program work as paid part-time teachers, or "interns," in a local school district while they take their courses; a few follow a more traditional student teaching model in which they progressively increase their leadership of classes throughout the school year. In 2006-2007, there were 9 paid interns in the program; they are the focus for this study.

The program includes science pedagogy seminars that emphasize the substance of student thinking. During seminars, which begin in the summer prior to their teaching placements and continue through the year, interns examine records of practice primarily with respect to evidence of student reasoning, first drawing on existing examples and then collecting their own (Hammer, 2000; Hammer & Van Zee, 2006; Sherin & Han, 2004). Their assignments include the preparation of case studies from their classes, at least one of which must include video the candidate selects and transcribes for presentation in seminar.

In addition, interns are supervised five times each at their schools. The first author shared responsibility for supervision with another staff member; he made one to five observations per intern. Supervisory visits and follow-up conversations also emphasize the substance of student reasoning, as evident in class. The science pedagogy courses are the only ones in the certification program that systematically focus candidates' attention on student thinking, as one might expect: The substance of that thinking is specific to science.

The data for this study include (a) video recordings, one to three classes per intern, prepared as part of their seminar assignments; (b) field notes from the first author's in-class observations, one to five observations per intern; (c) the teacher interns' papers in their science pedagogy seminars, taught by the first author; and (d) the teacher interns' remarks during an interview and in seminar discussions, gathered from field notes and recorded on videotape. We secured permission from the interns and from the schools to collect these data and use them as part of this study.

Our purpose in analyzing these data is to examine the robustness of the assumptions of stage-based theories regarding the abilities of novice teachers. To this end, we examined the interns' case studies of their classes, and field notes and video recordings from the seminar and from the classrooms of each of the 9 interns for evidence of attention to student thinking. As we document here, we found that evidence, which we argue challenges accounts of developmental limitations in novice abilities. We are not claiming that the teachers in this study were *uniform* in attending to student thinking; in fact, for most of the teachers we found that attention was episodic.

Criteria

For analyses of classes from field notes or video, we consider it evidence of attention to student thinking when the intern notices and responds to a student's idea. The response may be the intern's asking the student or other students to explain or elaborate on the reasoning, rephrasing the idea himself or herself, or shifting the flow of classroom activity in a way that addresses the idea. We also consider it evidence when an intern later reports noticing an idea during class when he or she identifies it specifically, even if the intern did not overtly respond at the time. It is not evidence, however, if the intern notices or responds only to correctness; the response or report must focus on the sense of the idea from the student's perspective. These criteria are quite similar to those Pierson (2008) developed independently for her category of High II responsiveness.

Although not the emphasis here, similar criteria apply to our analyses of written assignments: We consider it evidence when an intern makes a claim about student reasoning that is supported by evidence in the data—that is, in the video, transcript, or student written work. Again, it is not sufficient for the claim simply to identify whether the student is correct or incorrect; the claim and support must concern the sense of the student's thinking from the student's perspective.

From the data, we have selected examples from 4 of the 9 interns, whom we identify by the pseudonyms Scott, Susan, Emma, and Kay. We chose these 4 interns because they represent the diversity we observed among the 9; we provide brief descriptions of data for the remaining 5. See Levin (2008) for further documentation. The examples illustrate our application of the criteria for attending to student thinking, with respect to classroom observations and video and to interns' written reflections on these classroom episodes.

Early Attention to the Substance of Student Thinking

We begin with Scott and Susan, who needed little help in focusing their attention on student thinking. We then turn to Emma, who seemed to shift her attention toward student thinking over the course of the year, and Kay, who did not.

Scott

Scott was teaching three sections of high school biology in a public school. The following took place in October of his first semester teaching; it is based on field notes from the first author's observations.

Scott had filled a plastic bottle with water and frozen it to demonstrate that water expands when it freezes. (The water level rises in the bottle.) One student, Cindy, asked, "If something frozen expands, does it always expand to the same amount?" Scott asked her if she could explain more about what she meant, and she asked if she could draw something on the board. She drew six bottles on the board like the bottle in the demonstration. She labeled two bottles as *soda*, two as *water*, and two as *juice*. She indicated that one of each pair would be frozen, and she wanted to know in which would the level of the liquid rise the most.

Scott told her that it was a great question, and he asked her what her "instinct" was. Cindy said that she didn't know, and Scott turned to the rest of the class and said, "Let's open it up. What do you guys think? If they start at the same level, which will rise the most?"

Several students said they would all be different, although no one offered an explanation. Scott asked if anyone thought they would all be the same. Princess thought the water would not rise as high as the soda, and the order would be "soda, juice, then water, 'cause soda has caffeine in it." Scott asked her what caffeine had to do with it. "I don't know," she said. "It has to do with science."

Scott continued to push students to come up with explanations for why they thought the three liquids would rise to different levels. Kathy thought that the juice would be lowest but could not explain why. Another student didn't offer a prediction but pointed out that soda was "mushy" when it froze and water was "hard." Other students agreed that this would influence the outcome, although no one was really sure how it would affect it. Someone mentioned that the class could do an experiment to test the various predictions.

Scott talked about this class during the seminar. He said that he initially let Cindy come up to the board because she often had good ideas but was not always engaged, and he wanted to keep her engaged in the class discussion. He was very impressed with her question, pointing out that she had designed a controlled experiment without being directed. He also pointed out that students were able to draw on their everyday experience to think about the problem, like the student who observed that soda is "mushy" while water is "hard."

The evidence of Scott's attention to student thinking includes his request to Cindy to explain her original idea and when she had clarified her question, his using that question as the focus for the next several minutes of conversation.

Susan

The following is based on a lesson Susan videotaped and analyzed for the science pedagogy seminar. The lesson took place in November of her first semester teaching, at the same school as Scott; the two split a full-time schedule for their paid internships. Like Kay in the example that opened this article, Susan was teaching a lesson on mitosis, but her approach was quite different:

> My goal for the lesson was for students to come to an understanding of the cell cycle through exploration and discussion, rather than direct instruction. I wanted the students to construct their own understanding of the cell cycle process. I anticipated that this approach would produce really creative responses.

The students had no prior instruction on cell division. Susan began by showing a 5-second animation of a cell splitting into two and had the students discuss two questions in small groups: "Why do cells need to divide?" and "How do cells divide?" After about 15 minutes, Susan brought the class back together. What follows is a transcript of the discussion about the "Why" question and Susan's reflection.

1. Susan: Okay, let's go Addie and Jill—what reasons did you come up with for why cells need to divide?
2. Addie: So that there are always good cells and new cells and so that there are always more cells when cells die

3. Charles: Cells escape from your body.
4. Susan: How do cells escape from our bodies?
5. Charles: Ummm, like urine, spit, semen, tears, blood.
6. Nat: Like if you cut yourself
7. Charles: Anything that exits your body.
8. Claudio: Isn't dead skin cells
9. Nat: Growth
10. Susan: So let's get some of these up [on the board] . . . Nat, what'd you say?
11. Nat: Growth
12. Susan: So when we grow—
13. Nat: You need more cells, those cells need to break up and create more so that people grow. That's how we get taller.

We see evidence of Susan's attention to student thinking when she asks Charles to explain how cells escape from our bodies (4) and when she asks Nat to repeat what he had said (10) and to elaborate on his use of the word *growth* (12). We also see evidence of attention to student thinking in Susan's written reflection on this exchange:

> Right after Addie, Charles said something about cells "escaping from our body." Examples that Charles gave of cells "escaping from our body" were urine, spit, semen, tears, blood. I thought that this was a great response (that we needed to replace cells which we lost), and am so intrigued by the word "escape." I wonder if Charles had an idea that, in general, cells were trying to escape, but something was somehow keeping them in.[3]

Susan's statement that "I thought that this was a great response" is further evidence she noticed Charles's idea in the moment. Her subsequent wondering about the word *escape* illustrates what we take as evidence of an intern's ability to interpret student ideas from records of practice.

These examples illustrate evidence of interns' attention to student thinking during class. For 4 other interns, like Scott and Susan, there is evidence from video or field observations within the first few months of their starting to teach. For 2 other interns, we did not see evidence of that attention until the spring semester. In all however, the evidence shows 8 of the 9 interns in our program were attending to student thinking within their first year of teaching, during their classes as well as in their out-of-class reflections (Levin, 2008). Several of the teachers, including Scott and Susan, did seem to be contending with their roles as teachers and management of the classroom, but these concerns did not prevent them from attending to student thinking. In interviews, both Scott and Sarah identified attention to student thinking as the foundation of their teaching, and they credited the science pedagogy course sequence for focusing their attention in this way.

In the next section, we argue that part of the dynamic of the interns' attention reflects their involvement in two larger systems—the school and the credential program—and the ways in which these settings influenced the novice teachers' framing.

An Alternative Account of Early Difficulties

As we reviewed earlier, stage-based accounts hold that attention to student thinking is a later stage of teacher development, necessarily following the earlier steps of identity formation and mastery of classroom routines. In the previous section, we provided evidence of novices' early attention to student thinking, contributing to the case against accounts of developmental limitations. In this section, we offer an alternative theoretical account for why interns do or do not attend to student thinking.

In particular, we argue that the systems in which teachers operate direct their attention in various ways, and in general the systems they find in their school placements direct their attention to their own behavior, classroom management, and curricular fidelity. This direction influences how teachers frame classroom activity and in particular inhibits their focusing on the substance of students' ideas and reasoning. In contrast, we designed our science pedagogy courses specifically to direct attention to the substance of student thinking. We draw on observations of two interns, Kay and Emma, who split a full-time position in seventh- and eighth-grade science at the same middle school, to develop this theme.

Emma was one of the two interns for whom we did not see attention to student thinking until the spring. Kay was the only intern for whom we never saw that attention. Their cases provide evidence of influence by the respective systems of the school and program.

Emma

Throughout most of the year, Emma was trying to attend to student thinking to guide her teaching. She told university supervisors and school administration that she valued "discourse" and "inquiry," and she was occasionally able to engage students in substantive conversations about scientific phenomena. Frequently however, her class was disorganized and loud, and she had difficulty moving through lessons in a focused manner. Indeed, Emma fit the standard pattern of struggling at first with classroom management.

Her video case study in February illustrates both her coming to attend to student thinking as well as the tensions she felt about doing so. The students were discussing what happened when she dropped an Alka-Seltzer tablet into a cup of water. Emma had previously explained the definition

of *chemical change* as a change in which "a new substance is created." Now she wanted to see whether they could apply that definition to the demonstration.

1. Emma: So I have Alka-Seltzer and I add water to it. Is that a chemical reaction?
2. Students: No . . . no . . . yes . . . no . . . yes
3. Emma: [to students who said yes] So, okay, so why is it a chemical reaction?
4. Charles: [unrecognizable]
5. Emma: You are saying that the bubbles dissolving is a chemical reaction.
6. Charles: Yes
7. John: Because the Alka-Seltzer is mixing in the water
8. Emma: Because you're getting a mixture. Okay.
9. Alice: Because if it's creating bubbles then it's creating something new
10. David: No . . . I have a statement. It's just letting all the air out.
11. Emma: Okay. So you think it's because it's letting all the air out.
12. David: Yes

The evidence of Emma's attention to the substance of student thinking includes her reflecting students' ideas back to the class so that they could be considered by others (5, 8) and similarly with David's disagreement (11). In addition, Emma used this brief exchange as an opportunity to pursue the students' idea that bubbles were a sign of a chemical reaction. There was further evidence in what she wrote later:

> My inclination was to probe the students' association with bubbles and reactions. . . . I expanded on the original example with an additional visualization. This time I took a bottle of cranberry juice and shook it to create bubbles. . . .
>
> [David thought] you could simply see the bubbles more easily when you added water. The water was "letting the bubbles escape from the tablet." David believed that bubbles were already in the tablet and were trapped. I am unsure if he meant this as a physical or chemical reaction though.

Emma's uncertainty over whether David considered the release of the bubbles a physical or chemical change was an example of something she described more generally:

> On the video, I noticed a lot more assertions I could have probed to understand student thinking. However, we did not have enough time with those students I did probe. Hence, I again find myself facing the conundrum of getting through the curriculum as opposed to allowing the students to think independently.

In this way, Emma expressed a tension in objectives reflecting the different agendas of the systems in which she participated. On the one hand, Emma was learning to participate in the practices of the system represented by the credentialing program, which drew specific attention to student thinking and required evidence of student thinking for course assignments. On the other hand, she was learning to participate in the system represented by her school. Under pressure from the science department and administration to keep up with the curriculum, Emma's attention was divided. While she saw the value in attending to student thinking and asking students to articulate their ideas, she was always aware of the time she was taking away from coverage of the curriculum. Emma contrasted "getting through the curriculum" with "allowing students to think independently," suggesting that she experienced curricular expectations as a barrier to desirable learning outcomes.

Kay

Kay's attention was not so divided. By her accounts and by the observations and video data of her work, she attended primarily to classroom management, student behavior, and the correctness of students' answers judged against the canon. The snippet from her class at the beginning of this article was one example. Another was in a lesson on meteorology, when she asked for a volunteer to explain what an isobar was. Briana responded that isobars were "lines on a map joining the same air pressure." "Joining?" replied Kay. "Or connecting," said Briana. Asked later what she thought of Briana's initial response, Kay indicated that she wanted Briana to use the word *connecting* instead of *joining* because *connecting* was the word that Kay had used in defining the term *isobar* for the students. In all, Kay noticed and responded to the fidelity of students' language to the curricular versions; she did not probe for or notice evidence of student understanding, such as of how Briana understood the concept of a line of constant air pressure.

It was only when specifically pressed to comment on the substance of student thinking, in person during seminar discussions or in supervisor meetings, that Kay showed she was able to do so. That she could respond to direct requests—"What do you think the student might have been thinking"—suggests she too had nascent abilities, but there was not evidence of her using them.

Systemic Influences on Attention

Why did Emma come to attend to student thinking but Kay did not? There are many factors that could influence

interns' attention to student thinking, including their academic experiences, epistemological stances toward science and learning, and participation in the systemic contexts (or most likely some complex dynamic of these and other contributing factors). We are interested to understand how different teachers' abilities to attend to student thinking emerge, but an in-depth exploration into the complex dynamic around each candidate is beyond the focus of this article. Here we focus primarily on the role of the systemic contexts in which teaching is learned, the ways in which these contexts influence framing, and how that framing influences teachers' attention.

Kay, in fact, was the only intern to enter the program who did not take the program seminar in the summer before, taught by the first author. Rather, Kay had completed a more traditional initial pedagogy class focused on curricular fidelity and classroom management, and it satisfied the same formal requirement. In other words, when Kay began teaching, there was no tension of objectives or competing influences on her teaching; her coursework and the school directed her attention toward similar issues. As Kay began teaching, her attention was on student behavior and curricular fidelity, and this was only supported by the school system itself.

Emma did, in fact, struggle with classroom management, and for the school system that was the overriding issue. While university faculty and supervisors were concerned about Kay, the school administration was much more concerned with Emma. The assistant principal recognized that Kay's classroom was highly rigid and presented little opportunity for students to articulate their ideas, but she was gravely concerned with Emma's classroom management difficulties. She appeared to assume that Kay would learn to attend to student thinking, possibly influenced by developmental accounts, but treated Emma's management difficulties as a more serious problem. While Kay was left alone, in and out of the classroom, Emma was directed to meet with a staff development person daily to work on organizing her lessons, improving her presentation, and managing student behavior. Her continuing endeavors to engage her students' inquiry and listen and respond to their ideas were not prioritized in these sessions.

This example suggests that the system surrounding public school teaching prioritizes other concerns (i.e., classroom management and content coverage) over attention to student thinking. In this public school context, Kay's difficulty in attending to student thinking was a minor concern, sending the message to Kay that her practice was appropriate and possibly helping to stabilize her framing of teaching in terms of classroom management and curricular fidelity. Viewed alongside the evidence that other novice teachers (e.g., Scott, Susan, and Emma) were able to attend to the substance of their students' thinking, Kay's difficulty, and the lack of concern by the administration, supports reinterpretation of stage-based theories of teacher development, particularly the role of context in shaping what novice teachers do (Loughran, 2006). Our evidence suggests that the systemic context of public school teaching inhibits teachers from framing teaching as attending and responding to students' ideas and reasoning.

We do not doubt in the slightest that it was important for Emma to learn strategies of classroom management. What we challenge are practices of focusing on management and curriculum to the exclusion of substance, as well as the contention that she should first develop routines before she tries to hear and respond to student ideas.

Summary and Implications

In a famous set of experiments, Simons and Chabris (1999) showed research participants various video clips to demonstrate phenomena of "sustained inattentional blindness." In one clip, six students dressed in white or black play with two basketballs, and participants are asked to count the number of times a student in white passes the ball to another student in white. More than half the participants watching the video, with their attention directed on the passes, fail to notice that a person walks into the center of the action wearing a gorilla suit, stands and beats his chest, and walks off. Certainly everyone watching *has the ability* to see gorillas; they fail to see them because their attention is directed elsewhere. Framing the task as "counting passes," they do not notice the gorilla.

The situation with teachers is obviously far more complex, but the gorilla study provides simple, straightforward evidence of how framing can affect attention. Evidence from our case studies adds to existing arguments that novice teachers have abilities for attending to student thinking, but what they notice in class depends in part on how they frame what they are doing. Asked to pay attention to curricular objectives, standards, and their own behavior, it is not surprising that they do not notice the substance of student reasoning. In this section, we argue that this finding has implications both for how we design teacher education and how we understand learning to teach.

While we see some examples of novice teachers (e.g., Kay) struggling to attend to student thinking, we have presented evidence that many novice teachers can begin to attend to student thinking early in their teaching careers. If it is possible even for some novice teachers to

attend to student thinking, then we should make this an explicit agenda in science teacher education by structuring activities and assignments that give them practice in attending to student thinking and help them to frame teaching on these terms. Attending to student thinking is an important first step in providing responsive instruction that can help students construct understanding of scientific concepts, reason scientifically, appreciate the nature of science, and engage in scientific practices.

Absent other influences on their attention, beginning teachers may focus their attention on themselves and their behavior (as suggested by the teacher development literature) rather than on their students and may thus not draw upon their nascent abilities for attending to others. Teacher education programs that focus novices' attention on themselves, through practices such as "self-study" papers, may feed into this pattern. Arguably, as an effort in improving one's teaching practice, self-study could focus on learning to attend to student thinking (Samaras & Freese, 2006), but even the framing of such work in terms of the "self" may distract attention from the substance of students' thinking. Self-improvement of practice should occur in the context of understanding and improving the conditions in which students learn science. To do this well depends on first learning to attend to student thinking because that is the data or "stuff" teachers must work with in considering their practice.

We take a different approach in our science pedagogy course sequence, designing our courses to amplify attention to student thinking by having novice teachers watch videotape of classrooms and analyze data from their own and others' classrooms with an eye toward what students are thinking as they participate in science classes. We also encourage teacher candidates to identify themselves as responsive teachers, who listen and respond to student ideas. Participation in these practices apparently supported novices such as Emma in learning to attend to student thinking in real time, in the classroom. Teacher education should support and amplify novice teachers' nascent abilities to attend to the substance of student thinking.

We have argued that one major reason that novice teachers struggle to attend to student ideas and reasoning is their participation in the social and institutional systems of public schooling, which encourage framings of teaching in terms of classroom management and curricular coverage. As participants both as students and teachers in these systems, novice teachers learn teaching routines that focus on these priorities. For example, Kay's use of triadic dialogue can be thought of as a routine that functions to help the teacher to manage an orderly classroom and maintain authority as the holder of "correct" knowledge.

Routines themselves are not a problem. All teachers form routines in learning to teach. Emma used a routine of reflecting students' meaning back to them for further comment. This "reflective toss" (Van Zee & Minstrell, 1997) is a powerful routine for attending to student thinking. The reflective toss was modeled in the science pedagogy courses, and many of the interns who were successful at attending to student thinking engaged in this kind of dialogue with their students. The point is that routines should be learned from within a framing of teaching as attention to student thinking. We argue that if attention to student thinking is not prioritized until after novices begin to construct routines (as suggested by Kagan, 1992), then novices may construct routines that distract from attention to student thinking.

In short, the systems of traditional science teacher education and public school teaching fail to build on teachers' nascent abilities to attend to student thinking, encouraging routines that are focused on other priorities. A teacher who is not predisposed to think of science teaching in terms of attention to student thinking will not necessarily reconsider his or her practice on his or her own without outside support.

The institutional and social systems of public schooling are themselves complex. Teachers' participation in local communities of practice in their academic departments, for example, can strongly influence their attention (McLaughlin & Talbert, 2001; Siskin, 1990). Strong professional relationships, coplanning, and coteaching with others focused on attention to student thinking may help support novices in learning to attend to student thinking. Scott and Susan, for example, shared a classroom, met daily to plan together, and jointly reflected on lessons in their classrooms. By contrast, Emma and Kay did not have a close professional relationship, and they were not able to offer each other that level of support.

In conclusion, our empirical findings support challenges to stage-based theories of novice teacher development (Davis, 2006; Grossman, 1992) and provide evidence of novice science teachers attending to student thinking from their earliest experiences in the classroom. The evidence suggests an alternative explanation for the observation that novices often fail to attend to student thinking. This is largely a reflection of the ways in which the systems of public school teaching distract from attention to the substance of student thinking, and not inherent developmental limitations of novices. We suggest further exploration into the abilities of novice science teachers in order to better understand the complex dynamic that shapes novices' attention and further inform teacher education practices that can amplify novices' attention to the substance of student thinking.

Notes

1. All names are pseudonyms.
2. Also referred to as I-R-E, for "initiation–reply–evaluation" (Mehan, 1978).
3. We don't agree with Susan's interpretation here, but she does *have* an interpretation.

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