Breaking Silence: Initiating Conversations in Mathematics Classrooms

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Introduction

The character of the boring economics teacher played by Ben Stein in John Hughes's 1986 film *Ferris Bueller's Day Off* briefly crosses my mind as Mr Paavi (all names used here are pseudonyms) first asks the class "Any questions?" and moments later inquires if students have heard of a recent "pay it forward" advertising campaign by a local bank:

> Mr P: Any of you guys hear about this yesterday? ... Anyone? Right ...

Like the students depicted in the film, Mr Paavi's Grade 12 applied mathematics students stare back in silence. But unlike Ben Stein's monotonal character, Mr Paavi is a dynamic speaker who is sufficiently loud and commands attention. He is not afraid to challenge and engage with his students. Mr Paavi does not accept the silence:

> Mr P: Who has a heartbeat?! Does anyone have a heartbeat today? Let's start with that ... Who has a heartbeat? (Sam, smiling, holds his hand up. Geoff follows reluctantly.) OK. Oh, OK, so, all right, just checking, OK, good, thank you ...

As the class begins with an extracurricular chat about the local bank, charitable acts and advertising, the students and the teacher are explicitly exchanging their expectations. Through inaction, the students are communicating their reluctance to participate. For the teacher, on the other hand, the class needs a pulse. It has to be alive and responsive. Mr Paavi needs some reassurance that what he tells his students over the next 80 minutes of instructional time will not die from inattention. "Who has a heartbeat?" is a rhetorical question, but it is also a message that in this class participation is important.

Several days after I watched Mr Paavi ask his students, "Who has a heartbeat?" the following interaction in Mr Brodiew's classroom (Grade 12 pure or precalculus mathematics) caught my attention:

> Mr B: It's, it's going to be, right here (pointing to an exponential function written on the board), when you plug ... yeah ... when you plug negative three in, the negative three is going to reciprocate that and it will be two cubed, or eight.
> Mr. B: This will be?
> S1: Oh, four!
> Multiple students: Four, four...
> Mr B: Four!
> (Teacher points to the successive values of x as a number of students recite in unison.)
> Multiple students: Two. Two!
> Mr B: Two!
> Multiple students: One! Negative ... one over two! One over four! One over eight! One over sixteen!
> Mr B: Yeah! You're getting it! There is excitement! You're doing math!
> (Some students in the back playfully high-five each other, while several others smile.)

As students recite the answers, the spontaneous display of energy reverberates through the room. It is perhaps this type of excitement—the loud heartbeat of the classroom—that Mr Paavi, Mr Brodiew and so many other mathematics teachers strive to experience.

Study Background

In an attempt to explore student questions in secondary mathematics classrooms, I have collected a large amount of data that includes narrative accounts of students' questioning experiences, responses from a focus-group discussion among three experienced mathematics teachers on the topic of student questions, and observations and video recordings of 69 mathematics classes. Two of these classes are Mr Paavi's Grade 12 applied mathematics course and Mr Brodiew's Grade 12 pure mathematics course.

All video recordings, in particular classroom videos from these two classes, have been reviewed, and video clips containing instances of student participation (primarily student questions) were created. These clips were then coded thematically with keywords identifying particular aspects of each clip. Some of the keywords identified elements of student participation

(eg, formal requests to speak), others focused on the types of questions asked (eg, clarification), and still others described turn taking (eg, precipitating utterances), teacher moves (eg, delegation of response) or teaching style (eg, lecture). The observations of these classrooms and my analysis of student questions inform the ideas discussed in this work.

Introducing Mr Paavi and Mr Brodiew

Mr Paavi and Mr Brodiew are two experienced, well-respected and well-liked mathematics teachers. They are both dynamic speakers who can create a highly interactive dialogue with their students and their colleagues. Mr Paavi and Mr Brodiew are also two of four participating teachers who make extracurricular conversations, such as the interaction set out at the beginning of this paper, part of the classroom routine. Mr Paavi is well aware that he frequently spends significant amounts of instructional time discussing issues that parallel the topic of the lesson. He explains to his students that he cannot resist discussing the issues of finance, business and government.

Mr Brodiew, on the other hand, has a penchant for mathematics and movies. His lessons are full of references to popular culture and cartoons. These references are made in passing, interrupting conversations that otherwise focus on the lesson. Both teachers, and Mr Brodiew in particular, are skilful in eliciting laughter with jokes, impersonations and social commentary. In fact, laughter is a prominent fixture in Mr Brodiew's classroom.

Most of Mr Brodiew's students have agreed to appear on camera and to take part in my observations. A number of students routinely ask questions or reply to teacher inquiries. At the same time, a significant group of students seldom or never participate during my visits. The class is held in the final block of each school day.

Mr Paavi's class, which I featured in the opening quote, is small (20 mostly Grade 12 students) and held every morning. Only 10 to 15 students are in attendance on any given day. The total number of students who have agreed to participate and who have chosen to sit in view of the camera is even smaller. Students in this class are very reserved, and only a handful of "target students" (Tobin and Gallagher 1987) make occasional contributions through questions or answers to teacher inquiries.

I write this article for all the teachers who identify with Mr Paavi and Mr Brodiew in their need to hear their students; it examines the challenges in initiating mathematical conversations with students. In the concluding section, I make some practical recommendations that are not tested through practice but are born out of observation, through thoughtful reflection and a review of relevant literature. In making the recommendations, I recognize the individual differences of the many mathematics classrooms.

Theoretical View of the Role of Student Classroom Participation and Conversation

Many researchers consider student involvement and on-topic conversation in the classroom an important learning strategy (eg, Turner and Patrick 2004). Consequently, several mathematics curricula accept and promote student participation primarily through student communication of ideas. The Principles and Standards for School Mathematics (National Council of Teachers of Mathematics [NCTM] 2000) and the Western and Northern Canadian Protocol (WNCP 2008) documents describe communication of mathematical ideas as a significant area of student development. Both documents explicitly expect students to use conversation to become precise and to show reason in their discussion of mathematical concepts, and to form links between various representations of mathematical ideas.

Although the pedagogical aim to promote and sustain student participation may be reasonable, student participation in mathematics and other classes is a complicated matter in middle and secondary school classrooms (Daly, Kreiser and Roghaar 1994; Patchen 2005; Turner and Patrick 2004). Problems with student participation are further exacerbated by the presence of English language learners (ELLs) (Patchen 2005; Yoon 2007), students with diverse abilities and special needs, the gender composition of the classroom, and teacher approach to student participation, among other issues (Daly, Kreiser and Roghaar 1994; Patchen 2005).

Curiously, even reports that aim to quantify the problem of student participation, such as the one by Daly, Kreiser, and Roghaar (1994), report that the majority of students appear to be comfortable asking questions and, by extension, participating in class. That study has collected information from 24,599 students between the ages of 13 and 16. The authors report that the mean question-asking comfort score is close to 12 and the standard deviation is approximately 2.5 on a task with a score range from 4 to 16. However, they find that question-asking comfort does correlate inversely with the age of students and directly with gender (males report greater comfort than

females), socioeconomic status, personal goals, language ability and perception of teacher helpfulness.

Two questions arise for me:

- If the majority of students are comfortable participants, why at times don't they participate?
- What do we do about students who report discomfort with classroom participation?

Sfard et al (1998) raise a similar question, but they focus on teacher practice. In their exploration of the role of conversation in mathematics education they conclude

> In short, the question is not whether to teach through conversation, but rather how. Since learning mathematics may be equated to the process of entering into a certain well defined type of discourse, we should give much thought to the ways students' participation in this special type of conversation might be enhanced. (p 50)

The greater education community has been preoccupied for some time with similar challenges. To enhance opportunities for student conversation and participation, many innovations have been introduced but have had variable success. Classroom activities (for example, brainstorming and group work) and curriculum modifications with an emphasis on communication and a constructivist learning framework are being tried by teachers across Canada. It is now not unusual to find various classroom technologies such as the Student Response Systems (or clickers) and interactive whiteboards across North American classrooms (Anderson et al 2003; Dufresne et al 1996; Nocente, Belostotski and Brooks 2009; Penuel, Abrahamson and Roschelle 2006; Roschelle, Penuel and Abrahamson 2004). However, as Judson and Sawada (2002) point out, any success with the implementation of new technologies and practice that leads to an increase in student on-task participation still rests largely on the shoulders of the teachers who build a classroom culture conducive to participation.

Patchen (2005) expands on the general call for teachers to improve student participation with the following five recommendations, which focus on recent immigrant adolescents but include all educational settings: (1) deepen personal understanding of students' cultural background, (2) establish relationships, (3) diversify participation structures, (4) ask answerable questions and (5) solicit student feedback (pp 45, 46).

But how does one "deepen personal understanding" and "establish relationships"? What space—be it time or curricular—is available to meet these suggestions?

An Interactive Exchange: One Example from a Mathematics Classroom

To provide one example of a teacher having some success in drawing students into participating, I presented a sequence in the introductory section, in which a number of students join in a chorus listing the answers one by one. It is important to recognize that the unison recitation included some students who had not participated in classroom conversation in my presence before. At the same time, it is important to note that not all students participated. Still, I would like to propose that through laughter and lighthearted, often extracurricular, conversation, Mr Brodiew has created a class culture that enables student participation.

Consider how the conversation unfolds, as set out below in "The Mathematical Chorus and the Soloist." The transcript lines are numbered by speaking turn for later reference; overlapping speech is included in square brackets and formatted to vertically overlap.

The Mathematical Chorus and the Soloist

1. Mr B: It's, it's going to be, right here (pointing to an exponential function written on the board), when you plug ... yeah ... when you plug negative three in, the negative three is going to reciprocate that and it will be two cubed, or eight.
2. Mr B: This will be?
3. S1: Oh, four!
4. Multiple students: Four, four ...
5. Mr B: Four!

(Teacher points to the successive values of x as a number of students recite in unison.)

6. Multiple students: Two. Two!
7. Mr B: Two!
8. Multiple students: One! Negative ... one over two! One over four! One over eight! One over sixteen!
9. Mr B: Yeah! You're getting it! There is excitement! You're doing math!

(Some students in the back playfully high-five each other, while several others smile.)

10. S2 (off camera): {Inaudible}
11. Mr B: What's that?
12. S2: Why isn't it the square root ... like {inaudible} in the second {inaudible} ...
13. Mr B: OK. OK. Why would, why would I flip this? (The teacher points to a number with a negative exponent.)

(3.8 seconds)

14. S3: The negative?
15. Mr B: The negative in the exponent. What does the negative do?
16. S3: It flips [it]
17. Mr B: It flips it, so negative three is going to be ... see that?

(Several students are now talking among themselves.)

18. S4: Mr Brodiew?
19. (Mr B reacts to some suggestion he hears.)
20. Mr B: Oh, oh, hold on, don't do that, {inaudible} don't do that.
21. S5: Wait!

(Noisy)

22. S4: Do you mean the negative exponent flips [the fraction?]
23. S5: [What do you] mean, "Don't do that"?

(Noisy)

24. Mr B: Aha, so this becomes, this basically becomes two to the positive three. Exactly! Good! Now, now look at this ...

Though the transcript might create an impression of uniform participation, the classroom video clearly shows that many students in this large class do not participate. These students include those who perform well academically and those who do not.

The recitation in lines 3 to 9 clearly demonstrates how some students are able to recite the terms of a geometric sequence or, perhaps, continue the most likely number pattern without much consideration for the topic (note the desire by some students on line 8 to recite the wrong pattern continuing from one to the negative numbers).

Lines 10, 11 and 12, on the other hand, deserve additional consideration. Student S2 refuses to be swept away with the excitement and questions the simple patterning. In the process, she rescues the moment for some of her classmates who might have not understood what was being recited. In asking her question, the student risks being exposed as perhaps the only student—or one of the very few—who did not understand the process and thus facilitates a valuable learning opportunity for her classmates.

The decision to ask is selfless and brave. The risk of exposure and the social ramifications of this act cannot be understated, but they can be mediated by building an appropriate class culture where student participation is not evaluated, interruptions are accepted, the atmosphere is friendly, student participation is welcomed and students are part of an ongoing conversation. In short, students need to feel safe enough to, on occasion, stand against the flow of the class.

I argue that in the case of Mr Brodiew and Mr Paavi, the element of safety comes from frequent extracurricular commentary and as a greater social comfort of being in a friendly environment. Students of Mr Brodiew and Mr Paavi are drawn into discussion—become a part of the conversation—even before they actively participate in learning about mathematics. These opportunities appear to create the necessary conditions for keeping students involved in conversation as it shifts from extracurricular chat toward a discussion of the concept of the day.

Discussion

Earlier I asked the following two questions:

- If the majority of students are comfortable participants, why at times don't they participate?
- What do we do about those students who report discomfort with classroom participation?

One plausible answer to both questions lies in providing opportunities for all students to be part of a discussion. Be it joining a chorus of peers or a chat about the publicity programs by a local bank, the immediate relevance of the conversation in itself is irrelevant.

The Mathematical Chorus

Not all students reciting the numbers in "The Mathematical Chorus and the Soloist" understood what was being recited—perhaps only the ones who correct the pattern in line 8 did. However, such understanding of this particular pattern may be secondary to the value of participation. In the excitement, many students became a part of the living classroom. Several students who normally don't say a word finally added the sound of their voice to the classroom. They said things aloud. In a conversation some years ago, I asked a group of preservice teachers about classroom participation. One of the students said that she used to be shy about the sound of her own voice. As a result, she avoided speaking in class. A recital such as this, similar to singing in a choir, would provide an appropriate medium for students like her to join in and add the sound of their voices.

Besides creating a medium where even the shy students can add their voices, this group recital is a self-correcting process. The initial desire to follow the wrong path is not as important as the realization that their contribution was sufficiently close. Van der Meij (1990) describes several hypotheses and studies that suggest that perplexity—the first stage of questioning—arises from various internal or external events. Van der Meij writes:

> It is believed that the most likely condition leading to such a perplexity occurs when a stimulus resembles something well-known but is also distinct enough to be interesting. If it is too remote from experience, or too familiar, the reaction will be one of indifference ...). (p 141)

Consequently, the initial making of an error may offer a significant opportunity to confront and repair a student's own misunderstanding.

Extracurricular Chat

An opportunity to talk about a variety of topics offers the possibility that conversation in the classroom is not just for the satisfaction of the teacher—a means to determine the level of alertness of the students. Saying things aloud in a classroom provides an entry for students to become part of the classroom and join an ongoing conversation. Once part of a conversation, the students participate in the classroom conversation about mathematics amongst other things.

I cannot offer a guarantee that all students will remain in conversation. For example, student S2, following the initial utterance on line 10, was compelled to participate in the conversation she initiated only once—in line 12. It is also unreasonable to expect two groups of students to respond to the teacher in exactly the same way. However, in this instance, student S2 felt safe enough in the class to engage the teacher. Students reciting the numbers felt the safety of the chorus to speak. At the end of the interaction, students talked about mathematics with each other and the teacher.

My Recommendations

Having considered the issues of classroom participation and the literature on classroom participation, my recommendations for drawing students into participation include the following:

- Use Patchen's (2005) suggestions and promote talk that encourages the students to share their background and interests.
- Ask students to repeat terminology such as *dispersion*, *deviation* and *reciprocal*, because not knowing how to pronounce a word should not stand in the way of talking about concepts.
- Create opportunities for students to say things out loud, be it the mathematics term of the day (eg, on a count of three say *numerator*) or the part of the lesson you have found the most difficult (on a count of three say your name).
- Look for alternatives to speaking (such as classroom communication and presentation technologies).
- Invite students to answer questions, make suggestions and speak mathematically together, perhaps even at the same time, taking some of the risk out of the participation equation.
- Visit the classrooms of your colleagues and to see what their students are doing, saying, or not saying.

Join in the conversation and let us all know what has worked for you in giving your students a voice in your mathematics classroom.

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