SEEKING ATTENTION TO STUDENT THINKING: IN SUPPORT OF TEACHERS AS INTERVIEWERS

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In this paper, we analyze efforts to encourage teachers' attention to student thinking through a professional development (PD) program. We describe three groups of teachers within the same program who completed different types of assignments, either conducting interviews, planning classroom activities, or both. In both types of assignments, teachers were prompted to explicitly address student thinking. Teachers attended to specifics of student thinking when conducting and analyzing interviews, but struggled to do so when planning activities. While acknowledging the value of sustained attention to revision of lessons, reviewing classroom videos, and utilizing different forms of classroom discourse, we argue that conducting and analyzing interviews is an underused activity that can and should be an important part of teachers' professional development if we seek to encourage attention to student thinking.

Keywords: Teacher Education-Inservice (Professional Development); Classroom Discourse

Introduction and Theoretical Perspective

Student-centered teaching in mathematics classrooms has been at the heart of reform movements and curricula in recent years. We take the perspective that attention to student thinking is important, but that learning to notice and understand what students are doing is a difficult process. Recently, Schoenfeld (2011) has called us to consider how the practice of attending to student thinking may be developed. In the present paper, we respond to this call and argue that engaging teachers in conducting and analyzing mathematical interviews with students is extremely productive. To support this claim, we describe the work of teachers in an extended PD program that had the dual goals of enhancing teachers' mathematical content knowledge of functions and a functional approach to mathematics and enhancing teachers' understanding of students' mathematical thinking.

Attempts to enhance mathematics instruction in the United States (US) have embraced the ideas of student-centered or responsive teaching in varying ways. For example, Chapin, O'Connor, and Anderson (2009) describe types of classroom talk designed to elevate and utilize student contributions, such as restating student ideas in other terms and asking other students to address a proffered student idea. These strategies, and others designed to encourage rich student discussion in the mathematics classroom, are valuable, as is helping teachers to develop them. However, teachers cannot utilize these productively unless they are able to quickly understand what a student is saying or determine what questions to ask to clarify the student's thought. Thus, attention to and understanding of student thinking must underpin and accompany any strategies for encouraging classroom discussion.

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Similarly, PD often includes activities in which teachers create, review, and revise lesson materials and implemented lessons. The Japanese "lesson study" model (e.g., Lewis, 2000) includes these kinds of activities, and they are the focus of the recent call from Hiebert and Morris (2012) to shift attention away from teachers and towards the artifacts of teaching, including constantly revised lesson plans. Hiebert and Morris state that a key feature in the plans would be that "students' likely responses to instructional tasks and questions are predicted to allow teachers to plan how to use students' thinking during the lesson" (p. 95). Here, they, too, lend their support to the importance of attending to student thinking. In both of these models, being able to understand the students is essential to the work that the teachers are being asked to do, and again must either precede or develop along with the focus activity of revising materials. There is also a logistical challenge to the idea of using lesson creation and revision as part of PD in the US. As seen both in lesson study and in Hiebert and Morris' vision, these are practices to be taken on and sustained by groups of teachers. This is at odds with most PD for in-service teachers. Teachers may be from different schools using different curricula; they may also have time allocated for PD only sporadically. As a result, any attempt to focus sustained attention on lesson plans is interrupted, as teachers are not able to repeatedly implement and revise these "artifacts." While some schools have recognized that teachers may benefit from shared planning time and collaboration with their peers, it remains to be seen how widely this will be sustained and whether or not researchers will be able to access these practices and determine whether and how they enhance teachers' attention to student thinking.

However, research has shown that teachers can change how they attend to student thinking after PD that encourages this attention directly. For example, the video clubs described by van Es and Sherin (2008) show that teachers engaged in discussing videos of their teaching shift what they attend to, or "notice." Past work from Carpenter, Fennema, Peterson, Chiang, and Loef (1989) showed the results of a PD course in which teachers learned about student thinking in mathematics. Their approach, Cognitively Guided Instruction (CGI), included examination of student explanations. The teachers who took the course had significantly higher scores in knowledge of student strategies for their students, as compared to a control group of teachers. In addition, the students of the teachers who had participated in the CGI PD spent significantly less classroom time on number fact problems, yet they did significantly better than the students of control group teachers on questions of this type on a standardized test.

This work has been continued by Jacobs, Lamb, Philipp, and Schappelle (2011), using resources from CGI to provide sustained PD that included examining written work and video from classrooms. They showed that teachers improved in the extent to which they could attend to student thinking after extended participation in the PD. They assessed this by evaluating each teacher's responses as the teacher watched a videotaped interview with a student. Since Jacobs et al. consider teachers' viewing of a video of an interview to be suitable ground to elicit and measure teachers' attention to student thinking, this implicitly supports our suggestion that teachers have much to gain from analyzing interviews. We suggest that this becomes an even more powerful activity when the teachers conduct the interviews themselves and when the interviews are used to develop, and not just assess, the practice of attending to student thinking. By carrying out the interviews themselves, teachers have the benefits of evaluating the resulting video, but also the experience of attending to and responding to the student thinking in the moment.

Interviewing has been a powerful tool for researchers to gain rich insight into student thinking and capabilities. However, we argue that we have not sufficiently tapped this resource for teachers. We take the position that interviewing, as outlined by Ginsburg (1997), is not so very different from the forms of classroom talk endorsed by Chapin et al. (2009). In order to use "productive talk moves" in the classroom, a teacher has to be in the position of attending to students' thinking. We argue that through interviewing, teachers can take advantage of concentrating on student's responses without

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the responsibilities of managing a classroom in order to (1) begin to build a knowledge base of student ideas around particular mathematical topics, and (2) develop skills in attending to student thinking that they can then extend into the classroom.

In this paper, we report on our work with middle school mathematics teachers from multiple districts and schools engaged in a single PD program. The program focused on deep mathematical content knowledge of functions and a functional approach to mathematics as well as attention to student thinking. To encourage teachers to attend to student thinking, assignments included watching and responding to classroom videos, examining pieces of student work and classroom transcripts, and responding to questions asking teachers to predict what they thought students would do with different mathematical scenarios. In addition, we provided teachers with assignments in which they could choose to plan a lesson or to conduct an interview with a student. By comparing cases of three groups who completed different kinds of activities, we illuminate some of the benefits of having teachers conduct interviews as a way to consider student thinking, as well as describe challenges inherent in using lesson planning with the same intent. We argue that conducting and analyzing interviews with students can allow teachers to examine student thought in depth and that this should be put to use in PD.

Method

The data for this paper come from a PD program that offers three graduate-level semester-long courses, conducted partially online. To date, the program has had three cohorts of approximately 60 teachers each, from nine school districts. Here, we analyze the work of some of the teachers in the third course of the first cohort.

In this course, we had four three-week units, each unit concluding with an assignment that was framed as "Engaging Students." For each of these four assignments, teachers worked in groups of two to four; each group could choose to conduct and analyze interviews with students, or they could create a learning activity. We did not require teachers to develop a full-class activity that would extend for an entire class period, nor did we require them to use any particular lesson plan format.

Table 1: Assignment details

First option: Interview	Second option: Activity plan
With your group, discuss and compare what you each found in your interview. Together, write a brief report on what you found in your set of interviews. Make sure you include the following in your group report: What did the set of your group's interviews show about students' ways of thinking about inequalities? What did students say or do that surprised you? Use evidence from the transcripts of the interviews to support your ideas. How might the students' ways of approaching this problem help or hinder their understanding of equations and inequalities in future mathematics? What more would you like to be able to ask your students in order to better understand their thinking?	What is one mathematical idea, preferably relating to this unit's content, that your students have difficulty with and that you hope to address with an activity? What understandings do you think your students already have that can form a foundation for improved understanding of that idea? What misunderstandings do you think your students have that may hinder their understanding of that idea? What would you like to know about your students' understanding of that idea? Focus on students' understanding of the mathematical idea, rather than (or in addition to) their performance of specific tasks or algorithms. Work together to design a single activity (not necessarily a complete lesson) appropriate to your grade levels that addresses the idea you identified, builds on their understandings, and/or

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	addresses their misunderstandings. Design the activity so that you will learn something new about your students' reasoning.

The option to create an activity was intended as a way to allow teachers to apply their knowledge of student thinking to teaching practice. The text of the assignments is shown in Table 1.

In both cases, teachers were asked about student thinking and asked to describe their students' thinking about the content included in the interview or activity. PD facilitators gave feedback to assignments in writing via an online forum.

Table 2: Assignment choices

	Number of teachers	Grades taught	Unit 1	Unit 2	Unit 3	Unit 4
Group 1	4 teachers	5, 9	learning activity	learning activity	learning activity	learning activity
Group 2	2 teachers	7, 8	interview	interview	interview	learning activity
Group 3	3 teachers	6, 8	interview	interview	interview	interview

We chose three groups of teachers to analyze here. Group 1 chose to do learning activities for all four units. We selected this group because they were the only ones in the entire cohort who made this choice, not completing any interviews. Group 2 chose to do three interview assignments, followed by a learning activity for the fourth unit of the course. We selected this group, the only one to follow this specific pattern of choices, because we theorized that the interview assignments might better prepare them for the learning activity assignment. Group 3 chose to do four interview assignments. We selected this group because it represented the opposite end of the spectrum from Group 1. There were multiple groups (nine groups, out of nineteen in the cohort) selecting only interviews; from those, we chose Group 3 because they shared similar characteristics with Groups 1 and 2 as indicated through classroom observations carried out at the outset of the PD program using the Reformed Teaching Observation Protocol (RTOP) (Sawada et al., 2002). Together, these three groups illustrate a variety of paths followed by teachers.

For each group, one researcher reviewed the teachers' written analysis, the interview transcripts and/or activity plans, the online forum discussions, and the PD facilitators' feedback and produced a "thick description" (Geertz, 1973) of each group's work. Next, a second researcher reviewed each of the artifacts again and revised and added to the description.

The results we present below allow us to provide insights into the utility of these assignments and offer points of consideration for PD design.

Results and Implications

Analysis of the teachers' work showed that when teachers created learning activities, their attention to student thinking was not as detailed, not as specific, and did not form as substantial a portion of their work. They did address student thinking in some cases, but it was because the assignment required it. That is, they were responding to our questions in order to complete the assignment, not because attention sprang organically from planning an activity.

Group 1: Four learning activities – beginning to address generalities of understanding

In their learning activity for Unit 1, the group members planned an activity in which different types of candy represented positive and negative numbers and unknowns. However, it was unclear how the structure of the activity itself took into account their students' thinking. In response to the

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question, "*What understandings do you think your students already have that can form a foundation for improved understanding of that idea?*", they wrote only, "*Our students have the foundation of how solve an equation with the goal of isolating the variable.*" Here they made a general statement about what their students might be able to do, but did not provide evidence or specifics to support their claim. In response to the question, "*What misunderstandings do you think your students have that may hinder their understanding of that idea?*", they listed four related items: "*Vocabulary word - inverse // Inverse means the opposite in effect. The reverse of. // Some students lack the understanding of what an inverse operation is // Solve for an unknown within the equation.*" Here, they pinpointed the absence of a skill, but did not address what it is that their students *do* think or give any information other than the summary assessment. The Unit 2 work was similar.

By the Unit 3 learning activity, there is some evidence that Group 1 did try to respond to the instructors' requests that they provide more evidence and specifics about student understanding. They stated that, "*some of our students tend to be stronger graphing information than verbally interpreting it.*"In this statement, the group made some progress in attending to student thinking: they avoided listing mathematical competencies as "student understandings," as they did in Units 1 and 2, and instead addressed differences among students. The statement suggests that the group felt that their students had different competencies to build upon. However, note that the statement is still general and lacks supporting evidence. This continued in Unit 4, with general comments forecasting difficulties their students would have with the activity such as, "*Finding the connection between the word problem and the graph will be difficult for [the students]*."

Group 2: Three interviews and a learning activity – progress and regression

In conducting their interviews for Unit 1, Group 2 focused on correct and incorrect answers from students, following up more on incorrect responses and pushing for correct notation. While the correct/incorrect answers were also a focus of their written analysis, they did state that they understood why their student gave a particular incorrect answer: "*I feel that this was an overgeneralization of solving for the variable… As a side note, this makes sense to me. In the process of practicing the solving of inequalities, students made the observation that it 'was like solving an equation.'*" They also suggested a way to investigate the student's understanding: "*we would be interested in how this student would graph the inequality on a number line that has no values listed.*" Taken together, these two quotes demonstrate that Group 2was beginning to consider why students might give particular answers and how they might follow up on their perceptions of student thinking.

In Units 2 and 3, Group 2 continued to try to meet the assignment and instructors' requests for specific evidence and for details about student thinking. The group's primary focus was still on what students didn't understand in comparison to what they did; for example, they wrote, "*the 8th grade student didn't really to seem to understand the problem clearly.*" While they did not articulate details about students' thinking, they did identify specific issues and consider how to address them. In Unit 2, the group noted that a student seemed to have "*difficulty with the coordinate grid*," so their suggestion was to remove the grid and see how the student would approach the problem. In Unit 3, they directly addressed both their attempts to understand student thinking and their challenges: "*His misunderstanding of the line being diagonal confuses us. He seems to think the line on the apples graph is diagonal but the line on the oranges graph is not. (Refer to [line in interview transcript].) It was interesting watching him gesture with his hands to determine that both lines were indeed diagonal.*"

In Unit 4, with each teacher having previously completed three interviews, Group 2 decided to create a learning activity, asking students to find the length of the diagonal of a rectangle with an area of 90 cm^2 and length and width that were consecutive integers. While they included mention of having students explain their strategies, the background they gave on student thinking to justify the

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activity was quite general: "*Students are able to use formulas to solve problems as long as the problem is straightforward and there is only one step involved.*" The course assignment did not require Group 2 to implement and analyze the activity, but this group chose to do so. In the process, they tried to return to addressing specifics of student thinking: "*many of the students totally fell apart and started trying to do some different things instead of using the Pythagorean Theorem. One student in particular added 44 and 46 to get 90. A few other students tried to add some other numbers together. One student divided 90 by 2 to get 45 and then divided 45 by 2 again to get 22.5.*" They listed the student strategies, but did not try to determine why the students had used these, nor did they offer suggestions for what they might do when confronted with these student ideas, as they had done in Units 2 and 3.

Group 3: Four interviews – developing focus on individual students

As with Group 2, the Unit 1 interviews from Group 3 focused on students' correct and incorrect solutions. They had asked students to shade a number line to show $a<12$, and their analysis of the interviews included evaluative comments like, "*One student did not seem to understand what "less than" meant, he actually included 12 as a possible solution.*" While the students' accuracy was at the forefront, the group did demonstrate that they were considering specifics of what students were doing: "*Zero was a point of confusion for the inequalities. For example, when a student answered verbally he believed that all the solutions had to stop at zero, but when asked to place the "a's" on the number line he realized the solutions could include values less than zero.*" The Unit 2 work was similar.

In Unit 3, the group designed their own interview tasks. They stated that they designed this activity, which used drawings to depict a scenario that they then asked the students to graph, because the students struggled with graphing in the Unit 2 interviews and they wanted to think of ways to scaffold a graphing activity: "*we hypothesized that the images would aid the students in both activities if the student began with the image problem.*" They refer to specifics from their Unit 2 interviews as they're justifying their choice of topics here; however, when they shift to discussing the actual items, they revert to generalities. For example, to address the question, "*What understandings do you think your students already have that can form a foundation for improved understanding of that idea?*" they write, "*variables, linear relationships, coordinate plane*". The use of a list of topics, rather than what students understand about the topics, is similar to the work of Group 1, as described above. While the teachers in the group did go on to conduct the interviews, their analysis of the interviews was only a few sentences long, and mainly addressed whether or not the students thought the pictures were helpful.

In Unit 4, Group 3 again used the interview tasks supplied by the PD program. The group shifted away from their prior emphasis on correct answers, and mentioned wanting students to understand the full scenario in the problem. However, their statements often did not include specific supporting evidence; for example, "*Student 2 was able to independently arrive at two solutions and eventually was able to explain a deeper understanding of the scenario than student 1.*" After the departure in Unit 3, they again considered what individual students were doing, but they did not progress in providing evidence as much as Group 2 had.

Implications

As seen in the examples above, when teachers creating a learning activity did address student thinking, it was often generalized because they didn't have a case to examine. However, when teachers conducted interviews, we can see more instances where their analyses maintained a focus on the specifics of student thinking. For example, Group 2 wrote descriptions of the students' progression through the problems, pointing to specific moments in the transcript to justify times

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when they claimed the students were confused. In addition, while Group 2 exhibited attention to student thinking during the three interview assignments they completed, the activity plan that they devised for the fourth assignment, after the interviews, showed the same type of generalizations as seen in the work of Group 1. This shift away from attending to student thinking was also seen in the Unit 3 work of Group 3, in which they focused on designing interview tasks, rather than on conducting and analyzing their interviews. While Group 3 had not demonstrated the depth of attention to student thinking that we saw from Group 2, the Unit 3 work of designing the interviews seemed to detract from the attempts they had made in Unit 1 and Unit 2 to focus on specifics about what students were doing. While all groups show some evidence of shifts in their work, and all groups show room to continue to develop their attention to student thinking, these cases begin to illuminate the advantages of interviews.

In planning activities, we were asking teachers to recall student thinking from the past. Conversely, when the teachers conducted interviews, they had the video and written work, as well as recent memories. The specificity of what they had available to them allowed them to remain focused on students' thinking. While this specificity would also be a benefit of having teachers watch classroom videos, as in Van Es and Sherin (2008), the interviews afforded teachers the opportunity to focus on one student at a time without having to manage as many other tasks. This was the case both while conducting the interviews and while reflecting upon them. This advantage emerged in the example above from the Unit 4 activity plan by Group 2. When they reflected on their activity after implementation, they reverted to listing many student answers, rather than taking a deeper look at particular instances of student thinking.

Certainly, this analysis uses only a few cases of groups of teachers. Thus, it shows us what is possible when teachers conduct and analyze interviews, but of course it cannot conclusively say what the results would look like in a large-scale comparison of groups of teachers doing different series of assignments. It is also important to note that here we are analyzing teachers' work in groups, but each group has multiple teachers working together on joint final products. These joint analyses reflect the work of the group, but it's not possible to know how each individual contributed or what they might have done differently if they were working on the same task alone (see Bautista, Brizuela, Glennie, and Caddle (2014) for an examination of this issue). An additional complication is that when teachers chose to do interviews, the feedback from facilitators after each assignment was more consistently focused on the teachers' attention and interpretation of student thinking. When teachers planned activities, the facilitators tried to address student thinking, but also commented on the structure of the activity. This may be valuable feedback on an important task of teaching, but it means that facilitators devoted less time and space to supporting teachers' understanding of student thinking. As with the teachers, facilitators lacked a case to examine, and it adversely affected the support they were able to offer.

Researchers have much to learn about how to promote teachers' attention to student thinking, including how it may grow and evolve while teachers conduct and analyze interviews with students. While future work should include more rigorous examination of a larger number of groups of teachers, this analysis highlights some lessons for teacher educators and PD providers. Certainly, activity planning could be undertaken in a thorough and specific way, with constant revision, as well as videos of implementations, as suggested by Hiebert and Morris (2012). Equally, analyzing classroom video (e.g. Van Es & Sherin, 2008) can enrich teachers' understandings as well. Our analysis does not detract from these other approaches; rather, it shows the rich opportunities that arise when teachers conduct and analyze interviews with students. As mentioned, many PD opportunities involve teachers from different grades, different schools, or who are using different curricula. Interviews can be conducted and analyzed even within these constraints, and teachers' attention to student thinking can be enriched as a result.

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