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Reflections on Teaching with a *Standards*-Based Curriculum: A Conversation Among Mathematics Educators

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Many teachers and researchers have written about the challenges inherent in adopting new teaching practices in mathematics classrooms (e.g., Chazan, 2000; Clarke, 1997; Heaton, 2000). The authors of this article, all with secondary mathematics teaching experience, are convinced by research suggesting that *Standards*-based mathematics curricula are beneficial for student learning.[1] However, the first three authors had not used such curriculum materials in their own classrooms, and we desired experience using a *Standards*-based mathematics curriculum with secondary students. To this end, we

[1] For our purposes, *Standards*-based mathematics curriculum materials are those developed to align with the National Council of Teachers of Mathematics' standards (NCTM, 1989, 1991, 1995, 2000) with funding provided by the National Science Foundation.

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taught a week-long summer course with a focus on linear functions to high school students who had previously struggled with algebra and volunteered to participate.

The aim of our course was to improve students' understanding of linear functions through the use of an inquiry-based learning environment and a *Standards*-based curriculum. This was not a typical classroom setting since there were three instructors for less than 20 students. Nonetheless, it was useful for both teachers and students to experience participating in an inquiry-based curriculum for the first time. The purpose of this article is to stimulate thinking and conversation among teachers by sharing our own conversations about learning to teach mathematics using a *Standards*-based curriculum.

The curriculum selected for the course was the second edition of the *Connected Mathematics Project* (*CMP*) (Lappan, Fey, Fitzgerald, Friel, & Phillips, 2006), specifically Investigations 1 and 2 of *Moving Straight Ahead* which focused on linear relationships. The *CMP* curriculum (similar to other *Standards*-based curricula) uses a Launch-Explore-Summary model of instruction. During the *Launch*, the teacher poses a mathematical task or provides information that is intended to provide a "hook" to get students interested in the investigation, while making connections to their prior knowledge and experiences. During the *Explore*, students collaborate in small groups on a mathematical task that requires them to construct important mathematical ideas. The teacher's role during the *Explore* is to monitor groups' mathematical conversations and begin to plan a sequence of presentations for the *Summary*. Finally, the *Summary* provides an opportunity for students to present their work to the class and discuss the emerging mathematical ideas with one another. During the *Summary*, the teacher serves as a facilitator to synthesize students' ideas and draw out the key mathematical concepts and/or procedures from students' work.

Upon completion of the course, the instructors agreed that *Standards*-based teaching requires a great deal of on-the-spot intellectual work. The pay-off, however, which we learned through teaching the course, was that students seemed to be able to make sense of the mathematics rather than following prescribed procedures. For example, in addition to calculating the slope, the students could often understand what the slope represented in each of the application problems (e.g., walking rate). Seeing students' pride - and sometimes surprise - when they realized that they were able to write an equation to model a situation or solve a challenging question without the explicit direction of a teacher, was priceless. The week ended leaving us with much to think about (e.g., how to manage mathematical discourse). Teaching using an inquiry-based model with a Launch-Explore-Summary structure highlighted many dilemmas that we were able to experience firsthand. We composed reflections based on our experiences into a series of questions. We subsequently sent them to Lisa, the fourth author, who responded to our questions using her many years of experience teaching with *Standards*-based curricula. Our questions fell into three overlapping categories: (1) questions about mathematical discourse, (2) questions about facilitating the *Summary*, and (3) questions about general pedagogy. We have posed our questions (Q) in regular font, with the answers (*A*) in italicized font.

Questions about Mathematical Discourse

Q: It was often challenging to know how to respond to students' ideas during any part of the *Launch*, *Explore* or *Summary* when their answers were mathematically incorrect. I did not want to make them feel like the idea they shared was not useful, and I wanted them to feel safe sharing conjectures even before they had a chance to test and refine them. We all worried about what to do if the students said a "wrong" answer and the class agreed. This happened several times, but each time other students questioned the idea and it did not stand up to the rest of the class' judgment. What do you do during the *Summary* if a group presents a solution that has mathematical flaws that are obvious to you, and no student challenges it?

A: When you are circulating around the room while the students are working, this is an opportunity to see those students who have mathematically correct responses and those that are incorrect. If most of the students think the incorrect answer is correct, I would say something like, "Carmen, I noticed when I looked at the work that you and your partner did, you did not come up with this answer, can you explain to us what you were thinking?. This allows a different response to surface, and then I would pursue the differences between the two responses by asking the students to think about why the answers are different and what may account for the differences.

Q: I often found myself playing ping-pong in the conversation. I would ask a mathematical question, someone would make a remark or give an answer, and I would typically be the next person to speak again, to question the speaker further or summarize what he/she said. How do I de-center myself from the class discussion so that more mathematical discussion can occur between students?

A: When students would make a claim, I found that asking follow-up or extending questions such as "What do you think?" "What is your evidence?" "Does anyone disagree?" "Is there another way to look at this?" was helpful to promote productive *discourse and place the mathematical authority among the students. As a classroom teacher, it's important to model for students how to respectfully disagree, and encourage students to talk to each other, not the teacher.*

Q: As is always the case, some students volunteered to provide answers or explain their mathematical reasoning and others did not (or did so less often). Since *Standards*-based instruction is meant to engage all learners in mathematics, is it okay to randomly select students to present their work or answer questions or should it usually be on a volunteer-basis?

A: It's important as a classroom teacher to develop a classroom culture in which students feel comfortable sharing ill-formed ideas and students are willing to take risks. Students need to know that every student in the classroom is responsible for contributing to the discussion. I think though it's okay for a student to say, "I pass" when they really aren't comfortable explaining a specific problem. If this becomes a habit with particular students, teachers need to figure out what will work to keep these students engaged. Again, I think it's important that teachers from the onset of the school year develop a culture where students are motivated, engaged, and know it's okay to be wrong, and they will be supported.

Q: I noticed that if I responded to a students' mathematical answer or reasoning in a way that indicated I agreed with what they were saying, even in a subtle way, then when I asked, "Anyone disagree?" it produced nothing but silence. I began to wonder if because my students see me as the authority of correct answers in my classroom, they adjust or change their thinking to match what they think I want, regardless of what they were thinking previously. When students are sharing mathematical ideas with you, either one-on-one or as a class, and then they look at you with eager eyes, waiting for you to affirm or evaluate their idea, how do you respond?

A: *I wouldn't agree with the student. When a student presents a response, instead of validating you could ask, "what do you think?" to other students in the class. I would also be very explicit saying to students, "I am not the only mathematical authority in this classroom, it's important that we hear from everyone . . .we are working on these problems together, and we are all going to contribute to building our new mathematical knowledge together.*

Q: When two conflicting mathematical ideas are presented in the class, how do you facilitate a conversation about these without indicating which side you are on? Is it appropriate to "vote" or is it better to stay at a level of asking the student to logically "argue" the two cases?

A: *These conflicting ideas are significant mathematical learning opportunities. I think it's important for students to logically argue the two cases by asking students to clarify and justify their thinking. This notion speaks to the NCTM Reasoning and Proof process standard. Students need opportunities to evaluate others' mathematical claims as well as formulate mathematical arguments.*

Questions about Facilitating the *Summary*

Q: The *Summary* was by far the most challenging part of the lesson for us to implement. We often asked students to share their mathematical results with the class. Of course, this takes some time and I wondered if this is always the way to go. Should students always present their work during the *Summary*? If not, how might a teacher decide when it is necessary or helpful and when another strategy might suffice? What other strategies would you suggest as options for getting the main ideas on the table during the *Summary*?

A: The summary is very difficult to orchestrate. This is where the important mathematical ideas are coalesced. However, it seems to be the segment of the lesson that teachers tend to short-change. I think that while the students are working, it is important that the teacher looks for student work that they wish to highlight during the summary segment. Teachers should highlight not only correct mathematical responses, but incorrect responses as well. The summary takes practice, but it's important for teachers to understand that students need this summary, as this is where the important mathematics is made explicit.

Q: Students work at different paces in mathematics classrooms and this presented a challenge for deciding when to start the *Summary*. Can you provide any pointers for making this decision?

A: When the teacher is circulating around the room, they get a sense of how many students are near completion. I would often say, "let's take 5 more minutes to finish up." I just ask the students that are not finished to put their pencils down and listen. This is another reason why the summary is so important. Even if a student did not complete the problems, the summary should help them understand the important mathematical concepts.

Q: When a student or a group of students present their mathematical findings to the class, I would often want them to explain their thinking further or share something additional, and so I would ask them follow up questions to get them to share what I felt was mathematically important. How do I encourage students to ask their own follow up questions of their peers?

A: I would often look for students that looked confused. Then I would say, "Johnny you look confused, why don't you ask Kendra to explain her thinking again, or in a different way." Once you start doing this, it becomes part of the classroom culture and students know that they are expected to ask each other for clarification.

Q: The *Summary* seems to be where the important mathematics is highlighted. Teaching with this style seems to keep the *Summary* informal and more conversational, rather than formal involving traditional lecture and taking notes. How do you make sure that you emphasize the important mathematics without making it teacher-centered? Is there a way to create notes during the *Summary*, having students write down the formal math involved in the section? Or do you find that note-taking isn't as useful as simply discussing the mathematics?

A: Yes, the summary is where the important mathematics is highlighted. The summary is very informal and conversational. As mentioned earlier it's important to clear up any misconceptions before leaving the room—at least that's what I thought. I would have my students take mathematical notes from time to time, but these notes were often the work of other students on the board, and they would write notes to themselves about the mathematical work. For example, if a student solved a problem in a way that helped another student think about the mathematics, the student would write this in their notebook (we called them Toolkits). They would also write about anything in the explanation that would help them make sense of the mathematics.

Questions about General Pedagogy

Q: We had the luxury of three teachers in one classroom! If I were doing this alone, how would I go about helping all groups and listening to what all groups are doing? Is it necessary to get around to all groups? How would teaching it alone affect the speed/overall effectiveness of the lesson?

A: Teachers need to understand that teaching with Standards-based curricula is exhausting but also extremely rewarding. I didn't always get around to every group, but would make sure at least twice a week I spent time with each group. I don't think teaching alone affects the speed or the overall effectiveness. The reality is that it is very difficult to teach like this every single day. I would give myself a break once in a while, and have the students work on the unit projects, mathematical reflections, or additional practice provided with the curriculum. You need to give yourself permission to have a breather!

Q: Lecturing in mathematics classrooms seems to have a nice neat beginning and ending. Teaching mathematics with a *Standards*-based curriculum felt better (i.e., students were engaged in learning), but messier. Often the temptation to tidy things up (e.g., tell procedures, have the conversation go through me) was irresistible! Is this messiness normal?

A: When it appeared that we would run out of time for an adequate summary, I would have a mini-summary, but ask students to continue to think about the mathematical ideas, and we would resume the discussion the next day. In theory wrapping up the lesson at the end of the class period is ideal, but in reality that doesn't always happen.

Q: I worried about letting students go for a period of time believing an incorrect answer. Some educators say that getting the wrong answer isn't a big deal, as long as students are engaged in rich mathematical discussions and reasoning they will still improve and understand the mathematical concepts more deeply. But as a high school math teacher, I'm responsible for my students getting the "correct" answers according to the state exams, so allowing students to be "wrong" is something I find quite problematic. How do you know when or how long to let wrong answers go? For how long do you let them go? How do you correct them? Do you correct them? What are your thoughts about how this affects students, if at all, on state exams?

A: I always allowed incorrect responses to come out in discussions. I would purposely ask students who had incorrect responses to share their answers, and then I would ask students if they agreed or if someone thought about it differently. I would make sure that any mathematical misconceptions were reconciled before the end of the class period. I thought it was important that they didn't leave the classroom with misconceptions, especially if I assigned homework that evening.

Q: Some students seem to have locked themselves into using one mathematical representation and although they are becoming proficient in working with one type of representation, they're not learning to use others. For example, one student will always graph a function to understand it. Another student might always rely on a table. Another will attempt to write a mathematical equation. Will students typically voluntarily choose to learn to master another representation after some time? Do you just encourage them to use a variety of representations? Do you make it mandatory to vary their mathematical representations?

A: *I think that it is important for students to be able to move fluently among mathematical representations (e.g., graphs, tables, symbols). I would always require students to show at least two ways. Also, if I recognized that a student tended to gravitate toward one type of representation (e.g., always wanting to graph), I would suggest that they might try a table and an equation for the problem.*

Q: It seems difficult to determine, in advance, what to assign for homework when using a *Standards*-based mathematics curriculum, and it seems even more difficult to make multiple classes end at the same place each day in order to assign the same homework. Sometimes it seems like it would be impossible to plan homework ahead of time at all! How do you deal with this situation? How can you have homework planned when you don't know where students will end? What do you do when you don't get through an activity or even to a point where students could attempt the homework problems on their own?

A: *If I felt like students were not at a place where they would be somewhat successful with the planned homework assignment, I would consider just assigning a few of the less complex homework problems. If it didn't seem as though they had enough information and knowledge to be successful with any of the homework, I would readjust and assign it the following day. Part of being able to teach this way is to be flexible! For my own sanity, I did try to keep all the classes at the same spot, otherwise it would be too difficult to manage although students are very helpful when it comes to remembering what you did the day before.*

Using the Launch-Explore-Summary model or *Standards*-based practices is no easy task, particularly because this is not the way that most of us learned mathematics.

However, it has been said that many places worth going are not easy to get to (e.g., Great Barrier Reef, Mt. Everest, Antarctica). In these cases, the experiences (both the journey and the destination) make the difficult trip worthwhile. The same philosophy applies here. Excellence in mathematics teaching is not an easy place to go. In fact, it is more difficult to reach than the faraway destinations mentioned here because it is a challenging journey each day. We have not yet reached our destination, but will continue to move forward on the journey as we develop our practice. It is, without question, worth the trouble as students' engagement in and love for mathematics depends on it.

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