Talk Your *Math* Off: Communication in the Mathematics Classroom

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Abstract

One of the six process standards outlined by the National Council of Teachers of Mathematics is communication. This paper outlines how language, the foundation for communication, can be used to create both detrimental and beneficial communication in the classroom. Additionally, the different ways the language of mathematics can be learned and practiced by students is discussed.

Introduction

The importance of communication skills in the workplace cannot be understated, as, according to Wium and Louw (2012), employers see this skill as the foremost important quality for graduates. However, according to Wood (2012), effective communication is not a prime focus in the average mathematics classroom. This is a major problem as the negative effects resulting from a lack of effective communication in mathematics classrooms are not limited only to future work plans. Rather, negative effects can be immediately seen in students' understanding of mathematical concepts, and their abilities to continue growing in mathematical knowledge and understanding (Goel & Reid, 2012). In order to implement effective mathematical communication in the classroom, it is first important to take a deeper look into why and how this should be done.

Communication in Mathematics

The National Council of Teachers of Mathematics explicitly cites the importance of students' abilities to communicate mathematically. In one of only five process standards, they state "Instructional programs from pre- kindergarten through grade 12 should enable all students to organize and consolidate their mathematical thinking through communication, and communicate their mathematical thinking coherently and clearly to peers, teachers, and others ..." (PSSM, 2000, p. 348). Despite the National Council of Teachers of Mathematics' push to prepare students to communicate mathematics clearly, according to Wood (2012), it is currently a rare find to discover a mathematics classroom "where training in communications has been an intrinsic part of

mathematical learning" (p. 110). For example, in a case study focusing on analysis of mathematical discourse in a secondary mathematics classroom, researchers Huang, Normandia, and Greer (2005) found that in one teacher's classroom, though the majority of the students had participated in showing their work for a problem on the board before taking her class, none of them had ever been asked to explain how and why they solved the problem the way they did. In other words, none of them had ever been asked to partake in a mathematical discussion concerning their work before having this teacher.

In many mathematics classrooms, there is a great emphasis placed on reading and listening skills, leaving oral and written communication skills virtually out of the picture (Wood, 2012). Moreover, according to Wood, it is often assumed students learning mathematics will automatically pick up on and "absorb" the discourse used to explain it, and thus, be able to communicate the mathematical ideas being learned. Though this may be the case for some students, more often than not, this indirect style of teaching mathematical discourse leads to negative consequences for many students (Baber, 2011).

The National Council of Teachers of Mathematics' call for improved student mathematical communication is perfectly aligned with what research reveals about communication, and its foundation: language. According to Huang et al. (2005), since, in the classroom, language is the vehicle for learning, language and learning cannot be separated. Notice, mathematics is taught using language, teachers assess students' understanding through the language they use, and students make sense of their ideas using language (Wium & Louw, 2012). Huang and Normandia (2009) state that countless studies reveal language to be eminently important to students' ability to process and understand mathematics. In fact, Huang and Normandia (2009) say these studies show

that communication is actually a main factor in this realization. Further, creating understanding and developing language must exist together because they spur each other on to produce greater growth (Huang & Normandia, 2009). Language is the way through which individuals make meaning and gain knowledge. Since language is the foundation of communication, this begs the question, what happens if good language is not evident in the mathematics classroom?

The Language of Mathematics

While the National Council of Teachers of Mathematics calls for communication, they do not simply call for communication of any kind, as not all communication is beneficial. In fact, some can actually be detrimental to the learning process. Communication that uses incorrect mathematical terminology can create great confusion for students. Being taught using incorrect mathematical terminology has negative effects on students' learning that leads to many problems in their current schooling and future lives (Wium & Louw, 2012). Incorrect terminology causes students to fail obtaining a full and clear understanding of the material they are being taught, creating problems in future mathematics lessons that call for a clear understanding of the material it is believed students learned. If language is the medium for learning in the mathematics classroom, incorrect language can most naturally be directly correlated to students learning incorrect material, or constructing incorrect meaning.

Problems also arise for these students in their future classes taught by different instructors who use correct terminology the students are expected to know, but were never taught. Poor standardized test scores may result on exams where students are not

familiar with the formal terminology used in the test questions (Wium & Louw, 2012). The worst outcome, which is unfortunately the result for many, is that it makes the learning of mathematics so "unnecessarily difficult and time consuming" that students give up learning mathematics altogether simply because they misunderstand the language (Baber, 2011, p. 9).

Since research overwhelmingly shows communication, but not all communication, is important to mathematics learning, the important questions that follow are: what types of communication are beneficial, and how can these be implemented in an effective manner? The National Council of Teachers of Mathematics calls for specific communication that precisely expresses mathematical ideas (Goel & Reid, 2012). This type of communication centers upon the proper and correct use of language. To communicate mathematical concepts in an effective manner, one must not only understand the mathematical concepts, but the language required to communicate them. Mathematical language is not most students' primary language, as one may expect, and is, at best, only a secondary language for many. As one might assume, it is very difficult to communicate effectively in a foreign language if the person attempting to do so does not know the language. Similarly, it is difficult to communicate mathematics effectively if the language of mathematics is not known. So what is the language of mathematics?

Mathematical communication is the ability to communicate mathematical knowledge properly and effectively (Wood, 2012). Making mathematical communication correct and effective relies heavily on the language of mathematics, which is the mathematical notations and vocabulary used to represent abstract ideas (Baber, 2011). These notational forms include expressions that are built upon varying values, variables,

and functions, along with their unlimited combinations (Baber, 2011). The language of mathematics is known for being precise and free from ambiguity, within context, as vague terminology is not a part of its vocabulary (Baber, 2011). Thus, mathematical language is critically important for mathematical communication as it leads naturally to clear, unambiguous discourse. To communicate mathematically with others, the particular symbols and terminology of the mathematical language are used in addition to students' primary language, making it vitally important that students, and teachers, know the language of mathematics in order to communicate well with one another (Baber, 2011). All mathematical problems in English text must be transformed into a "mathematical model" using mathematical symbols and rules, in order to think and reason about the problem in an abstract manner (Baber, 2011, p. 9-10). Notice, "Facility with the language is a prerequisite for understanding and applying mathematics effectively" (Baber, 2011, p. 9). Thus it is no wonder students have a difficult time with mathematics when they do not fully grasp its language.

Strategies for Effective Mathematics Discourse

Some experienced teachers have observed, over many years of teaching, that there students' difficulty often is not the result of material they are teaching, but the incorrect mathematical language their students past teachers used (Goel & Reid, 2012). To avoid difficulties with mathematics as a result of not fully understanding the language, teachers must make a conscious effort to use the proper mathematical language themselves. This means that teachers must be aware of their own use or non-use of the language (Wium & Louw, 2012). They must not only correctly understand the terminology used in the

language of mathematics, but also consciously make the choice to use it, so they do not confuse their students and put them in a position to have more difficulty in their current and future mathematical learning (Wium & Louw, 2012; Goel & Reid, 2012). After teachers have determined they are using the language of mathematics themselves, or have made changes so they are, they must not assume their students will naturally absorb the language they are using in the classroom (Wood, 2012). Rather, they must set aside time to teach it to their students who may not pick up on it automatically.

To make certain students understand and can use the language themselves, they must not only be encouraged to use it, but required. In the case study conducted by Huang et al. (2005), the authors found that one mathematics teacher's classroom was very noisy, however, it was a good kind of noise as it was the result of students conversing about mathematics. This teacher was picky and persistent when it came to her students' use of mathematical terminology (Huang et al., 2005). She believed that requiring students to use the proper language of mathematics was "a way to socialize students into the discourse of school mathematics" (Huang et al., 2005, p. 38). However, this case study revealed that students often needed clear direction and command to what and how they should say something in order for them to say it (Huang et al., 2005). Hence, the students needed mandatory practice.

Though one of the main characteristics of the language of mathematics is its clarity, it is a complex language that is typically not clear to students without its explicit teaching. It often poses challenges and causes confusion for students when it is not explicitly taught, but used in such a way that students are intended to pick up various meanings and slight differences in meanings on their own. However, all of these

challenges can be overcome with proper teaching of the vocabulary and forms of notation that are a part of the mathematical language.

Good communication in the classroom takes design. Creating designed communication in the mathematics classroom is an important job of the teacher (Huang & Normandia, 2009). Teachers must wisely plan their implementation of classroom discourse in order to guide and direct these mathematical discussions so that students receive the greatest benefit possible (Huang & Normandia, 2009). Since good language is essential to good communication, teachers must first seek out ways to incorporate the language of mathematics in their classrooms. It was mentioned earlier that teachers must use the language of mathematics themselves in their discourse. In this way, teachers are able to model the use of the language of mathematics for their students, to guide their students to correct usage (Huang et al., 2005).

In Huang and Normandia's case study (2009), students revealed, that the way they gained confidence and precision in talking mathematics was due to the mandatory and frequent practice they had using the language. Hence, students must also have a variety of opportunities in which they are mandated to practice this mathematical language, modeled by their teachers, in their own discourse (Wium & Louw, 2012). Opportunities for students to do this are up to the teacher to provide. In order for students to verbally practice and use the language of mathematics, they must have the opportunity to speak. Thus, it is imperative teachers elicit the use of classroom discourse on a regular basis. As mentioned earlier, the presence of "teacher discourse do[es] not automatically transfer to student discourse through class discussion" (Huang & Normandia, 2009, p. 48). Hence,

there is more for teachers to think about than simply using the language of mathematics and allowing their students the opportunity to speak.

During these discussions, teachers should ask their students thought-out, probing questions that require a detailed explanation using the language of mathematics. When students use the correct language, positive attention should be drawn to their phrasing and praise should be given to ensure this language continues (Johnston, 2004). This will also help correct or reinforce other students' understandings of the mathematical language. On the other hand, if a student's response does not use the language of mathematics correctly, attention should be brought to this as well. It should not be severely negative, as to cause the student to shut down and refrain from answering following questions. Rather, the teacher should work with the student's answer, acknowledging the part that is partially correct, and asking probing questions to help the student transform their original response into a more precise answer using the correct language of mathematics (Johnston, 2004). In these instances, it may be beneficial for the teacher to, by questioning, point out the reasons the word choices in the original response were not as strong as they could be, or, how they were not as precise and understandable as the revised response. This will help students to understand the importance and benefits of proper terminology. Hopefully, this understanding will transfer to an appreciation for the language and a desire to use it correctly, since students' perceptions on communicating mathematically greatly determines their success in good communication skills (Huang & Normandia, 2009).

Another finding from the case study conducted by Huang et al. (2005), was that students were more motivated to go into greater depth in their discourse and to be more

specific when they spoke from the role of a teacher. Speaking from this perspective, students appeared more interested in explaining concepts in detail than when they explained their thoughts from a student-role (Huang et al., 2005). In other words, one possible way to encourage students to speak, thus placing them in a position to practice using the language of mathematics, is to place them in a leadership role of explaining a problem to the class.

Another way for teachers to assist their students in practicing proper mathematical communication is through personal mathematics journals, as it is equally important that students can communicate mathematics effectively and correctly in written form (Kostos & Shin, 2010). With the springboard of a probing question, students can write their own responses using the mathematical language in a journal entry. After seeing how the teacher grades their work, students will begin to gain a better idea of the language of mathematics, and, since all their work will be in the same journal, they can look back at previous entries to see how their writing has developed.

Implications and Benefits of Effective Mathematical Discourse

Student's communication of their mathematical ideas reveals a great deal about their understanding of mathematical concepts, or lack there of. Analysis of the students in the case study conducted by Huang et al. (2005) showed when students were not using the language of mathematics to correctly describe a particular mathematical concept, it was also true that they did not fully understand this mathematical concept. Furthermore, according to Huang et al. (2005), students' use of mathematical terminology reveals their true understandings, or misunderstandings, of mathematical concepts. Thus, students'

abilities to correctly explain mathematical concepts are a good indicator they understand them, and their inabilities are a good indicator they do not.

Communicating mathematically in the classroom is extremely beneficial to the learner for many reasons. Though at the outset it may seem a daunting task for teachers, Huang and Normandia's study (2009) is encouraging in that it shows when students are supported by their teachers to use correct mathematical language, and are given frequent opportunities for practice, they are able to grow in their comfort of and engagement in using the correct language of mathematics. This is imperative, as doing so allows students to share and receive feedback on their understanding, contribute to class discussions where students form meaning corporately, and listen to other student's ideas, comparing and contrasting them with their own in order to discover for themselves what part they understood correctly and which part, if any, needed correction (Huang & Normandia, 2009). According to Wium and Louw (2012), when students are able to use the correct notations and terminology they have learned to speak or write about their mathematical ideas, they will gain an increased level of confidence that is exceptionally beneficial to the learning process.

Conclusion

Since mathematics is taught and learned through communication, the communication used to teach it should not be taken lightly, as it holds great weight for the learner (Wood, 2012). Good communication in the classroom centers on good, appropriate, and concise language. This language must be used by the teacher, required of students, and fostered in the minds of students by teachers' designed opportunities for

learning and mandated practice. However, language is only the start of good communication. While using the language of mathematics, in order for teachers to bring forth good communication in their classrooms, they must also have good techniques for doing so. This takes creativity on the part of the teacher to design environments where students are comfortable and engaged in using the language of mathematics through different activities. That being said, teachers striving to obtain effective communication in their classrooms must start somewhere, and that somewhere is the language of mathematics.

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