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Implementing Change in Mathematics Instruction

Abstract: This literature review looks at methods for implanting change in mathematics instruction. In order for teachers to be able to implement change, they need to have a vision of what this new environment will look like. To create this vision, teachers must become students in which they are involved in collaborative discourse to build a better understanding of mathematics content knowledge. These understandings represent the language of mathematics. Teaching mathematics as a language is an important change that will help students to have a better understanding of the concepts.
There is extensive research that has been done in understanding how teachers can best facilitate learning opportunities in mathematics for their students. “The success of efforts to close the gap between reform visions of mathematics teaching and learning and the practices most common in mathematics classrooms today ultimately relies on teachers and their ability to make substantial changes in their classroom practices” (Koellner et al., 2007, p. 275). This is a very difficult initiative because teachers often teach the way they were taught. This is a vicious cycle that makes change very challenging.

The traditional model of school categorizes students by age into grades to learn age appropriate content. To learn the content the students are provided with a teacher, who often feels as part of their job, that they must have an answer to every student’s question. However, the teacher does not always have an answer and this creates a feeling of defensiveness because they do not want to feel that they are not doing their job. Argyris (1991) has a solution for changing these feelings of defensiveness:

Despite the strength of defensive reasoning, people genuinely strive to produce what they intend. They value acting competently. Their self-esteem is intimately tied up with behaving consistently and performing effectively. Companies can use these universal human tendencies to teach people how to reason in a new way—in effect, to change the master programs in their heads and thus reshape their behavior. (p. 106)

Teacher’s espoused theories often include providing meaningful learning experiences for their students. If the students are not learning the necessary
understandings and skills from these experiences, how can teachers be helped so that their theories in action match their espoused theories?

In order for teachers to be able to change the environment of their classroom, they need to have a vision of what this new environment looks like. This can be done through creating a “memory of the future.” De Geus (1997) references David Ingvar’s idea of a “memory of the future:”

We have...a “memory of the future,” continually being formed and optimized in our imaginations and revisited time and time again. The memory of the future, as Ingvar calls it, is an internal process within the brain, related to man’s language ability and to perception. It apparently helps us sort through the plethora of images and sensations coming into the brain, by assigning relevance to them. We perceive something as meaningful if it fits meaningfully with a memory that we have made of an anticipated future. (p. 35)

In order to help teachers to develop a “memory of the future” and allow them to view learning in new ways, they need to have first-hand experiences. Fullan (2008) discusses the importance of learning in context. He thinks that unless teachers are provided with ongoing opportunities to learn ways to improve, they will not sustain change and will resort to the status quo. Research that has been done on providing teachers with contextual learning experiences has proven successful.

A research study by Langham, Sundberg, and Goodman (2006) found that teachers need to deepen their content knowledge because many teachers were taught algebra as a set of skills and procedures. This is fundamentally different from
the expectation today that students are provided with opportunities to focus on algebraic concepts and relationships. In order for teachers to accomplish this goal, they need to have opportunities to learn in an environment that is consistent with the environment that the students learn in. To accomplish this goal a “Mathematics Academy” was established. In this academy teachers participated in eight middle school algebra lessons that were designed with a focus on understanding and deepening algebraic reasoning. These lessons could then be implemented in each of the teachers’ classrooms. In order to promote ongoing learning the academy also provided regional coaches to visit the teachers throughout the year and facilitated several Saturday meetings for the teachers to network, brainstorm, and collaborate with each other. This academy has the potential to build a “memory of the future” and help teachers to visualize a new way of teaching math.

Another study completed on providing teachers with learning environments comparable to those students are expected to learn in, was completed by Lubinski and Otto (2004). They researched the impact that a mathematics methods course had on preservice teachers. The course was problem driven with problems that have multiple solutions. The students worked in groups to solve these problems. The instructor’s role was to ask questions that probe the reasoning of the students and engage the entire class in discussions about the validity of their reasoning. When the students from the course were surveyed about their experience, many responded that they initially did not like the course because they had to struggle with the mathematics, however, by the end of the course many students recognized that they had a better understanding of the mathematics concepts and recognized
the benefits of the course. After this experience many of the preservice teachers responded that they would teach mathematics in a similar way because it is important for students to be able to reason through problems. This research demonstrates the importance of providing teachers with learning environments that are different from traditional classrooms because it allows teachers to see the benefits of learning in a new way and provides them with a visual of how to provide students with this type of environment.

These contextual learning experiences helped the teachers to create a vision for a new method of teaching mathematics and also helped them to recognize the importance of deepening their mathematical understandings. An important aspect of these experiences was collaborative discourse. Langham et al. (2006) states, “An emphasis was placed on facilitating appropriate mathematics discourse among the teachers as they carried out the explorations. This helped them recognize the richness of such explorations and the importance of having students communicate their thinking” (p. 322). Lubinski and Otto (2004) also address the importance of collaboration, “Group work done both as a class and outside of class with smaller numbers of students encouraged support and development of each other’s ideas” (p. 346). Other research has also highlighted the importance of collaborative discourse in developing deeper mathematical understandings.

Horn (2005) conducted a comparative case study of mathematics teachers in two high schools to investigate teacher’s everyday on-the-job learning. In her research she found that collaboration was an important aspect of learning. She states:
The East math teachers also learned as they worked to make a “group-worthy” curriculum, yet individual and collective practice changed fundamentally, as they brought in complex problems to their classrooms, worked together to effectively use multiple representations and understand student thinking. In the end, they broadened their understandings of what mathematics is, who can do it, and how it can be done. (p. 220)

These teachers were able to deepen their own mathematical understandings through collaborative discourse, which in turn helped their students to gain a better understanding of mathematics.

Another research study on collaborative discourse was conducted by Marrongelle and Larsen (2006). They investigate the use of professional development resources to generate mathematics discourse among teachers and provide them with opportunities to learn mathematics. They found that there were two types of mathematical education discourse. The first was when a teacher attempted to make sense of a student’s ideas from their point of view. The second was when a teacher was assessing a student’s difficulties and evaluating if their response was correct or incorrect. They found that teachers, who were involved in discussions to make sense of students’ ideas, may learn to think about mathematical ideas in different ways, such as how the students thought about it, and therefore deepen their own mathematical understandings. These findings complement Fullan’s (2008) ideas that learning needs to be ongoing in order for change to be sustainable. It is an important idea that teachers can learn from their students. This is a significant change from traditional teaching.
Further research to demonstrate the importance of collaborative discourse in developing deeper understandings of mathematical concepts includes Koellner et al.’s (2007) study of the “Problem-Solving Cycle,” a professional development designed to help teachers support their students’ mathematical reasoning. One of their findings was that as teachers collaboratively discussed a math problem their understanding of the mathematics content evolved. The teachers were able to compare, reason, and make connections between the various solution strategies that they did not previously recognize. The ability to recognize multiple solutions to a problem is another important departure from traditional mathematics instruction.

It is evident from the research that as teachers engage in collaborative discourse they are deepening their understanding of mathematics. It could be said that the teachers are becoming fluent in the language of mathematics. Mathematics has many shared attributes with language. Wakefield (2000) identifies these attributes as:

- Abstractions (verbal or written symbols representing ideas or images) are used to communicate.
- Symbols and rules are uniform and consistent.
- Expressions are linear and serial.
- Understanding increases with practice.
- Success requires memorization of symbols and rules.
- Translations and interpretations are required for novice learners.
- Meaning is influenced by symbol order.
Communication requires encoding and decoding.

Intuition, insightfulness, and “speaking without thinking” accompany fluency.

Experiences from childhood supply the foundation for future development.

The possibilities for expressions are infinite. (p. 273)

These common attributes indicate that the difficulties that individuals experience when learning a language may also be difficulties in learning mathematics.

Adams (2003) has identified some of the challenges in learning the language of mathematics. When learning to read students need to know the meaning of the words they are reading in order to understand the passage. In mathematics, if students are not familiar with the vocabulary, they will be unable to solve problems. This can become even more difficult when words have a different definition in everyday use than when used in mathematics (examples would include yard and product). Another challenge in defining words can be homophones, words that sound the same, but have different meanings (examples would include some/sum and hole/whole). Besides the challenge of the vocabulary, mathematics also requires learners to understand numerals and symbols and the relationships between these three types of characters. Adams (2003) describes this relationship in the following way:

Words, explicitly or implicitly, tell the reader what is to be known and done.

The reader’s response to numerals is guided by what the words tell. Symbols
are efficient means of showing what the words say and how the numerals are to be responded to according to the words. (p. 793)

If an individual struggles with any of these relationships they will not make all of the necessary connections to understanding the mathematics. Another reason comprehending math can be difficult is because order is important and operations are not always performed in the same order that they are read. Mathematics can be read left to right, right to left, top to bottom, and bottom to top. These aspects of mathematics make the reading of it imperative to the understanding of it.

In order to help individuals understand the language of mathematics, Wakefield (2000) provides some methods. One way to help students to learn mathematics is through “translations.” Students should convert number sentences (equations) from numbers and functions to words and phrases. This will help them to see the similarities between math and language. Another way to help students learn mathematics is to expose them to a significant amount of spoken math before exposing them to written math. This will allow students to store and retrieve math as needed. Students should also be provided with a margin of error. “In early language learning, the emphasis is not on error-free speech, but on proximal communication that eventually becomes accurate. Teachers supply directional feedback so students may refine their understanding” (Wakefield, 2000, p. 276).

It is also suggested that math equations be considered from a subject-verb approach. The absence of a subject in a sentence or an equation can lead to misunderstanding and confusion. The verb in an equation is the action in respect to the subject. This format helps students gain a better understanding of math
problems. Another strategy that is imperative to the understanding of mathematics is that it should be spoken in all of the subject areas. These strategies will help learners to become fluent in the language of mathematics.

Another similarity between language learning and mathematics learning that has implications for instruction is the ability to make connections. Making connections is involved in every aspect of reading comprehension. It is necessary to make connections in order to activate prior knowledge to relate the text to other texts and things in the real world (Hyde 2007). A simple mathematics connection that is not always recognized is in multiplication. Often people think of multiplication as making things larger. This is not the case if you are multiplying by a fraction or a decimal. If this connection is not made then the individual does not have a complete understanding of multiplication (Hyde, 2007). This ability to make connections has implications for instruction in both language arts and mathematics. In order to help students to make connections between concepts, teachers need to activate their prior knowledge. Barton et. al (2002) state, "Activating students’ prior knowledge prepares them to make logical connections, draw conclusions, and assimilate new ideas" (p. 25). A simple way that teachers can activate prior knowledge is by prompting students to recall what they know about a topic. Their responses reveal what they know, misconceptions they may hold, and gaps in their understanding (Barton et al., 2002). Knowing this information can help the teacher to prepare activities that will help students to confront their misconceptions and gain prerequisite knowledge (Barton et al., 2002). The ability to make connections between concepts is instrumental to the understanding of mathematics.
Through examining the characteristics of mathematics it is evident that it is a language. In order for teachers to be able to provide meaningful learning experiences in mathematics they must be fluent in this language. Teachers can deepen their mathematical content knowledge to become more fluent through collaborative discourse with their colleagues. It is important for teachers to have a conceptual understanding of mathematics. This is necessary because it is expected that students understand the concepts behind the mathematical procedures. If teachers are going to be able to implement a change to this type of instruction they will need to have a vision of what this new type of instruction looks like. This is best accomplished through providing teachers with experiences that correspond to new methods of teaching mathematics. As change is implemented and students develop deeper understandings of mathematics they will be better prepared to meet the expectations of the future.
References


