

The Role of Facilitator Feedback in Shaping Teacher Attention and Response to Student

Thinking

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Abstract

Many effective professional development (PD) activities, ranging from video clubs (van Es & Sherin, 2002), to lesson plan critique (Franke, Carpenter, Levi, & Fennema, 2001), to interview assignments (Bautista et al., 2014), promote teacher attention and response to student thinking. That such diverse activities are all fruitful in achieving their respective program goals raises the question: what common mechanisms accompanying these activities enable the success of the PD programs? While there is little research regarding which mechanisms may be associated with increased attention to student thinking (Hill et al., 2013), understanding the characteristics of common PD mechanisms may help future PD developers. The purpose of this paper is to examine the impact of one common PD mechanism: facilitator feedback. Facilitator feedback is one of the few techniques ubiquitous in PD programs and has proven effective in other contexts (Colvin et al., 2009). This paper presents a study of two groups of teacher participants in a PD program to answer the following question: in what ways may facilitator feedback shape teacher attention and response to student thinking?

The Role of Facilitator Feedback in Shaping Teacher Attention and Response to Student Thinking

Researchers have argued that teachers, as experts in the field of education, should be able to attend to important events, such as a student observation of a pattern or an answer that may be incorrect but illustrative, that non-experts may not identify as significant (Jacobs, Lamb, & Philipp, 2010; Levin, Grant, & Hammer, 2012; van Es & Sherin, 2002). More specifically, teachers ideally can attend to context-specific student strategies, use evidence to interpret students' understandings of a specific mathematical concept, and build on their interpretation of students' ideas to craft questions and lessons based on student reasoning. When teachers use these skills, referred to here as "attending and responding to student thinking" or "responsive teaching," they are more likely to teach mathematics for understanding (van Es & Sherin, 2002). Consequently, their students may perform better in mathematics (Jacobs et al., 2010; van Es & Sherin, 2002).

Prior to PD focused on responsive teaching, most teachers evaluate or describe student thinking, rather than interpreting student thought (van Es & Sherin, 2008). Therefore, most PD programs focused on responsive teaching chart an "ideal trajectory" for participants to shift from evaluating and describing student thinking to interpreting and responding to student ideas (van Es, 2011). In order to develop teachers' ability to attend and respond to students' ideas, researchers have asked participants to engage in activities such as analyzing video clips (van Es & Sherin, 2002), critiquing lesson plans (Franke, Carpenter, Levi, & Fennema, 2001), and conducting and interpreting interviews with students (Bautista, Brizuela, Glennie, & Caddle, 2014). These studies found that when teachers analyzed students' mathematical thinking, they increased their focus on students' mathematical ideas. Despite disparities in program activities,

these PD programs have a common mechanism that may influence shifts in teacher focus: they all incorporate feedback as part of their design.

There is reason to suspect that feedback given in PD programs aimed to develop teachers' responsive teaching practices may positively influence teacher attention and response to student thinking. Researchers have documented that feedback, when implemented properly, can increase performance and motivation (Kluger & DiNisi, 1996; Hattie & Timperley, 2007). In education, most feedback research focuses on the feedback students receive from teachers; for example, Hattie, Biggs, and Purdie's (1996) meta-analysis of 196 studies documents that feedback can have as much of an impact on student performance as class size, socioeconomic status, and homework. Since feedback has been proven to be effective for students, it stands to reason that the feedback teachers receive may increase their performance as well. In fact, researchers have shown that teachers may improve their practice after receiving feedback given by administrators during educator evaluation or following routine observations (Gregory, Allen, Mikami, Hafen, & Planta, 2014; Malu, 2015). Similarly, Darling-Hammond (2014) argued that teacher learning is more effective when teachers receive feedback on their lesson plans and assessments, especially when teachers are then given the opportunity to revise. However, the research on the feedback that teachers receive is preliminary; for instance, its effectiveness is often measured in terms of student outcomes on standardized tests or behavior improvement, which may or may not reflect actual increased student learning (Gregory et al., 2014; Khachatryan, 2015). Further, most research focused on feedback for teachers is only in the context of educator evaluation or routine observations, rather than feedback from facilitators in PD programs (Dobbelaer, Prins, & van Dongen, 2013). Because learning is a situated process (Lave & Wenger, 1991), teacher responses

to course facilitators may differ compared to their reactions to administrator feedback. Therefore, special attention must be given to feedback given in PD settings.

The purpose of this paper is to examine two groups of teacher participants in order to answer the following research questions: first, how may facilitator feedback shape a group's ability to attend and respond to student thinking? And second, what types of feedback may be associated with positive growth? Two groups were selected for this analysis. One followed the "ideal" path described by the literature: as they progressed through the PD program, they grew more interpretive and better equipped to respond to individual student mathematical thinking. The other group began the course with a strong focus on student thinking, but their analyses became less interpretive of specific student ideas as they progressed through the course. This paper will explore the nature of the groups' shifts and the facilitators' feedback to determine whether and how the facilitator feedback may have influenced both groups' progression through the PD program.

Background

One aim of this study is to draw connections between research on feedback and on how teachers learn to attend and respond to student thinking. Therefore, in this section I will explore prior research related to responsive teaching in mathematics and research tied to feedback within responsive teaching PD, as well as highlight the theories I will draw from when determining how feedback may have affected groups of teachers' growth over time.

Attending and Responding to Student Thinking

Over the past few decades, much attention has been given to help teachers better attend and respond to students' mathematical thinking (e.g., Fennema et al., 1996; Jacobs, et al., 2010; van Es & Sherin, 2002). As the body of literature on this topic has evolved, researchers have

developed various terms to refer to the act of attending and responding to students' mathematical thinking, such as noticing (van Es & Sherin, 2002, 2008), professional noticing (Jacobs et al., 2010), and responsive teaching (Levin et al., 2012). Each term has its own nuances and the definitions in this work are based on Jacobs et al. (2010). In this paper, I will refer to two skills: attending to students' ideas and responding to students' ideas.

When attending to students' ideas, teachers *identify* (van Es & Sherin, 2008) a piece of incoming data, such as student work or discourse. In doing so, teachers note a moment from a wide range of incoming student ideas to consider in more depth. The moment teachers attend to does not "need to be particularly noteworthy or important" (Sherin & Star, 2011, p. 69); rather, the moment should be specific and tied to the details of a student's mathematical idea or understanding (Jacobs, Lamb, & Philipp, 2010).

After identifying a moment, teachers interpret that moment to make hypotheses about student's ideas and understandings (Jacobs et al., 2011). From the perspective of Schoenfeld (2010)'s decision-making theory, which I will explain in more detail below, teachers' interpretations are shaped by their resources, such as their mathematical knowledge for teaching (Ball, Thames, & Phelps, 2008; Schulman, 1986), and by their orientations, such as a believing that attending to students' ideas is a worthwhile endeavor. Hence, as teachers make interpretations of students' ideas, they draw connections between a specific interaction and "the broader principles of teaching and learning they represent" (van Es & Sherin, 2002, p. 573). Finally, teachers' interpretations should be based on their evidence at hand, as opposed to broad evaluations of student understanding with little empirical support (Jacobs et al., 2010; Mason, 2002). As such, when teachers interpret students' thinking, they ideally should develop multiple interpretations of students' ideas (Jacobs et al., 2010).

After teachers have attended to student thinking by identifying and interpreting a student's idea, they may respond to it. The ways in which teachers elect to respond is context-dependent and should be based on their interpretations of students' ideas; for example, Sherin and Star (2011) suggested using Socratic questioning if a student "seems confused" (p. 70), in comparison to gathering the attention of the class in response to a noisy classroom. My work follows Jacobs et al. (2010) in the belief that there is not a "single best response" (p. 173) to use when responding to students' ideas, instead, the emphasis is placed on alignment between a teacher's interpretation of a student's ideas and the decisions a teacher makes in how to respond.

Feedback in Responsive Teaching Professional Development

While most PD programs aimed at developing responsive teaching practices embed feedback as part of their design, feedback has been utilized in different PD programs in different ways. Although there is not, to date, a comprehensive review of different forms of feedback in responsive teaching PD programs, there appear to be differences in the format (e.g., written or orally); the directness of the feedback (e.g., asking open questions compared to stating the program's agenda); and whether teachers' work is tied to grades, among other differences (e.g., Bautista et al., 2014; Fennema et al., 1996; Sherin & van Es, 2009). For instance, the Cognitively Guided Instruction (CGI) PD program asked teachers to engage in discussion over video clips of individual children solving problems, read the researchers' analyses of the students' thinking, and try the problems they had seen in the videos with their own students. In that program, facilitators "emphasized that the important criteria for making decisions about what and how to teach were children's understandings... that children should not be asked to practice procedures they did not understand, and that the way to find out if they understood was to ask them to

explain their thinking” (Fennema et al., 1996, p. 408). In that case, it appears that facilitators conveyed a specific viewpoint directly to PD participants.

In contrast, Sherin and van Es (2009) organized video clubs that asked teachers to view and discuss video clips of one-another’s teaching. A facilitator helped launch and maintain discussion, but the questions the facilitator posed included ““What do you notice?”” and ““What stands out to you here?”” (Sherin & van Es, 2009, p. 23). Sherin and van Es (2009) wrote that “although the facilitator had in mind the goal of helping teachers learn to attend to student thinking, she was also aware of the importance of providing space for the teachers to discuss issues related to the video that they viewed as significant” (p. 23). As such, the feedback the facilitators gave was indirect; by asking teachers to specifically describe what they had noticed, the facilitators acknowledged the kinds of conversation they wanted to hear but did not explicitly convey an agenda or try to guide participants’ thinking. In this study, facilitators provided written feedback to groups of teachers following the completion of a written assignment, of which there were several over the course of the PD program. The teacher groups received grades for their assignments as well. As such, the feedback offered in this PD program were perhaps more formal than in the previous two examples, as it was given in written form. Additional details of the program will be given in the methods section.

Learning about Reform Practices

The focus of this study is to understand how feedback may influence whether and how teachers learn to attend and respond to students’ mathematical thinking over time. As such, I am drawing from sense-making theory as used by Coburn (2004) and from decision-making theory (Schoenfeld, 2010, 2011), because these theories both help explain how teachers’ practices may change over time.

Coburn (2004) applied sense-making theory to model how teachers enacted new state policies to varying degrees. She described sense-making as an iterative, incremental practice (Coburn, 2004), which starts when teachers become aware of and interpret messages from their environment. After teachers interpret the messages they receive, they place the messages into their existing belief system. Based on these interpretations, teachers may make efforts to “create new practices, patterns of interaction, and ways of thinking that may become institutionalized over time” (Coburn, 2004, p. 214). Hence, messages from the environment become embedded into the fabric of the classroom as they become part of a teacher’s beliefs. Further, because interpreting, creating new practices, and embedding new practices is an ongoing process, past interactions shape teachers’ future interpretations of new messages from the environment (Coburn, 2004). In my analysis, I used sense-making theory to determine how the influence of feedback may have affected groups of teachers’ learning of responsive mathematical teaching.

Schoenfeld’s (2010, 2011) theory of decision making provides a complementary perspective to Coburn’s (2004) sense-making theory, and I also drew upon his theory when analyzing how teachers learned responsive teaching. Schoenfeld (2010) argued that most teachers’ decisions are born from their orientations, goals, and resources. Schoenfeld (2011) defined resources as a teacher’s “knowledge, but also include[s] the social and material resources that are available to him or her... [and] personal and interpersonal skills and connections” (p. 459). Goals are both conscious and unconscious acts that teachers hope to accomplish, whereas orientations include “beliefs, values, preferences, and tastes” (Schoenfeld, 2011, p. 460). In this model, the interplay between goals, orientations, and resources shape teachers’ iterative decision-making process. In my analysis, I would hope that teachers would set goals based upon their

experiences and resources that aligned with responsive teaching and would make decisions that built upon students' mathematical ideas.

Methods

I will begin this methods section by detailing the PD program and the participants that are the focus of this analysis. I will then explain how I used sense-making theory to help me determine the ways in which feedback may have affected teachers' learning of responsive teaching methods.

Professional Development Program

This PD program was a year and a half in duration with sixty-three participants. It was designed to deepen teacher understanding of algebraic concepts and to develop teacher attention and response to specific student mathematical thinking. Participants were drawn from several districts across three neighboring states in the northeast region of the US and ranged from fourth through ninth grade teachers. The program was divided into three graduate-level courses, each lasting one semester (thirteen weeks) and consisting of both online and in-person components. Each course was further subdivided into four three-week units. Two of the three weeks had a mathematical focus. The math content-specific units were conducted entirely online; as they completed individual assignments, teachers participated in online forums to collaborate with peers and facilitators. By contrast, the third week consisted of an assignment that focused on student mathematical thinking. These assignments were referred to as *Engaging Students* assignments. Teachers worked in groups at the school level and met face-to-face with facilitators to discuss their findings once per month. Figure 1 displays a diagram of the PD program's structure.

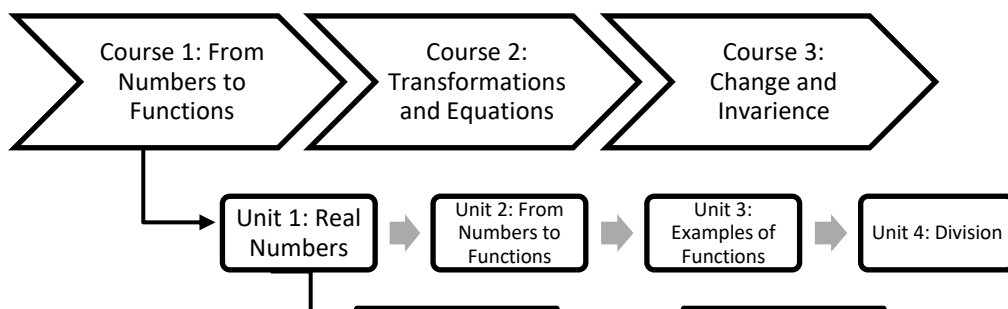


Figure 1. Course Layout. This diagram illustrates first course topics and the structure for unit 1.

Participants were divided into 26 groups for the *Engaging Students* assignments. Teachers were asked to complete nine interview assignments as part of the program, or approximately three each semester. The other *Engaging Students* assignments asked teachers to analyze videos of facilitators teaching a lesson to students from prior research projects. Interview assignments were designed to run approximately 10 to 15 minutes and the interview tasks were primarily generated by the research team, although some were designed by the teachers themselves. Teachers were encouraged to frame their interviews as “clinical” in nature (Ginsburg, 1997); in other words, teachers were instructed to initially elicit their students’ ideas, ask questions based on student responses, and push them to elaborate. The goal of the assignments was to aid teachers in their ability to understand and describe their students’ thinking. By asking teachers to do this, the hope was to encourage teachers to gain insight into what students *do* know about a topic, rather than leading students to a “correct” answer using direct instruction or “leading questions.” The teachers were also asked to be specific. Rather than describing what students understand generally (e.g. “The student doesn’t understand fractions”), the program goal was for the teachers to describe and interpret their students’ thinking in detail by analyzing small clips of transcript and student work. 2 shows a sample interview task.

Show the student a copy of the number line... where only the 0 point appears in the line. Then ask the student to place, on the same number line, each one of the fractions in the set. For each set of fractions, ask the student to place one fraction at a time, all on the same number line.

- For students who are not yet familiar with fractions, ask: “Where could you place $\frac{1}{2}$, $\frac{1}{4}$, $\frac{2}{4}$, $\frac{1}{3}$, and $1\frac{1}{2}$ on the number line?”
- For more advanced students, ask: “Where could you place $\frac{1}{5}$, $\frac{2}{5}$, $\frac{2}{3}$, $\frac{4}{5}$, $\frac{2}{10}$, and $\frac{4}{7}$ on the number line?”
- For even more advanced students, ask “Where could you place $\sqrt{2}$, $\frac{3}{2}$ and $\frac{4}{5}$ on the number line?”

Figure 2. Interview task from Course 1, Unit 1.

After participants had completed and transcribed their interviews, they worked in small groups to analyze the data they had collected. In each assignment, teachers were asked to describe students’ initial ideas and how their ideas changed, the effect of teachers’ questions on students’ answers, follow-up questions they could propose to students, and the interview’s relevance to teaching. Teachers were required to supply evidence from the transcript or include photographs of student work to substantiate any claims that they made. Hence, the interview task was deeply connected to the program goal of fostering a focus on attending and responding to student thinking. The assignment explicitly asked teachers to identify specific student ideas, to interpret these moments and justify their claims with evidence from the interview, and then to respond to students’ ideas by reflecting on how their questions may impact their students’ thinking, as well as to generate follow-up questions and activities to respond to student ideas. Finally, starting in the second course, teachers were asked to reflect on the feedback they received from facilitators from their previous *Engaging Students* assignment. The research team decided to add this component to the assignment because the team was unsure as to whether teachers read the feedback they had received.

Teachers then received feedback from course facilitators on their assignments. As the program progressed, teachers were required to respond to the feedback in writing. Although the

feedback structure varied among course facilitators, it often consisted of an overall summary paragraph followed by specific comments inserted directly into the teachers' assignments. Because the purpose of the *Engaging Students* assignment was to encourage teachers to more closely attend and respond to specific student thinking, the goal of facilitator feedback was to provide questions and comments aimed at developing that focus. Hence, facilitators might question a group's broad description to help them identify a specific moment, challenge a group's evaluation to foster a more in-depth interpretation, or encourage the group to ground their future questions for students in their interpretations of their students' ideas. I will provide examples of feedback given to the teachers of this study in the results section.

Participant Selection

Two groups were selected for this study in order to illustrate the divergent ways that teachers may change as a result of course feedback. They were selected not because they are necessarily representative of the entire cohort, but instead to demonstrate possible changes in attention to student thinking that may occur (e.g., Charmaz, 2014; Nemirovsky, Kelton, & Rhodehamel, 2013). The first group, from the Campton Public Schools (pseudonym), was selected because they followed the "ideal path" as described in the literature: as they progressed through the program, they grew more attentive and responsive to specific student ideas generated in the interviews. Conversely, the second group, from the Ashland Public Schools (pseudonym), initially demonstrated the ability to attend and respond to student thinking; but this ability grew less apparent in their assignments as the program progressed. Both groups were comprised of two middle school teachers in districts located in the Northeast. However, teachers from Campton taught in a smaller, somewhat more affluent district—Campton's district held 4,104

students and 6.8 percent of families below the poverty line, whereas Ashland's district held 5,986 students and 9.7 percent of families were below the poverty line.

Both groups were comprised of a team of a professor and post-doc to provide them feedback. In both instances, the facilitators were familiar with the goals of the PD program, had helped in the development of the program and/or assisted with creating materials or generating research about its effectiveness. The data selected for this paper were from the second cohort of teachers; many of the facilitators who provided feedback for the second cohort had also provided feedback for the first cohort and had other, prior experience working with in-service or pre-service teachers.

This work stems from the belief that learning is a socially constructed process (e.g., Cobb, 2006). As such, when analyzing whether and how teachers demonstrated shifts in how they attended and responded to student thinking, I considered teacher learning at the group level. There are limitations to this perspective, as individual learning may vary from group learning (e.g., Bautista et al., 2014). However, this work draws from prior research on group-level change, where the emphasis is on whether and how groups may have shifted over time (e.g., van Es, 2011).

<i>Engaging Students Assignments</i>			
	Course 1	Course 2	Course 3
Unit 1	Researcher-Designed Interview Task Interview Assignment 1	Researcher-Designed Interview Task Interview Assignment 4	Researcher-Designed Interview Task Interview Assignment 7
Unit 2	Video Clip Analysis	Video Clip Analysis	Video Clip Analysis
Unit 3	Researcher-Designed Interview Task Interview Assignment 2	Researcher-Designed Interview Task Interview Assignment 5	Researcher-Designed Interview Task Interview Assignment 8
Unit 4	Teacher-Designed Interview Task Interview Assignment 3	Teacher-Designed Interview Task Interview Assignment 6	Teacher-Designed Interview Task Interview Assignment 9

Note: Assignments selected for analysis are in bold

Data Selection

Table 1 shows which assignments were included for analysis in this paper. In order to control for the impact of the interview task design, only assignments with a facilitator-designed interview task were selected. As shown in Table 1, each course ended with a teacher-designed interview task; these assignments were excluded from analysis. The first assignment submitted by each group in Course 1 was selected to determine the initial level of attention each group gave to student thinking. The third assignment in each unit was selected for analysis, as it provided data regarding how the groups had changed by the end of each course. The feedback that Campton and Ashland received following each assignment was also analyzed to determine similarities and differences in the feedback received by each group.

Data Analysis

The goal of this paper is to give context-dependent insight into specific cases, as opposed to producing “high level theory” (Flyvbjerg, 2006, p. 223). This is a worthwhile goal because it is essential to consider a breadth of cases *before* developing more general theory, and cases themselves are useful for producing a more “nuanced view of reality” (Flyvbjerg, 2006, p. 223).

This paper contributes to the literature by illustrating two cases that sit at the intersection of research focused on professional development and feedback.

In order to capture how Campton and Ashland shifted over the course of the program, I drew from Coburn (2004). Coburn (2004) sought to determine the ways in which three Californian teachers adopted state literacy reforms, as well as the factors that may have influenced teachers' decisions. As such, she compared teachers' actions to the wider historical timeline of California's changing literacy policies to see how four influences, which she called factors, may have affected how teachers enacted state literacy reforms. Coburn (2004) observed teachers, wrote oral histories of the teachers' careers, and analyzed state documents, and when she analyzed the data, she coded influences mentioned by teachers. She used those codes to identify the four most prevalent influences (congruence, intensity, pervasiveness, and voluntariness, in her study), and then identified patterns in the data between the influences and teachers' classroom practices. In this study, I already identified the influence I wanted to explore—facilitator feedback—but used her approach to look for patterns between the feedback and teachers' decisions around attending and responding to students' ideas over time.

Like Coburn (2004), I sought to describe the ways in which the teachers changed over time, although my focus was on whether and how they attended and responded to students' ideas in their written reports. To begin, I summarized both the assignments themselves and the feedback given to Campton and Ashland using Geertz's (1973) "thick description" technique. I chose this technique for its ability to provide a detailed description of the data as the groups evolved over time. While this technique has been used to describe observations in the field (e.g., Gertz, 1973), it has also been used to describe written work (e.g., Bautista et al., 2014). In this way, I was able to explore the research question at hand: in what ways may facilitator feedback

shape teacher attention and response to student thinking? Because I was interested in how the groups and facilitators may have attended and responded to student thinking in their assignments and feedback, my “thick description” focused on specific moments in the assignments and feedback when the groups or facilitators discussed student ideas. When I highlighted these moments in my description, I noted whether each moment was analyzed in an *evaluative*, *descriptive*, or *interpretive* manner (van Es, 2011; Jacobs et al., 2011). *Evaluative* analysis refers to making a general judgement on student ideas with little evidence to substantiate the claim, *descriptive* analysis offers some evidence but with little accompanying discussion; and *interpretive* analysis includes specific, evidence-supported claims about the moments selected in the interview and provides multiple interpretations of student work and talk (Jacobs et al., 2010; van Es, 2011). See Table 2 for examples of evaluative, descriptive, and interpretive analysis. One intent of our PD program was to enable teachers to provide more interpretive statements and fewer evaluative statements.

Table 2

Examples of Evaluative, Descriptive, and Interpretive Analysis in Group Assignments

Type of Analysis	Example	Explanation
Evaluative	“By looking deeply into these students’ understanding and misconceptions, we believe that neither have very good number sense.” (Campton, Course 1, Unit 1)	The Campton teachers evaluated their students’ entire mathematical understanding (“number sense”) based on their students’ attempt at the fractions task, rather than describing specific ideas that their students do have.
Descriptive	The student and teacher “talked about the graphs and decided that the lines should never go ‘down’ because that would mean money was being taken out... later in the discussion [the teacher] talked with [the student] about why all of her lines ended up on top of the graph” (Ashland, Course 3, Unit 3)	While Ashland did include somewhat specific moments from the interview here, they did not interpret what the student may have been thinking based on the student’s answers. Instead, Ashland provided a description of the interview as a whole.

Interpretive	<p>“Although this student is not remembering conceptually what the numerator and denominator stand for, she is still realizing/remembering that a fraction represents a part to whole relationship” (Ashland, Course 1, Unit 1)</p>	<p>This excerpt from Ashland’s first assignment follows a short transcript clip from their interview. Ashland selected a specific moment from their interview and used it to showcase their interpretation of student thinking: that while the student may not be able to entirely complete the fractions task, the student demonstrates some understanding of fractions properties, which they explain in detail in this clip and throughout their paper.</p>
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For example, I summarized Campton’s first assignment by writing that “Campton’s analysis consisted of a blend of specific moments and generality, while remaining focused on their students’ conceptual understanding versus whether their students could follow a procedure.” The purpose of producing this summary was to be able to concisely compare the ways in which each group changed across all four assignments.

I wrote thick descriptions for the facilitators’ feedback in a similar fashion. My intent was to capture themes from the facilitators’ feedback, rather than critiquing it or determining whether it correlated with known characteristics of effective feedback. For example, I summarized one piece of feedback given to Campton by one of their facilitators, Charles, by writing:

Charles’ comments on Campton’s analysis begin very positive... He gave some specific feedback by highlighting and generally explained why he suggested what he suggested, as well as giving positive reinforcement when he saw things he liked (giving examples, reflecting on questions asked). He tended to push the teachers to focus less on correctness and to deemphasize the role of leading questions. Towards the end, he [asked] the teachers to reflect on specific questions that he may have thought were too leading.

In this example, I noted that Charles exercised some characteristics of effective feedback—specificity, reinforcement, and alignment with course principles (Hattie & Temperley, 2007)—but that was not the focus of the summary. Rather, it was to capture the essence of Charles’ comments to allow for the comparison between his statements and the changes that occurred in Campton’s assignments.

Finally, I sought to compare the groups’ assignments to the feedback they had received. I went about this in two different ways. I created a table for each group that highlighted key characteristics of that group’s assignment from the summary, in conjunction with a high-level summary of the feedback they received for that assignment (see Tables 3 and 4). In addition, I collected all selected assignment and facilitator feedback summaries and condensed them into a second narrative for each group. When producing the second narrative, I first placed descriptions and summaries into one document. From Tables 3 and 4, as well as the second narrative, it was apparent that assignment 1 and 2 results were similar enough to exclude one of them. Campton still primarily evaluated and described their students’ ideas, whereas Ashland continued to analyze student thinking in-depth. Because assignment 1 had been selected to demonstrate how groups initially performed on the task, I eliminated the analysis of assignment 2.

Creating the tables allowed me to have a broad view of the changes that occurred over the course of the PD program, whereas the narrative gave me a more nuanced view of the changes that occurred. Together, the tables and narrative enabled me to compare the summaries of the groups’ assignments to their feedback to examine how feedback may have played a role in the shifts that occurred between the assignments. In doing so, I looked for patterns between the feedback each group received and the ways in which they analyzed their students’ thinking in their subsequent assignments.

In the following section, I will describe how the two groups, Campton and Ashland, changed over time in the context of the feedback they received.

Results

In this section, I will argue that Campton grew more attentive and responsive to student thinking over time, in part because their facilitators, Charles and Jenn, maintained a focus on specificity and providing feedback on the group's interpretations of what students understood in the interview in a particular moment. Conversely, Ashland began the course demonstrating the ability to attend and respond to specific student strategies, but over time their analyses grew less focused on specific student ideas. As I will illustrate, this may be related to their course facilitator, Sarah, who provided many of her own interpretations of the interview data not grounded in specific moments of student thinking.

I will first describe how the Campton teachers' assignments changed over time in relation to their facilitator's feedback and then describe Ashland's assignments and facilitator feedback. I will begin each section with a table that summarizes the changes that occurred over the course of the PD program, and then provide more detail regarding the changes that occurred over selected assignments. The purpose of providing these descriptions of the assignments and feedback is to provide evidence with which to argue that facilitator feedback may influence whether and how a group's attends and responds to student thinking.

Campton

Table 3
Summary of Campton Changes and Feedback Received

	Course 1, Unit 1	Course 2, Unit 3	Course 3, Unit 3
Attending to Student Thinking	<ul style="list-style-type: none"> • Evaluative and Descriptive • Focused on correctness 	<ul style="list-style-type: none"> • Descriptive and Interpretive • Identified specific student ideas to explore 	<ul style="list-style-type: none"> • Descriptive and Interpretive • Interpretations were lengthier than in Course 2

		<ul style="list-style-type: none"> • Focused on correctness 	
Responding to Student Thinking	<ul style="list-style-type: none"> • Response appears not grounded in student thinking 	<ul style="list-style-type: none"> • Proposed follow-up questions based on interpretations 	<ul style="list-style-type: none"> • Connected students' ideas to interview questions • Reflect on how they can ask better questions to illuminate student thinking
Feedback Given by Course Facilitator	<ul style="list-style-type: none"> • Asked Campton to increase specificity in analyzing student thinking, to consider what students do understand, and to reflect on the role that interviewers' questions may have on students' responses 	<ul style="list-style-type: none"> • Encouraged teachers not to "push" students to the solution, but to ask questions that illuminate student thinking 	<ul style="list-style-type: none"> • Asked Campton not to "push" students to the solution, but to ask questions that illuminate student thinking

As illustrated in Table 3, Campton began the course primarily focused on evaluating whether their students had a “correct” understanding of a concept and proposed responses that were not grounded in their students’ ideas. As the PD program progressed, they became more descriptive and interpretive, as well as considering how the questions they asked may influence student responses and how they could ask more open-ended questions. The feedback Campton received may have encouraged them in this direction, as their facilitators Charles and Jenn asked them to attend more specifically to students’ ideas and try to identify what students did understand, as well as to consider the role that the teachers’ questions may have had on students’ understanding. As such, by the end of the PD program, Campton appears to have shifted towards using the approach intended by the PD program: specific interpretations of students’ ideas alongside reflections on questions one may ask to further understand student mathematical

thinking. To better illustrate this shift, I will describe Campton's initial assignment, their course 2, unit 3 assignment, and course 3, unit 3 assignment, alongside the feedback they received. This description is based on the narratives I developed from the data and also contains quotes directly from Campton and their facilitators.

Course 1, Unit 1. In their first assignment, Campton teachers asked their students to sort fractions on a number line (see 2). The group primarily used a mixture of evaluations and descriptions in their first analysis, but a notably strong moment featured a brief interpretation of one student's difficulty with fractions. Campton wrote that the student "understood that different fractions represented specific positions on the number line, however was not able to correctly determine the order, or relative magnitude of the fractions," and included a piece of interview transcript and student work to justify their interpretation. Yet, rather than extensively analyzing that one moment, Campton concluded by writing that "we found the student's lack of consistency even within his own (sometimes incorrect) rationales surprising and frustrating." Therefore, while Campton gave specific examples at times, they also provided a more general evaluation of student thinking as opposed to interpreting what the student did understand.

Campton's suggestions for follow-up questions were not grounded in student thinking. Instead, they wrote that "in working with the student in the future, the first steps would be to ascertain where the holes are in his understanding and help the student fill in those gaps." Campton did not specify how they would determine the "holes" in the student's understanding, nor did they explain how they would utilize the information they had gathered from the interview to help shape future instruction. Rather, the Campton teachers' future goal appeared to be to provide remediating instruction.

Charles provided Campton's feedback for the first and second course. He wrote, "You suggest that the interviewees lack a strong number sense in relation to fractions and fractional relationships... what do you mean exactly by 'number sense' in each specific case?... You talk about students' lack of consistency. We would like to suggest a slightly different notion, 'local consistency,' which can certainly be observed in your transcripts." This is an example of how Charles often suggested focusing on what students *do* understand and discussing their thoughts specifically, rather than evaluating students in terms of correctness. His critiques are aligned with the program goals of developing teacher attention to specific mathematical thinking, as he asked the teachers to describe student ideas in detail.

Charles proposed a few interview follow-up questions as well, perhaps to encourage Campton to use their interpretations of student thinking to inform future questions and lessons. He made the request to include "a little section to 'criticize' your work as interviewers, reflecting on things like what other questions you could have asked, or questions you think you should have asked differently, issues you think you should have explored further or taking a different approach, etc." Finally, Charles requested, "Even though the assignment doesn't require this, in upcoming [interview assignments] we would like to read your ideas about how what you've learned from this interview will impact your teaching practices (if at all)." By asking the teachers to consider how the questions they asked affected the interview and what questions they might ask in the future in a teaching context, Charles appeared to try to shift the group's response to be more grounded in student thinking. Again, this is aligned with the PD program goal of increasing teachers' attention and response to student thinking. In summary, Charles' comments were primarily attuned to fostering a more specific interpretation of student thinking, promoting a

stronger focus on what students *did* understand, and on increasing the frequency of group reflection on questions.

Course 2, Unit 3. Teachers asked students to solve equations in the Course 2, Unit 3 interview assignment. For instance, students were given the situation that “Joe has 3 boxes of candy. Each box has the same number of candies in it. Sandy has 1 box of candy. Her box has the same number of candies as in each of Joe’s boxes... Joe has the same number of candies as Sandy.” Students were then asked to determine how many candies each child had.

As with their assignment in Course 1, Campton described many moments in their write-up for the Course 2, Unit 3 interview assignment. However, their assignment is much more specific and interpretive than previous work. For instance, they wrote, “We believe that [the student’s] willingness to work with this intermediate step [of writing expressions for each part of the problem before writing an equation] indicates her understanding of the equivalence of the first expressions to the new ones, as she wrote them below.” They substantiated their claim with images of student work and lesson transcript. Also, rather than evaluating their students’ “lack of understanding,” they described and interpreted what the students shared in the interview. For instance, they wrote that “despite being unconventional, we think this actually demonstrates good understanding.” This moment perhaps demonstrates that Campton had attended to Charles’s feedback: rather than describing what their students did not understand, they looked beyond conventional solutions to interpret student understanding. This follows repeated examples and requests from Charles to consider alternative interpretations of their students’ thinking.

In addition, Campton’s comments demonstrate their ability to reflect upon the influence of their questions on student responses: one teacher “admits to being frustrated at this point in the

interview and agrees that, in retrospect, it would have been much more powerful if she could have found a way to have [the student] reach this conclusion on his own.” Charles had requested for Campton to include such statements. Along with fulfilling Charles’ request to analyze the impact of their questions on their students, Campton built upon student thinking by proposing follow-up questions and describing how the insights they gained from the interviews would shape their teaching. They wrote, “We hope to change our approach with future students from where we feel we are currently: ‘Here’s an equation & here’s how we solve it.’ To where we would like to be: ‘Here’s a situation, let’s model it with an equation and then solve it keeping the situation in mind!’” Campton made this reflection after witnessing the students’ success with solving the problem within the context of the situation, despite their students’ difficulties with more traditional middle-school algebra problems.

Campton’s Course 2, Unit 3 assignment demonstrated increased attention and responsiveness to student thinking. They provided more evidence and interpretations based in their transcript, rather than general, unsupported evaluations. Their claims emphasized a focus on what students did understand, rather than on “gaps,” and they provided follow-up questions and activities based on the knowledge they gained from the interviews.

Charles’ comments on Campton’s assignment began by providing validation for Campton’s interpretations and often explained why he appreciated their claims; for instance, he wrote that “I agree with your interpretation... I like... that you include quotes from the students within your analysis. This helps support your claims.” Charles provided positive reinforcement for teacher reflection on questions as well: “I totally agree with your self-critique here... obviously, it’s very easy to see this in retrospect but difficult to realize when you are ‘there’, conducting the interview. So don’t worry about it!” Hence, many of Charles’ comments focused

on reinforcing the inclusion of interpretation, substantiated by evidence. Charles' comments align with the PD program goals, as he was reinforcing the kind of analysis that the PD program is aiming to develop: one that focuses on a specific interpretation of student thinking.

Charles also continued to give constructive criticism. When the teachers commented that one of the students found the correct answer after some "pushing," Charles wrote, "This is great, but as you guys know, [it] is not the most important goal of the interview. If the student finds the solution, great. Otherwise, please don't stress about it. Ok? The most important thing is that you learn stuff about your students' thinking." Later, Charles gave feedback on the questions the teachers asked, writing the comment "maybe this was too much guidance?... what do you think?" Charles' comments regarding questions teachers asked appear primarily focused on shifting the teachers' view from guiding their students to the "correct" answer to gaining access to student thinking through the interview process – again, a goal aligned with the PD program's emphasis on exploring student thinking rather than correctness. Furthermore, because Charles reiterated that "the most important thing is that you learn stuff about your students' thinking," and then gave feedback on the questions asked to illuminate how the teachers could modify their questions to better gain access to student thinking, Charles may have helped the teachers to identify important moments and to respond to them with student thinking in mind.

Course 3, Unit 3. Finally, teachers asked students to graph the following scenario for their Course 3, Unit 3 interview: three cousins needed to raise money for their grandmother's birthday. One cousin set aside the same amount every month, one cousin set aside only a little at first, but then saved more as time went on, while the last cousin saved a lot of money initially, but not as much towards the end. They all saved \$1000 by the end of six months.

Throughout their assignment, Campton made claims regarding student understanding and described how student ideas changed in relation to questions posed by the interviewer. For instance, they wrote that one student “had a seemingly easier time accessing the information to produce the graphs. He chose to graph Patty's data first, because he could identify the constant rate of deposit as the easiest to work with. He initially believed he should create a graph of time vs. deposits, which looked like this... After a brief discussion... [the student] understood that he should have graphed Patty's savings over time, not her deposits.” This excerpt illustrates how, by the end of the PD program, Campton was able to make claims (e.g., “he could identify the constant rate of deposit”), substantiate them with evidence, and correlate students’ ideas to the discussion and questions posed. This excerpt is just a small piece of a longer analysis of the student’s thinking and typifies the deep level of interpretation apparent throughout the assignment. The lengthy exploration of student thinking might reflect Charles’ continued requests for more information and explanation. It also corresponds with the type of analysis that the PD program hoped to develop, as it identified and interpreted specific moments of student thinking.

In Course 3, Unit 3, Campton annotated their transcripts with specific comments denoting what they could have done differently, as requested by Charles. For instance, they reflected that “I should have asked her why she was placing the points where she was.” They included many such comments, as well as proposals for follow-up activities. For example, they wrote that one teacher “wishes she had probed deeper into [the student’s] claim that visualizing the graphs as smooth curves was easier for him than a step function, since she expected the opposite. She could have spent some time trying to ascertain why, and then perhaps used that conversation as a springboard.” Campton appeared to be highly attuned to improving their response to student

thinking in this moment, building on a specific moment in the interview that confused them to determine exactly what the student was thinking and then discussing how they might respond to it.

A different facilitator, Jenn, provided the feedback for the third course. Jenn, like Charles, reiterated the purpose of the interview task: “the goal was NOT to get students to do something specific, or ‘correctly’ (so there was nothing that she was ‘intended to produce’), but to see what they do intuitively.” This is comparable with Charles’s previous requests to focus on student understanding, not correctness. Therefore, Jenn appeared interested in enabling the teachers to provide more specific interpretation of the interviews in order to better describe what the students understood.

Jenn also provided specific feedback about the questions that the teachers asked, writing, “I do think that because there was much leading, the students did not reveal to you as many of their intuitive ideas. We usually get many different unconventional graphs that reveal students’ intuitions. This one is a great example. It shows so much: [the student] is thinking of deposits, not money accumulated; he understands that the same amount is deposited each month, etc.” Jenn primarily critiqued without offering alternative questions to pose, but she did occasionally offer suggestions. For instance, she wrote that “here I wonder what [the student] would have said if you had asked him where in the graph it shows information that Patty deposited the same every month... I wonder what parts of the graph he might have pointed to show this difference.” Therefore, Jenn was focused on how the teachers responded to students’ ideas, and also gave feedback on the questions and activities Campton proposed. Like Charles, Jenn appeared aligned with the PD program’s goals: she requested that the group be specific in their attention and response to student thinking and to focus on what students did understand.

Ashland

Table 4
Summary of Ashland Changes and Feedback Received

	Course 1, Unit 1	Course 2, Unit 3	Course 3, Unit 3
Attending to Student Thinking	<ul style="list-style-type: none"> • Interpretive • Focused on what students understood 	<ul style="list-style-type: none"> • Descriptive and Interpretive • Identified specific student ideas to explore • Focused on correctness 	<ul style="list-style-type: none"> • Descriptive • Focused on what students understood
Responding to Student Thinking	<ul style="list-style-type: none"> • Discussed teaching implications 	<ul style="list-style-type: none"> • Proposed follow-up questions based on interpretations 	<ul style="list-style-type: none"> • No discussion of how to respond to student thinking
Feedback Given by Course Facilitator	<ul style="list-style-type: none"> • Facilitator provided additional interpretations of student data; interpretations were of large grain-size, in contrast to the PD program’s focus on identifying and interpreting specific moments of student thinking 	<ul style="list-style-type: none"> • Facilitator provided additional interpretations of student data; interpretations were of large grain-size 	<ul style="list-style-type: none"> • Facilitator provided additional interpretations of student data; interpretations were of large grain-size • Provided interpretations of how Ashland’s questions affected students’ responses in the interview

As shown in Table 4, Ashland initially interpreted students’ understanding from their interviews, focusing on what students understood and discussed teaching implications based on their interviews. However, as the PD program progressed, they became more descriptive to provide an overview of the entire interview, rather than identifying and interpreting specific moments as was the goal of the PD program. In addition, they did not provide any reflections regarding how to respond to students’ ideas in their last assignment. The facilitator’s feedback may be associated with these shifts; as will be explained in more detail, their facilitator Sarah offered additional interpretations of the student interview data. However, the kinds of

interpretation she offered did not necessarily align with the PD program's design; rather, she made claims regarding student understanding of a large grain-size and drew evidence from across the interview data. As such, Ashland perhaps tried to mimic her approach by drawing evidence for their own analysis as the PD program progressed, but they did not make the kinds of large-scale claims that Sarah made. Instead, their analyses became increasingly descriptive. To better illustrate this shift, I will describe Ashland's initial assignment, their course 2, unit 3 assignment, and course 3, unit 3 assignment, alongside the feedback they received. This description is based on the narratives I developed from the data and contains quotes directly from Ashland and their facilitator.

Course 1, Unit 1. In the fraction sorting task, Ashland selected just a few specific moments from their interview and used them to shape their entire analysis. Their interpretations were grounded in the moments they selected instead of general claims; for instance, Ashland wrote, "Although this student is not remembering conceptually what the numerator and denominator stand for, she is still realizing/ remembering that a fraction represents a part to whole relationship. In this last excerpt from the student we also realized that she was mixing some of her knowledge of fractions with decimals and measurement." In this moment, Ashland tried to tease apart exactly what this student understood based on what she said in the interview, emphasizing what the student *did* understand ("a fraction represents a part to whole relationship"). They also placed the student's knowledge in the broader classroom context, recognizing that the student was "mixing some of her knowledge... with decimals and measurement." This stands in contrast to Campton, who described their frustration with their student's seeming "inconsistency." Ashland wondered "whether or not she was mixing these ideas conceptually, or was it a question of linguistic mastery. Did she think of the number line as

a ruler, or did she have no other vocabulary for the ‘little bits’ other than centimeters or decimals?” In this moment and throughout the assignment Ashland proposed multiple interpretations of a portion of their interview and demonstrated their ability to interpret student talk.

Ashland also offered follow-up topics grounded in student thinking and provided rationale for each suggestion. While they did not list specific questions, Ashland included thoughts such as, “It wasn’t until [she] had transcribed her interview and reflected over the student work did she realize the student’s use of words like ‘decimal’ and ‘centimeters’, and ten bits in every whole when referring to the wholes and bits of fractions and how to order them. If she had caught this during the interview she would of like[sic] to explore this connection in the student’s thinking.” They concluded by justifying their suggestion, writing that, “because of language acquisition, we can’t be sure whether she was mixing different conceptual models/tools, or whether she didn’t have other mathematical language to express her thinking.” Ashland narrowed their focus to a perplexing moment in their interview: why was their student using such a range of vocabulary, and what might it imply about their student’s overall understanding? They explained what they hoped to learn about their student’s understanding and why it was important, which demonstrates that Ashland could respond to student thinking with considerable thoughtfulness as well.

Their course facilitator, Sarah, praised the group’s attention to student thinking: “You carefully consider possible explorations for students’ incorrect answers to the task and identify moments when you could further probe the students’ understanding. In the interviews you showed attention to students’ thinking, trying to understand what students do know even when they could not accomplish the task.” Sarah was more mathematically focused than Charles and

more frequently offered her opinion; for instance, she argued that the student developed her “own system” of fractions. This claim is problematic because it is a larger grain size than the interpretations sought by the PD task description. Sarah substantiated her claim by selecting moments from across the interview, rather than one specific moment. Hence, her feedback deviated from the PD task description, which instructed teachers to narrow their attention to a few specific moments from their interview for analysis.

Sarah also acknowledged the potential usefulness of Ashland’s follow-up questions, writing that, “We agree that exploring ways to connect her understanding of the decimal system to the representation of fractions would be a worthwhile follow-up.” She suggested other areas of exploration, writing that “it would have been interesting and helpful to also explore in your report how their previous experience with the metric system could be an asset towards understanding how fractions can be represented on the number line.” Sarah explained why this would be a useful task and how the group might go about implementing such an activity. In this instance, Sarah’s feedback was aligned with the PD program’s focus on responding to specific student ideas.

Course 2, Unit 3. The Course 2, Unit 3 interview task asked students to write and solve equations in a real-world context. Like their first assignment, Ashland’s assignment included detailed interpretations of just a few selected moments from the interviews. For instance, they described that when their student saw “the 3 unknown boxes written as $a \times 3$ (as opposed to $3a$) [it] tripped her up in knowing how to solve. $A \times 3$ made more sense to her as a representation of the situation, but because she is more familiar with solving equations when multiple variables have a numerical coefficient, she couldn’t make this jump on her own.” The group provided quotes from the transcript as well as student work to substantiate their claim that because the

notation was different, the student “couldn’t make this jump.” While Ashland continued to offer primarily interpretive analysis, they did not provide multiple interpretations for this or any other selected moment, which demonstrates a slight shift from the first assignment.

While Ashland did deviate slightly from their previous assignment in their attention to student thinking, the major difference was in how Ashland responded to the ideas generated in their interviews. Rather than discussing follow-up questions for the students they interviewed, Ashland discussed possible consequences for their teaching practices: “Reflecting on prior Algebra lessons, [the teachers] are both not sure they have ever shown kids how to go from pictures to writing an equation for the same problem. Through this interview [we] see how important this critical step is for kids to see and make the connection. We also see how we sometimes take for granted that students understand that different ways of representing the same situation mean the same thing.” They described how the interview helped illuminate this for them, noting in the end that “We need to bridge this gap for our students.” Ashland had not previously made connections to their teaching practice and such a reflection had not been requested by their course facilitator. Instead, this may have been prompted by a slight shift in the written assignment description prepared by the PD program developers. Starting with the second course, teachers were asked to address “potential implications” of the interview on their teaching. Their reflection could have also been influenced by the seeming relevance to their classes; it appears that this task particularly resonated with Ashland and issues they noticed in their classroom. Regardless, Ashland demonstrated a significant degree of reflection about their practice grounded in their interviews.

In her feedback, Sarah highlighted the points that Ashland made and noted that they were “right on target.” She noted that “you mention: the use of letters as a variable, an unknown, or a

solution; how different representation (x^3 , $3x$, $x+x+x$) may not be seen as the same by the students..." By making a list of the claims she agreed with from the analysis, Sarah continued to demonstrate her attention to interpreting students' mathematical ideas. Yet, by listing all claims in such short order, Sarah's feedback might have modeled identifying many moments and briefly interpreting these moments, a goal that was only partially aligned with the aim of the PD program and one that does not promote a deep exploration of student thinking. Later, whereas Sarah wrote that, "your thoughts on the relevance of your interview findings to your teaching are right on target," she did not further develop her comments on Ashland's connections between the assignment and their teaching practices. Therefore, although she did validate Ashland's attention to that aspect of the assignment, she did not appear to encourage dialogue. This comment stands in contrast to her list of all of Ashland's major claims and her brief discussion of each claim. By providing little feedback on the teachers' commentary about relevance to teaching, Sarah did not emphasize responding to student thinking, at least in the way suggested by the PD program. She appeared more attuned to investigating student thinking briefly in every aspect of the transcript.

Course 3, Unit 3. Ashland's Course 3, Unit 3 assignment, an analysis of the "three cousins" money-saving problem, held descriptions of numerous events. Some of Ashland's event descriptions contained a small degree of interpretation, such as when they described that "[the student] begins the task at hand by writing the three girls' names across the x-axis. His initial idea about Elizabeth was that her line would start 'going down.'" They included a quote to illustrate the student's ideas, but instead of providing a deeper interpretation of the student's "initial idea," they continued: "When [the teacher] began seeing [the student] using these curves instead of a straight line she had to ask questions about it. She did not expect the student to use this 'loop' method rather maybe a bar graph like the students did in Unit 3 Week 2 or a line..."

Therefore, rather than delving into each moment in-depth, the Ashland teachers shifted their focus frequently and only described brief moments from the transcripts. Whereas they did interpret their students' ideas, they only made superficial observations that did not reflect the depth of thought provided in earlier assignments.

Ashland did not include any follow-up questions for their students in this assignment, nor did they discuss classroom implications. This absence could perhaps reflect Sarah's lack of attention in previous assignments to the implications they included. Instead, they wrote, "This interview raises a lot of concerns for [the teacher] as she wonders how many other students would have a hard time with this prompt. [This student] is considered to be 'accelerated.' Would a student in the regular math class be able to even comprehend that a graph can represent a story? Have they ever learned how connect the two?" These comments were a more negative take on the interview; Ashland was focused on correcting what they perceived as student misconceptions, rather than on building activities structured around what the student did know. This is very different from the ideas they demonstrated in previous assignments; not only is the tone different, but the brevity of the responsive aspect of the assignment is significant as well.

In feedback more brief than previous assignments, Sarah seemed to focus on how Ashland's questions affected their students in the interview. She described how one teacher's questions "helped [the student] realize that her first attempt to draw a graph did not correspond to the story." She then included a long quote to substantiate her claim and provided her interpretations of other moments in the interview. Again, by shifting from moment to moment, Sarah perhaps modeled the kind of analysis that she would like to see: one that did not contain interpretations of specific events, but instead offered broader claims about student understanding.

This does not align with the goal of the PD program, which was to foster attention and response to specific moments from the interviews.

Discussion

Both Campton and Ashland appeared to shift in response to the feedback they were given. Campton grew more attuned and responsive to student thinking, whereas Ashland grew less attentive to specific student thinking. This divergence may have been influenced by their respective facilitators' feedback. Researchers have already identified certain contexts in which teachers can demonstrate growth from receiving feedback, such as in an evaluation setting after a routine classroom observation (Gregory et al., 2014; Malu, 2015). However, these results suggest that feedback given by course facilitators may also influence the ways in which teachers change, at least in the case of these two groups.

Campton began the PD course by using a mixture of evaluation and description of student thinking. They wrote generally and tended to discuss what students did not understand. Their suggestions for follow-up questions and classroom activities reflected this approach: they sought to "fill gaps" instead of building on student knowledge to reach the end goal of a "correct" solution. Therefore, they did not display skill in responding to student ideas. Charles, and later Jenn, repeatedly emphasized that Campton should explore what students did understand, both in the interview and in the analysis, rather than asking "leading questions" to achieve the "correct" solution. Hence, both Charles and Jenn attended to specific student thinking in their feedback.

As the program progressed, Campton grew more specific and interpretive, selecting fewer moments and using those moments to explore student thinking in detail. Charles and Jenn also encouraged the group to reflect on the questions they asked in the interview and on questions they might pose in the future, perhaps to foster greater responsiveness to student

thinking based on the group's interview interpretations. Charles especially emphasized making explicit connections to classroom practice. Campton shifted accordingly, discussing how they could use what their students did know to shape classroom activities. They also analyzed the questions they asked in-depth, going as far as to critique their interviews on a line-by-line basis.

Ashland's course facilitator, Sarah, took a broader scope. Her feedback often consisted of her own interpretations of student thinking based on the interview transcripts, drawing from moments across the transcripts to make larger claims regarding student ideas. For instance, following another assignment that focused on a speed versus time graph, Sarah argued that while the students made an inaccurate graph, they still had some understanding of the problem. Sarah's purpose appeared to be to argue that students had productive knowledge to build upon throughout the entire interview rather than during a specific event. In order to justify her claim, Sarah selected and interpreted moments from across the transcripts, shifting from moment to moment in the process instead of delving into just a few moments of the transcript more deeply. Sarah's choice was not aligned with either the PD program or the literature's emphasis on interpreting *individual* moments of student thinking. Perhaps Ashland's later lack of interpretation of specific moments of student thinking from the interview could be related to an attempt to model Sarah's analytical technique of drawing from events across the interview, while still making small, moment-based claims. Because of the disparity between claim grain-size and evidence used, their assignments lost their focus on giving a deep interpretation of student thinking.

Sense-making theory (Coburn, 2004) describes how teachers interpret messages from their environment and how they may incrementally change their practice. In this case, some of the messages the teachers received were the same—specifically, they interacted with the same

course materials and the same assignments. However, the feedback Campton received may have reinforced the PD program's goals, whereas the feedback Ashland received did not. This corresponds with Coburn's (2004) findings; she found that messages' intensity and their pervasiveness were associated with adoption of reform practices. Here, between the course materials and the feedback, the messages that Campton received were likely more intense and pervasive than the messaging Ashland received. Therefore, it is perhaps unsurprising that Campton appeared to shift towards the PD program goals. However, Ashland's shift is perhaps more surprising; when presented with messages that aligned with program goals (via the course materials) and messages that did not (via feedback), they shifted away from the program goals. This may speak to the influence of facilitator feedback, especially in the context of a graded course.

In summary, researchers have highlighted various PD activities that can cause teachers to grow more attentive and responsive to student thinking over time (Franke, Carpenter, Levi, & Fennema, 2001; Goldsmith & Seago, 2011; van Es & Sherin, 2002). These results contribute to this body of research because as Campton's case illustrates, appropriate facilitator feedback may be associated with an increased focus on student ideas. Conversely, when facilitator feedback is not attentive to specific student thinking, teachers may grow less attuned to student thinking, as happened in Ashland's case.

Implications

This study has important implications for PD course design. Campton and Ashland finished the course in two very different places. While we do not know how each group would have responded with different facilitators, the feedback that each group received was markedly different. Charles and Jenn pushed for positive views of student thinking and for connections to

classroom experiences, whereas Sarah modeled larger, more encompassing claims.

Consequently, Campton grew more interpretive and Ashland became less interpretive of specific moments of student thinking. This is highly problematic; if facilitators have different goals in mind when providing feedback, groups may or may not shift in the manner desired by the PD program as a whole. Therefore, when designing PD courses, careful consideration should be given to the type of shifts that the PD program hopes to achieve. Once these shifts are determined, facilitators need to be trained to maintain consistency in which aspects of the PD program they emphasize and how they emphasize those aspects.

Limitations and Future Work

This study only examined two groups, one of which had a facilitator change. Therefore, there is still much research to be done on the role of feedback in shifting teacher attention and response to student thinking. For instance, I only argue here that facilitators appear to shape the path that groups take, but I have not considered what factors led the groups to accept the feedback and work towards meeting the facilitators' goals. Because individuals may accept or reject the feedback they receive (Kulhavy, 1977), it is important to study more cases of feedback influence in order to be able to develop a framework to represent teachers' developing attention to student thinking. To make the issue more complex, it is also important to note that while only facilitator feedback was considered here, many other factors could have influenced the group. Other such factors could include the discussion among group members or the influence of grades, since the assignments were graded. In order to fully understand the shifts that the teachers experienced, one would need to consider a greater spectrum of factors influencing the group development.

Further, this analysis examined the participants at the group level. However, previous research has shown that individual teacher development can be markedly different from the development of the group as a whole (e.g., Bautista et al., 2013). Therefore, additional research is needed to determine the role of facilitator feedback in shaping how individual participants identify, interpret, and respond to student thinking.

In addition, Schoenfeld's (2010, 2011) decision-making theory highlights the importance of teachers' resources when they make decisions. In this case, teachers likely drew from several different resources when deciding whether and how to adopt the feedback they received, such as their own mathematical knowledge and mathematical knowledge for teaching (Ball, Thames, & Phelps, 2008). Another aim of the course was to deepen teachers' understanding of mathematics. This deepening understanding may have also played a role in the ways in which Campton was able to provide a more robust interpretation of student thinking. While beyond the scope of this analysis, future work could explore the influence of a teacher's mathematical knowledge for teaching on how teachers learn to attend and respond to students' mathematical thinking.

Finally, more research is needed to determine the most productive types of feedback to promote shifts in teacher attention to student thinking. Although I examined two different approaches here, feedback can take many forms. By developing a more exhaustive list of feedback structures, one may better be able to understand how to assist teachers.

Conclusion

Facilitator feedback appears to play an important role in shaping how participants consider student thinking in PD programs. When facilitators are aligned with the program goals, they may help groups to shift in ways valued by the PD program. This extends previous PD research, which has identified PD activities, such as video clubs and lesson analysis, that

effectively promote teacher attention to student thinking. These cases may suggest that it is important to consider other factors influencing teacher growth, such as facilitator feedback, in order to better understand the characteristics of successful PD programs. Ashland's case also suggests that when facilitators have a focus that deviates from the PD program, the work produced by teachers who receive their feedback may shift accordingly. Hence, it is essential for facilitators to remain consistent with the program goals and with each other in their overall approach.

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