Benefits and Strategies for Classroom Discourse

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 Language is an extremely powerful tool; not only in everyday life, but in the classroom as well. Learning is very much a social interaction, thus language plays a very important role in the classroom. As Johnston (2004) stated in his book *Choice Words: How Language Affects Children’s Learning,* through the use of language, teachers can “build emotionally and relationally healthy learning communities—intellectual environments that produce not mere technical competence, but caring, secure, actively literate human beings” (p. 2). Often people can forget the importance of language in a mathematics classroom. Strong mathematical language can have a huge impact on a student’s mathematical career. There are many ways that language can be used successfully in the mathematics classroom. Language can be used to promote agency. Promoting agency can be as simple as referring to students in the classroom as mathematicians. Creating a student’s identity as a mathematician can provide the student with the mentality that what they have to say is important. An effective teacher can also use language to connect ideas across different subjects and contents. Phrases like “What if” “Suppose” and “That’s like” are just a few examples of simple ways that reassure teachers that students are able to apply what they are learning to other areas. When a teacher uses language in these types of ways, they are promoting classroom discourse. Classroom discourse refers to the language that students and teachers use to communicate in the classroom. Recent studies in mathematics teaching supports the use of effective classroom discourse. The National Council of Teachers of Mathematics for example, in their *Principles and Standards for School Mathematics* puts a strong emphasis on mathematical discourse and the positive impact it can have on student achievement in mathematics. This paper will explore some literature that supports the use of mathematical discourse in the classroom and provide some possible strategies for implementing successful mathematical discourse.

 Mathematics is often a difficult subject for many students. Perhaps language plays a more important role in mathematics than most people think. Students often unknowingly use mathematical language inappropriately. The term language in the mathematical context refers to the words given to mathematical objects and definitions (Kotsopoulos, 2007, p. 301). Even though the mathematical register is very unique in that most of the language is used in specific ways, some of the words used in mathematics are also used in everyday language. The words cancel or eliminate, for example, have specific meaning in mathematics but have a different meaning in everyday conversation (Kotsopoulos, 2007, p. 302). This complication stresses the importance of language in a mathematics classroom. It is important for a teacher to be aware of the possible struggle a student may have in transferring the meanings of these kinds of words from everyday life to mathematics. These types of words have to be learned within the mathematics contexts. Students also have to learn the vocabulary that is specific to mathematics itself. According to Cummins, (1984) in order for students to master the meanings of mathematics vocabulary, they must be given the opportunities to speak it:

Meaning and language can be developed simultaneously through contextualized problems that require students to talk about what they are learning as they are learning it. At first the language may not be precise, but as students continue to work together and talk with one another and the teacher, the underlying meanings of the words evolve (as cited in Kotsopoulos, 2007, p. 304).

In other words, mathematical discussions are critical in the development of mathematical proficiency. However, there is a fine line between just allowing students to talk about mathematics, and conducting meaningful mathematical discourse. Teachers must also be careful as to not dominate classroom discussion.

 There are two important types of discourse. Univocal discourse deals primarily with the teacher telling and stating mathematical ideas to the students. Dialogic discourse occurs when the student and teacher engage in mathematical conversation (Truxaw & DeFranco, 2007, p. 268). It is not uncommon for a mathematics classroom to consist of primarily teacher talk and not enough student interaction. This type of environment runs the risk of limiting student participation and further complicating the meaning of mathematical vocabulary. If a teacher is speaking 80 percent of the time in a classroom and is using complicated mathematical terms that may be unfamiliar to students, the students can develop a notion that mathematics is like a foreign language (Kotsopoulos, 2007, p. 304-305). It is important for teachers to reconsider the ways in which they are using discourse in the classroom because for many students, the mathematical register is new in both meaning and use (Kotsopoulos, 2007, p. 304). Thus, mathematics educators must have a good grasp on the mathematical register and must also know how to successfully use it to build understanding.

 In order to fully understand how improving mathematical discourse can improve a student’s mathematical ability, we must first discuss what constitutes mathematical proficiency. According to the National Research Council (2001), mathematical proficiency consists of the following:

conceptual understanding: comprehension of mathematical concepts, and relations; procedural fluency: skill in carrying out procedures flexibly, accurately, efficiently, and appropriately; strategic competence: the ability to formulate, represent, and solve mathematical problems; adaptive reasoning: ability for logical thought, reflection, explanation, and justification; and productive disposition: habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one’s own efficacy (as cited in Walshaw & Anthony, 2008, p. 519).

Measuring all of these characteristics is not an easy task. Oftentimes traditional assessments alone are not a good enough indication of student performance. Classroom discourse can also be used as a way for teachers to assess their students to check for characteristics described above. Teachers should be able to ask questions in such a way that encourages rich mathematical conversation. This not only gives the students an opportunity to share and expand on their ideas, but it allows the teacher to check for understanding and mastery of the content. This idea of probing quality questions to stimulate mathematical discussion is an inquiry based approach to discourse. According to Manouchehri (2007), when this approach is used in the classroom, a variety of student strategies and unexpected mathematical results can emerge (Manouchehri, 2007, p. 290). These types of discussions are a great teaching opportunity that mathematics educators should take full advantage of. Sometimes it is instinct for a teacher to stop a student when they give a wrong answer. This is often due to the fact that the teacher is crunched for time or doesn’t want to confuse students with false information. However, ending the discussion in this manner can “close the door not only on mathematical investigations but also on the formation of a learning community in which members willingly explore mathematics and engage in collaborative construction of knowledge” (Manouchehri, 2007, p. 299).

 The extent to which students can benefit from inquiry based instruction depends highly on the quality of questions that teachers ask. Teachers need to ask more open ended questions that invite the students to think critically and abstractly. To avoid too much “teacher talk” in the classroom, teachers should anticipate student responses and formulate good open ended questions prior to a lesson (Cirillo, 2013, p. 3). “Good” questions are questions that force a student to answer with more than one word, and require a deeper level of mathematical thinking. These questions open the door for rich discussion and allow students a chance to provide their own insight into the problem at hand, provided that the questions are not too complex for the students’ current mathematical level (Cirillo, 2013, p. 3).

 As previously mentioned, expanding on incorrect student responses can create good discussion. When a student gives an incorrect response, instead of just telling the student they are wrong and moving on, the teacher can seize the opportunity and have the class explore *why* the answer is wrong or *why* the chosen process does not work. For example, if a student gives a wrong solution, the teacher might say “Can you walk me through how you got that?” The student can then explain step by step how they reached their answer. If they don’t catch the mistake themselves, more than likely another student will be able to identify the error and explain the correct way to solve the problem. This creates the type of communal learning environment that teachers should be aiming for.

 Another advantage to classroom discourse is the opportunity to explore multiple approaches to a problem. When many students are working on one problem, it is almost guaranteed that more than one strategy will be introduced. It is important that students are introduced to multiple strategies for approaching and solving math problems. Not all students learn exactly the same and therefore not all students should be expected to solve a problem the same exact way. When a student gives an answer to a problem, a teacher can respond to the class with “Good. Now did anyone else have another way of getting to this answer?” This continues the flow of mathematical ideas and stimulates higher order thinking.

 On the contrary, some scholars say that accepting all student answers can be counterproductive. Although this strategy keeps conversation going and in turn increases participation, it is not necessarily the route teachers want to take. Teachers should recognize the need to filter student responses and influence the discussion to ensure that it is indeed productive. Walshaw and Anthony state that any practice “that does not attempt to synthesize students’ individual contributions tends to constrain the development of mathematical thinking” (Walshaw & Anthony, 2008, p. 526). In other words, the teacher should not be primarily focused on making sure that mathematical discussion occurs. Although this is good that students are willing to share ideas and participate in class, the teacher must play an active role in facilitating the discussion in such a way as to guide the class towards a better understanding. This requires a good amount of skill from the teacher. The teacher not only needs to be proficient in the mathematics, but must anticipate student response and be able to respond with appropriate questions and comments that will further guide the class in meaningful discourse. Being able to tie students’ ideas together is also an important part of the teacher’s role as discussion facilitator. Thus instead of just getting students talking, it is important for a teacher to recognize and filter the kinds of students’ responses that are going to make the most of the time in the classroom. This relies a great deal on noticing and naming. In other words, a teacher must have good listening skills when promoting discourse in the classroom.

 Walshaw and Anthony found in their research that teachers who listened carefully to what their students had to say were generally more effective. These teachers demonstrated great subject knowledge of course, but also were very focused on “listening, observing, and questioning for understanding and clarification” (Walshaw & Anthony, 2008, p. 527). Furthermore, the teachers

“provided responsive rather than directive support, all the while monitoring student engagement and understanding. The teachers did this through careful questioning and purposeful interventions and with a view toward shifting the students’ reliance from the teachers toward the support and the challenge of peers with varying levels of skills and understanding” (Walshaw and Anthony, 2008, p. 527).

This reinforces the idea that the teacher acts like a discussion coordinator in that he or she stimulates conversation by asking questions, and know what kinds of student comments need elaborating on. Sometimes it is just a matter of knowing your students and knowing when they are confused or when they do not fully understand something. Other times, this requires more. Teachers really need to be able to recognize these “teachable moments” where a student asks a question or makes a claim that if expanded on, would create a deep mathematical understanding of the material. Some strategies for creating teachable moments include creating more situations by asking students to share their ideas, help students expand on their ideas, encourage students to make connections among different explorations or content areas, and include multiple representations of the presented idea.

 Although the type of discourse that has been discussed thus far is ideal for all classrooms, this is not necessarily easy. In classrooms where student knowledge and skill level is highly varied, attaining this level of mathematical thinking can be difficult. When teachers have to teach to low achieving students in mathematics, they oftentimes oversimplify things in hopes to clear confusion. Walshaw and Anthony refer to this as path smoothing and found that it did not lead to “sustained learning because the strategy deliberately reduced a problem to what the learner could already do—with minimal opportunity for cognitive processing” (Walshaw & Anthony, 2008, p. 595). An important aspect of teaching mathematics is scaffolding. Rather than directly leading students to the right answer, teachers should guide the students through the thinking process allowing them to build upon and expand on their own ideas. Scaffolding is designed to develop higher order thinking among students. Walshaw and Anthony found some benefits to scaffolding such as “allowing students to see mathematics as created by communities of people, supporting students’ learning by involving them in the creation and validation of ideas, and helping students become aware of more conceptually advanced forms of mathematical activity” (Walshaw & Anthony, 2008 p. 530).

 Unfortunately, path smoothing can occur in classrooms where student achievement and participation in classroom discussion is very low. For example, students with lower socioeconomic status and or students with language barriers may be passive during classroom discussions and may not contribute to activities where the teacher attempts to use the scaffolding strategy. A study showed that in a particular classroom,

“the lower SES students were reluctant to contribute, stating that the wide range of ideas contributed to the discussions confused their efforts to produce correct answers. Their difficulty in distinguishing between mathematically appropriate solutions and nonsensical solutions influenced their decisions to give up trying” (Walshaw & Anthony, 2008 p. 526).

Clearly, scaffolding may be difficult in a classroom with these types of students, and this type of strategy is often more geared towards higher achieving students. However the results of scaffolded instruction have been shown to really benefit the lower achieving students by improving their sense of agency.

 As previously stated, one of the benefits of scaffolded instruction and valuing and shaping students mathematical ideas is that it directly involves the student in the creation and development of ideas. The type of conversations and types of language teachers use in the classroom have a great impact on student agency. According to Johnston good classroom discourse can “show children how, by acting strategically, they accomplish things, and at the same time, that they are the type of person that accomplishes things” (Johnston, 2004, p. 30). As soon as the teacher passes the responsibility of discovering a mathematical concept along to the student, the student then begins to think like a mathematician and consequently takes ownership of the discovery. Students with a higher sense of agency are more likely to work harder, focus more on their studies, and less likely to give up when faced with a difficult problem (Johnston, 2004, p. 40-41). Teaching students the processes rather than allowing them to be strategic and develop the processes on their own can hinder students’ conceptual understanding of an idea.

 Conceptual understanding is a great concern in mathematics. Many students fail to have a deep understanding of the underlying concepts of mathematics because they are so focused on the procedures that guarantee the correct answer. Students with a deep conceptual understanding are more likely to retain the procedural knowledge in the long run because they know where it comes from and, in some cases, how to derive it. Cobb, Stephan, McClain, and Gravemeijer (2001) argue that “classroom discussions in which the discourse is conceptual rather than calculational can be particularly productive settings for mathematical learning” (Cobb, Stephan, McClain, & Gravemeijer, 2001 p. 134). Calcualtional discussions are primarily centered on how to do a particular procedure. Some examples would be telling how to use a formula, or how to use the calculator to graph a function. Although these discussions might be necessary, it is important that students are forced to elaborate on the processes. If students are asked to discuss why the particular procedure works, then they are simultaneously developing their conceptual understanding of the material through discourse. Students must develop the ability to support their solutions because this is an important skill in mathematics, especially in upper level mathematics.

 A common theme in new mathematical research is the idea that teachers should be steering away from traditional methods of teaching, which is for procedural proficiency most of the time. Recent research advocates focusing on students’ conceptual understanding, as discussed previously. Classrooms that incorporate rich mathematical discourse show more potential in improving conceptual understanding among students. There are many ways teachers can improve the discourse that goes on in their classrooms and shift towards better conceptual understanding. Teachers need to know when to tell and when to allow students to discover mathematical ideas. Traditional practices consist of a lot of teacher telling and not enough student discovery. Cirillo suggests that teachers can initiate these discoveries by

“summarizing student work in a manner that inserts new information into the conversation, providing information that students need in order to test their ideas or generate a counterexample, asking students what they think of a new strategy or idea, presenting a counterexample, engaging in Socratic questioning in an effort to introduce a new concept, and presenting a new representation of the situation” (Cirillo, 2001, p. 3).

It is apparent that conceptual understanding stems from good classroom discourse. As much of the literature mentions, conceptual development is closely related to social processes. Through promoting classroom discourse, teachers “shift cognitive attention toward making sense of their mathematical experiences, rather than limiting their focus to procedural rules” (Walshaw & Anthony, 2008, p. 522). Conceptual understanding is yet another benefit from classroom discourse.

 Another way to promote classroom discourse is to use high-level mathematical tasks. Mathematics is a hands-on subject in that students learn by doing and practicing. Thus, the types of instructional material that teachers choose to use directly impacts the education the students receive. Teachers should choose tasks that are challenging and require more critical thinking yet stay within the students’ mathematical knowledge. These types of tasks are good at improving classroom discussion because they touch on a variety of different concepts and require students to connect ideas, communicate amongst each other mathematically, and are complex. It is also beneficial for teachers to choose tasks that are of interest to the students in hopes that the students are more willing to contribute to the discussion. Incorporating good proof writing skills into the curriculum would also be beneficial in promoting quality classroom discourse because proofs require discussion, and defending and explaining ideas. However, one would need to steer clear of the traditional two column proof idea and move towards a more beneficial method of teaching proofs. The idea of a proof is a social construct and is thus greatly related to classroom discourse. Proofs are an important part of mathematics and the NCTM put them as number five in the process standards. The *Principles and Standards for School Mathematics* suggests that all students

 “learn to recognize reasoning and proof as fundamental aspects of mathematics, make and investigate mathematical conjectures, develop and evaluate mathematical arguments and proofs, and select and use various types of reasoning and methods of proof” (NCTM, 2000 p. 56).

Proofs require argumentation and justifications that the teacher can develop through transactive reasoning. Transactive reasoning is characterized by clarification, elaboration, justification, and critique of one’s own or another’s reasoning. Transactive prompts, consequently, and questions or statements that get a student thinking this way. Blanton, Knuth, and Stylianou claim that “transactive prompts are a critical part of discourse because they serve as a scaffolding tool to build practices of argumentation necessary in the development of a proof. Thus, when a teacher gives a transactive prompt, she is potentially shifting students’ cognitive stance from passive to active, from accepting to questioning, and these transactive prompts scaffold the development of structures of argumentation” ( Blanton, Knuth, & Stylianou, 2009 p. 295).

Again we see that discourse that gets the students to participate in a mathematical community, expand on ideas, and question each other constructively has a positive impact on mathematical understanding.

 Many people argue that learning is a social activity. Halliday (1993) states that “the distinctive characteristic of human learning is that it is a process of making meaning—a semiotic process; and the prototypical form of human semiotic is language. Hence the ontogenesis of language is at the same time the ontogenesis of learning” (Halliday, 1993, p. 93). He also goes on to say that “language is the essential condition of knowing, the process by which experience becomes knowledge” (Halliday, 1993, p. 94). This last statement can easily be forgotten in a mathematics classroom, since a lot of people associate mathematics only with numbers. However, language is critical in the mathematics classroom. The literature reviewed in this paper advocates the importance of meaningful discourse in the mathematics classroom. It must be stressed that the use of mathematical discourse must be productive and there are disadvantages that occur when teachers try to incorporate mathematical discourse incorrectly. This paper gives some insight on the benefits to using discourse appropriately and effectively. It also provides some techniques for teachers. This topic is of great concern, as mentioned so in the *Principles and Standards for School Mathematics* published by the NCTM, and should be highly focused on in the mathematics classroom.

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