PRODUCTIVE DISRUPTION IN A AN ONLINE PROFESSIONAL DEVELOPMENT ENVIRONMENT

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The EnCoMPASS project (Emerging Communities for Mathematical Practices and Assessment) at Drexel University has produced a web-based software tool for the assessment of student work. This paper discusses research on the impact of this tool on teachers' attitudes toward engaging with students in the software environment. The tool supports teachers adopting a more dialogic perspective towards learning and teaching through cycles of problem solving, discussion and mathematical development. It is suggested that the tool aids teachers' transition toward this more interactive approach to teaching mathematics while also acknowledging and addressing concerns about the time it takes to engage in more detailed dialogue and thinking about mathematics with their students.

Keywords: Problem Solving, Professional Development, Technology, Teacher Knowledge

Introduction

EnCoMPASS (http://mathforum.org/encompass) is an NSF-funded project that is focused on creating an online community of teachers that supports and encourages the use of students' mathematical work – particularly detailed and structured analysis of students' work – to inform instruction. As a central part of the project, the EnCoMPASS tool, was developed to support teachers to shift from the assessment of the "products" of student work toward a process-oriented approach involving interaction with students around mathematics. The EnCoMPASS Tool is a web-based software environment focused on the assessment, analysis and support of student mathematical problem solving. We argue that the EnCoMPASS tool disrupts the normative tendency for teachers to focus on what students know and correct answers. Instead, it provides a scaffold for teachers to look carefully at student work, selecting specific evidence from that work, and using that evidence to begin the process of dialogue with students about mathematical thinking and ideas. Built into the EnCoMPASS tool is the Noticing & Wondering (N&W) framework that was developed and promoted by the Math Forum to encourage teachers to focus on the evidence from the work that student have produced. N&W also scaffolds teachers as they begin a process of dialogue with students about how students' ideas and understandings are developed and supported by those noticings and wonderings.

The EnCoMPASS tool is designed to collect student work and allows a teacher to identify and highlight potentially significant excerpts from the student work and comment on selected text or "selections". These selections can then be sorted and categorized into a number of folders that allow for quick categorization of the work of multiple students and for teachers to easily look at the aggregated work in the folders. In addition, teachers can craft feedback to a student,

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or the students in a particular folder, to push their mathematical thinking further. Through a process of iterative design testing of the tool with teacher collaborators, the N&W framework was integrated into the tool to scaffold teachers in their efforts to comment upon selections from the student work and organize the work into folders with the selections connected to their N&W comments.

In this segment of our research, we have attempted to understand how the EnCoMPASS tool helped to disrupt traditional norms mathematics teaching, as recognized by the participants, and further, helped teachers see the value of taking students ideas seriously and beginning a conversation with those students about the mathematics. The research questions guiding this work are: 1) How does the EnCoMPASS tool support teachers to engage in a processual approach to mathematics?, 2) What does the shift toward process look like in this context?, 3) What forms of teacher reflection are produced through the EnCoMPASS tool and the Noticing & Wondering scaffold?, 4) How does the tool support a continued dialogue with students?

Theoretical Framework

Researchers at the EnCoMPASS project see mathematics as part of people's everyday lives. Many of the math problems used come from everyday life and they remind students and adults that doing math is part of what we all do. Everyday problems remind us that math is about the practice of problem solving. And problem solving involves understanding situations, assumptions and includes conversations with others. Thus, mathematics is a communicative and social process. Finally, the result of working out problems and talking with others about that work results in mathematical thinking. The way for all people, students and teachers alike, to get better at math is to improve their mathematical thinking.

Central to this practice is the relationship between conversation, interaction and thought. Several philosophers and social scientists have pointed out that thinking, learning and knowledge production are social phenomena (Peirce, 1931; Bakhtin, 1981). Sfard (2008), bringing together the work of scholars such as Dewey (1938), Vygotsky (1978, 1986) and Wittgenstein (1953) claims that communication and cognition are flip sides of the same coin and that our traditional ideas about knowledge acquisition are incorrect. Knowledge and what we call learning, are communicative acts and necessarily social. She coined the term commogition to underscore that communication and cognition are social and intersubjective. To Sfard (2001), mathematical development involves being assimilated to a new discourse akin to the ways that Lakoff & Johnson (2003) talk about how metaphor is used to expand understanding in general.

These ideas are compatible with the notion of sociomathematical norms and mathematical identity (Cobb, Gresalfi,& Hodge, 2009; Boaler & Greeno, 2000). Teachers must be immersed in a discourse of mathematics, but they also need to be able to help students move to use these new signifiers before they are fully able to understand the mathematical objects they represent (Horn & Kane, 2015). Students and teachers must then find themselves in a discourse community where problem solving and mathematical practice is part of the norms of that social group (Gresalfi & Cobb, 2011). Being a member of that discourse community leads in a dialectical way to more conversation and more thought and deeper forms of knowledge and understanding (Bannister, 2015). Lave & Wenger (1991), for example, note that it is impossible to distinguish the learning from the context within which the learning takes place.

We can think of the traditional norms of math education, where students and teachers focus on using the right procedures and getting the right answer as a scaffold to this more complex process of building mathematical knowledge. The problem with that scaffold is that it reifies the

process and the product and only aids the development of and only values mathematical thinking in a limited way. The EnCoMPASS tool, and the N&W model built into it, was designed to provide a more productive scaffold. For the purposes of this paper N&W allows teachers to notice things about student work, wonder what the student was thinking and where that thinking could go. This scaffold them allows the teacher to begin a dialogue with the student about their ideas and move both the teacher's thinking about the students' understanding and the students' mathematical thinking forward.

The EnCoMPASS tool not only allows N&W to move a conversation and a process forward, but it also productively disrupts the normative practices and assumptions in mathematics education (Figure 2 above). The online tool allows the conversation about mathematics to slow down and not move so quickly toward correct answers.

Disrupting traditional norms of the mathematics classroom (Yackel & Cobb, 1996) then makes room for a more process-oriented approach. The notion of productive disruption has been used in other contexts by other education researchers (Hall, Stevens & Torralba, 2002; Ma, 2016). What is consistent in those contexts and ours is the idea that we are disrupting existing norms and assumptions in order to have a productive effect on the conversation and thinking of a group of people. The scaffold the tool provides support for teachers and as a result they attempt to engage in a more organic conversation about the math centered on the student's thinking. In this way it mitigates against teachers' anxiety about not having enough time.

Methods and Data Sources

Because the goal of this analysis is to look closely at the ways in which teachers interact with student work in the EnCoMPASS environment discourse analysis was used (Gee, 2014). Data sources for the discourse analysis came from several teachers who were enrolled in a graduate education program at Drexel University and were using the EnCoMPASS tool as part of the work they did in a course focused on student problem solving and student thinking. There were a total of 18 middle or high school teachers enrolled in the course. Several different kinds of text-based data sources were subject to an interpretive and iterative analysis. In the course, teachers first highlighted selections from student work with the EnCoMPASS tool. They then commented upon these selections by making a noticing about the highlighted selection and/or a wondering about the selection. For our analysis we paid attention to what was highlighted, the kind of commentary the teacher made (noticing or wondering) and then the content of the comment.

Additional data included teachers' reflections upon their experience using the tool, using the noticing and wondering framework and the process of taking students ideas seriously. These comments were also analyzed using an interpretive and iterative analysis. At the point this data was collected, students had used the EnCoMPASS tool, as a sometimes option tool, in assignments/class for over 6 months.

Data Analysis

In our data, we see teachers who are working with the EnCoMPASS tool attending closely to the students' mathematical work. They are more likely to respond to specific aspects of student solutions. In follow up interactions with teachers, we observed three important characteristics. First, teachers noted the importance of slowing down their interactions with students and how the N&W approach allowed her/him to see things in the student work. Second, we saw evidence of teachers asking the student what they were thinking, wondering about connections the student

was making. The teacher was moving toward a more dialogic approach to working with this student on mathematics, placing emphasis on continued and generative mathematical conversation and not just evaluation of correctness. Teachers also noted that much of this work was not part of their "initial instinct[s]" about this student's thinking. In addition, we saw that the EnCoMPASS tool and the N&W framework encouraged shifts in their practice. Teachers would compare their solutions to the problem with those of their students. The teachers also discussed how the N&W framework really forced them to think about what the students were doing and to ask questions about what the students were thinking. One teacher noticed that the value of the software tool was not only to help the process of dialogue with the student, but also the tool helped organize the teacher's thinking and perhaps aided efficiency.

Discussion

As we can see, from the brief summary of examples in the data, the EnCoMPASS tool allows teachers to use student work and student thinking as the starting point for pedagogically purposeful conversations with students. Evidence indicates teachers believing this work has enabled shifts in their instructional practice and the value they found in these student-centered instructional practices. Of course, not all students respond to these prompts. But the nature of the prompt is to disrupt a more normative response and reorient the teacher toward dialogue about mathematics and thinking rather than the assessment of correct strategies and correct answers. We can see further from some of the responses, that in order to reflect on what the student is doing it is natural to reflect on what one did to work with the problem – a process referred to as double reflection (Shumar, 2017). Double reflection can be a critical attitude and practice in the building of mathematical knowledge for both the teacher and the student. It enables teachers' changing orientations toward problem solving, student engagement and making the focus process not production, allowing the teacher to more naturally move toward the dialectical process of practice-talking-thinking.

Significance

The analysis here demonstrates that the EnCoMPASS tool and the N&W scaffold helps to move teachers toward an interactive stance with students around the doing and talking about mathematics. The tool has helped move them toward paying close attention to their own mathematical work and has transformed how the look at student work and student assignments. There are suggestions here for future research. We suggest that this tool and way of working will help teachers deal with unique situations and more unusual responses on the part of students. This should help teacher take advantage of opportunities to help students make insights and advance their thinking. The tool moves everyone from reified notions about being good at math toward genuine dialogue. Our contention is that this should make both students and teachers better mathematical thinkers. Looking at how to assess teachers and students as mathematical thinkers is a next step in the research.

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