

Incorporating Discourse in Secondary Mathematics

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Abstract: During my teaching experience, I often came across students who could not speak about the mathematics that we were dealing with. There was a disconnect between mathematical concepts and processes. I kept wondering, what do math educators and researchers know about discourse and how do we effectively engage students in it? When the teacher acts as a guide and uses certain strategies such as reflective discourse, funneling, or word walls, students will better conceptually understand the mathematics they are trying to learn. Not only will their conceptual understanding and achievement increase, but also students will reap the important benefit of seeing math as created by communities. This article will share strategies to enhance student discourse in secondary mathematics classrooms.

Introduction

What do we, as math educators, know about discourse in higher education mathematics classrooms? This is a question that came to the forefront of my inquiries during my student teaching experience. Throughout the past year in my geometry classroom, it has become clear that students lack understanding of mathematical vocabulary and the ability to reason and communicate about mathematical ideas and practices. I remember one specific time I asked students, “How do we find the slope of the perpendicular line?” Immediately, a student responded saying, “What does perpendicular mean?” Once they were reminded of what perpendicular meant, they automatically remembered the process of finding its slope. There was a clear disconnect between concepts and procedures. By not knowing the language of mathematics, the student was confused. Math and talk are not normally something that students (or teachers) think go together. In a traditional mathematics classroom students and teachers see mathematics as a process of “doing” and only that. As a math teacher, not only do I want my students to be able to “do” the math, but I also want students that are able to explain and share their reasoning or ideas with others. In the process of doing so it will create well-rounded students and critical thinkers.

The answer to the question, what do we know about discourse, is critical for mathematics teachers (especially new teachers) because mathematical ideas can be more deeply explored when communication and discourse are involved and required. Students who do not have the ability to communicate tend to lack conceptually the basis of the mathematics at hand. Although, many researchers have noted the difficulty of engaging students in productive discourse, they have also shown how effective and important it is for mathematics students. Discourse has become a part of the reform in math education and has made its way to be a part of the National Council of Teachers of Mathematics (NCTM) Standards for Teaching Mathematics (as related to discourse). Their standards provide expectations for both the teacher’s role in discourse (standard 2) and the student’s role in discourse (standard 3). First, what is effective discourse? As defined by NCTM, “Discourse is the math-

emational communication that occurs in a classroom. Effective discourse happens when students articulate their own ideas and seriously consider their peers' mathematical perspectives as a way to construct mathematical understandings" (NCTM 2010, 1991). There are many different ways to incorporate discourse into the math classroom. Although it is tough at first, a teacher must take on specific roles when implementing and engaging students in discourse. By engaging students in discourse with different strategies, students' conceptual understanding and achievement will be greater.

Teacher's Role

Cobb, Boufi, McClain, and Whitenack (1997) did an analysis between classroom discourse and mathematical development in order to find possible relationships between the two. This study used two episodes/situations from a first-grade math classroom. This study specifically focused on reflective discourse where mathematical activity is objectified and becomes an explicit topic of conversation. This study differentiated between students' development of mathematical concepts and their development of a general orientation to math activity. Within the analysis and study it addressed the issues of both the teacher's role and the role of symbolization in supporting reflective shifts in discourse. They analyzed two areas of the students' understanding: 1) their construction of specific mathematical conceptions and 2) the general orientation to mathematical activity that participation in the discourse might foster. From this study of the two classroom episodes and two areas of student understanding, it showed that the teacher has specific roles in reflective discourse. The teacher's role should be to guide and as necessary initiate shifts in discourse such that what was previously done in action can become an explicit topic of conversation. Another role that both episodes made apparent is that the teacher must develop the symbolic records of the children's contributions. It is important that the students develop and notice the concepts from their activities and NOT the teacher providing it for them. The teacher needs to practice the "elicit-support-extend" strategy. This study shows that when the teacher takes on these roles it creates effective and positive classroom discourse (Cobb, Boufi, McClain, & Whitenack, 1997). By purposefully choosing to involve discourse in a mathematics room and following the teacher roles there will be many different benefits created in the classroom for the students.

Benefits of Discourse Rich Classrooms

Walshaw and Anthony (2008) completed a study by reviewing and analyzing many research articles involving classrooms where communication about mathematics (discourse) is the central focus. Walshaw and Anthony highlight key themes and assess the kinds of characteristics/strategies that promote mathematical discourse in the classroom that allow students to achieve learning outcomes. For their study, they used the National Research Council's (2001) understanding of mathematics, which included conceptual understanding and adaptive reasoning. Through their review, they found that a number of activities related to pedagogical practice came to the

forefront. These include participating rights and obligations, articulating thinking, fine-tuning mathematical thinking through language, and shaping mathematical argumentation. Together these activities provide insight into definitions of effective domain specific pedagogy for discourse in mathematics. From reviewing classrooms with these activities and focus, Walshaw and Anthony found three main (and huge) benefits of classroom discourse. Valuing and shaping students' mathematical contributions serves these important functions (Walshaw and Anthony, 2008):

1. allowed students to see mathematics as created by communities,
2. supported students' learning by involving them in the creation and validation of ideas, and
3. helped students to become aware or more conceptually advanced forms of math (p. 529-530).

The results of each study reported in their review showed these benefits and the theme that encouraging discourse has to be made a priority by the teacher. I can attest to the value of these benefits. In my internship my students completed a hands-on activity where students found the relationship between a central angle and an inscribed angle (of a circle). Afterwards students were asked to formulate a conjecture about the relationship they saw. Using reflective discourse and prompting students by asking questions such as, "What relationship did you see?" students were able to communicate with each other (and building upon each other) to verbalize the concept that the central angle is two times the size of an inscribed angle. After doing the activity and reflecting upon it as a class the students felt like geniuses because they were able to see this math concept as created with each other and they were involved in the creation of the conjecture (or rule) about what they saw and validated their ideas. During the discourse as the teacher I had to guide and prompt them to use the correct language such as central angle, inscribed angle, and lead them to discuss the relationship between the two (not random facts or what they did in the activity). As the teacher I did NOT say, "Did you see how the central is twice the inscribed?" Asking a question or making a statement telling them the relationship is not going to allow them to reap these benefits or learn socially together through communication in a community, which are the important factors of discourse. In order to create discourse that reaps these benefits there are specific strategies and practices that a teacher can implement into their classroom.

Strategies and Practices

Temple and Doerr (2012) completed a study with the goal of identifying the interactional strategies that one teacher used in a discourse rich tenth-grade classroom to develop her students' facility with the mathematical register. Looking at the mathematical register as multi-semiotic and having a specific grammatical patterning, they used discourse analysis to examine the teacher's initiation and feedback moves that supported students in using symbolic and natural language in mathematical ways during three consecutive lesson episodes. From this study, the findings show that when the goal was to activate prior knowledge or get them to talk about newly

learned concepts the interaction followed a pattern of “funneling” or “leading” the production of accurate and precise language rather than exploration or explanation. However, when the goal was for students to co-construct new knowledge the interaction followed a “focusing” or “probing” pattern that pushed the students to explain their thinking and build on each other’s contributions.

To understand what one of these looks like in a classroom we will look at one of the learning episodes that incorporated “funneling” and “leading” questioning techniques by the teacher in this study (Temple and Doerr, 2007, p. 299-300; see <https://doi.org/10.1007/s10649-012-9398-6>). At the end of each line, they have defined the type of question or feedback move made by the teacher to aid in your reading of the learning episode where T is for the teacher’s remarks and S is for a student’s remarks.

From this learning episode, we can see that repetition and metalinguistic feedback (turn 59) were two feedback strategies that the teacher used to push the students to correct inaccuracies in their descriptions. Most of the teacher’s recasts consisted of her converting well-formed student sentences into symbolic expressions that were variations on the representation constructed by the class during the teaching of new material (turns 61 and 71). It is significant to note that the teacher was not the only source of feedback in this episode; students also gave feedback to each other and to the teacher (turns 66 or 72). The students’ feedback turns show that they were actively following the conversation and monitoring their own understanding (which is what we want to happen through discourse). In this episode, the teacher’s interactional strategies would be an example of “funneling” students toward predetermined answers. Yet, both the initiation and feedback moves demonstrated by the teacher pushed the students to use the mathematical register to work with newly learned concepts. Importantly, the data from this study shows that students were able to do this with increasing accuracy and fluency throughout the episode (Temple & Doerr p. 300, 2007). From this specific learning episode, we as teachers can learn how to guide our students through specific feedback questioning techniques in order to “funnel” to an answer that we want our students to learn about the mathematical concept at hand.

Similarly, Smith and Stein (2011) present what they believe to be the five practices for orchestrating productive discussions in the classroom. After studying student work from a math teacher’s classroom, they have identified an “incorrect” way of having mathematical discussions. The work shows that when a teacher conducts “show and tell” discussions, they cannot be counted on to move the entire class forward mathematically. “A related criticism concerned the fragmented and often incoherent nature of the discuss-and-summarize phases of lessons. In these “show-and-tells,” as exemplified in Mr. Crane’s classroom, one student presentation would follow another with limited teacher (or student) commentary and no assistance with respect to drawing connections among the methods or tying them to widely shared disciplinary methods and concepts. There was no mathematical or other reason for students to necessarily listen to and try to understand the methods of their classmates” (p.319). From the faultiness that they had noticed in mathematical classrooms and in the generation trying to implement discourse (not so greatly), Smith and Stein created a framework that should be used for discussion facilitation. Their model consists of five practices:

1. anticipating likely student responses to cognitively demanding mathematical tasks,
2. monitoring students' responses to the tasks during the explore phase,
3. selecting particular students to present their mathematical responses during the discuss-and-summarize phase,
4. purposefully sequencing the student responses that will be displayed, and
5. helping the class make mathematical connections between different students' responses and between students' responses and the key ideas (p 321).

With the practices that Smith and Stein integrated together from their observations and other research, they believe it is a model that will help prepare teachers to become facilitators of discussion. The premise underlying this article and their theory is that the identification and use of the five practices (anticipating, monitoring, selecting, sequencing, connections) can make student-centered approaches to mathematics instruction more accessible to and manageable for more teachers (Stein, Engle, Smith, & Hughes, 2008). By incorporating this framework of practices as new teachers, it will be easier to have a mathematics classroom that is rich in discourse by having a model to follow. These strategies and practices are not the only ones in creating mathematical discourse, but they guide and provide many keys and processes for a new teacher wanting to have productive discourse.

Conclusion

So, what does all of this research mean for mathematics teachers? This research shows the importance and how vital discourse and communication is in the classroom for students. By being a guide and using strategies such as reflective discourse, Smith and Stein's model (2008), or feedback moves that funnel or probe, teachers can create positive and productive discourse. By doing so, students' conceptual understanding is going to be heightened and not only will they "do" mathematics, but they will also be able to communicate mathematics. Most importantly, students are going to reap the vital benefits of seeing mathematics as created by a community and being involved in the validation of the ideas they have created together.

References

- Cobb, P., Boufi, A., McClain, K., & Whitenack, J. (1997). Reflective discourse and collective reflection. *Journal for Research in Mathematics Education*, 28(3), 258-277.
- National Council of Teachers of Mathematics (2010). Discourse. Retrieved from https://www.nctm.org/uploaded-Files/publications/write_review_referee/journals/mtms-call-Discourse.pdf
- National Council of Teachers of Mathematics (1991). *Professional standards for teaching mathematics*. Reston, VA: NCTM.
- Smith, M. S., & Stein, M. K. (2011). *5 practices for orchestrating productive mathematics discussions*. Reston, VA: NCTM.
- Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating productive mathematical discussions: Five practices for helping teachers move beyond show and tell. *Mathematical Thinking and Learning*, 10(4), 313-340.

Temple, C., & Doerr, H. (2012). Developing fluency in the mathematical register through conversation in a tenth-grade classroom. *Educational Studies in Mathematics, 81*(3), 287-306. Doi 10.1007/s10649-012-9398-6

Walshaw, M., & Anthony, G. (2008). The teacher's role in classroom discourse: A review of recent research into mathematics classrooms. *Review of Educational Research, 78*(3), 516-551.



About the Author

Bethany Borton earned her Bachelor in Mathematics from Mount Vernon Nazarene University. Afterwards she substitute taught which allowed her to fall in love with education. She then earned a Master of Education from the University of Toledo and gained her licensure for AYA Integrated Mathematics.