Diary of Shifting Mathema

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Changes to classroom rules of engagement, such as assessment, the curriculum, instruction, and the environment, can produce real results.

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As the sole math teacher in my middle school, I (Edwards) have always worked hard to provide quality mathematical experiences for my students. In an era of accountability defined by standardized test scores, I have also closely monitored my students' performance on such tests. After a few years of hoping that scores would improve, I realized that I was a key part of the problem. My teaching methods—lectures focused on students memorizing mathematical rules and working individually to enact these rules in decontextualized problems—were simply not effective. Through the help of various influences, including *Principles and Standards for School Mathematics* (NCTM 2000), I began to change. The classroom environment was modified using the Teaching Principle, learning resources were aided by the Curriculum and Technology Principles, and

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assessment practices were influenced by the Assessment Principle. My own expectations evolved into helping students understand mathematics deeply.

My rather unique situation (providing three consecutive years of mathematics instruction for every student in the school) affords me a one-of-a-kind opportunity to closely monitor the impact of the changes that I make. I can not only compare the mathematical understandings of one sixth-grade class to the next but also gauge the learning of that initial group of sixth graders over several years. Although other factors could be involved, the teacher represented the primary source of instructional variability, namely, me. Therefore, documenting my changes was critical to ensuring ongoing improvement toward best practices. My reflections describe key aspects of effective mathematics instruction and how my thinking changed from year 1 (2006–2007) to year 3 (2008–2009). They also illustrate how my teaching of sixth-grade surface area and volume changed as my teaching philosophy evolved.

CLASSROOM ENVIRONMENT

While exploring literature and discussing improving instruction with professors and fellow professionals, it became clear that establishing a classroom environment conducive to effective mathematical learning was critical (NCTM 2000).

2006–2007

Group work was a novelty to me. I did not consider the academic ramifications of the physical arrangement of students in my classroom. Groups were used occasionally but not for a particular educational purpose. I did not encourage or facilitate discussion or ask students probing questions.

For the sixth-grade surface area and volume unit, students generally worked by themselves. Several examples of rectangular prisms were presented for students to copy after viewing them via an overhead projector. The lack of engagement was evident from the amount of unproductive talk in the classroom. Although desks were spaced out, that arrangement did not stop students from discussing everything *except* surface area and volume.

During this year, I did not have the full benefit of research guiding my practice. Soon thereafter, I began to distill and implement what I had found, one of which was this: Working collaboratively can provide many benefits for students in the mathematics classroom. The teacher can facilitate discussions and can pose questions to delve deeper into student thinking. Such discussions can encourage personal reflection and can elicit different points of view. In considering other students' ideas, students have the opportunity to latch on to thoughts that make sense. They can also borrow someone else's understanding. The changes inspired by these findings are noted below.

2007–2008

Significant changes were made in how I used groups. I noticed that in starting free discussion, higher-level students could demonstrate their unique understandings. Discussions pertained to processes, and students began to understand that multiple approaches were possible when solving a problem. Even lower-achieving students understood that listening to others and sharing ideas could help enhance their personal understandings.

For the surface area and volume unit, students were organized into groups of two, three, or four on the basis of their abilities to effectively work with and communicate mathematical ideas with one another. Although I remained at the front of the classroom, I listened closely to student conversations. During these discussions, I began to notice students developing observations not covered in earlier discussions. As simple as this may sound, groups were able to figure out that one does not have to add all six faces on a rectangular prism to find the surface area, since, they discovered, opposite sides take up the same amount of space. This was the beginning of student talk, which led to alternate solutions that I did not initiate.

2008–2009

Students became comfortable collaborating in groups, and group work became a daily expectation. I facilitated students' group conversations by injecting comments and reflective questions, to keep discussion flowing. When groups finished, we had a whole-class discussion. Students from each group shared ideas that others had not considered. To further enhance the learning, a question of the day was displayed for students to answer. They used desktop white boards to document their solutions and then shared the processes involved. In so doing, they could hear and grapple with ideas from their peers. For students who had already formulated solutions, this method provided other points of view.

Working collaboratively can provide many benefits for students in the mathematics classroom.

By the time we began the surface area and volume unit, my method of teaching involved walking around the classroom and questioning students instead of lecturing at the front of the room. I used a classroom whiteboard to illustrate three examples of rectangular prisms, with dimensions in inches. Underneath the examples, I simply wrote that the surface area of a shape is how much space is used by the faces of a three-dimensional shape. I also provided a collection of cubic inch blocks and stated that volume was the number of cubes the prism would hold. I let the groups figure out how to calculate surface area and volume, providing little direct instruction.

While circulating around the classroom, I asked additional questions to keep the conversations progressing and also helped groups that were stuck, without slowing down the other students from thinking on their own. At the end of the group collaboration, the class discussed the ideas that they had developed and how they fit together. Additional questions were added, and students were also asked to devise more formal ways of solving the problems on the basis of what they had discovered.

ASSESSMENT

Because my classroom environment changed significantly, assessment needed to, as well. The reflections below concern the quality of instruction and the decision making that occurred after the assessment (NCTM 2000).

2006–2007

The assessments I administered were usually either form A or form B from our textbook, and the questions were multiple choice. Since I could only glean whether or not correct answers were given, I knew very little about my students' thinking. The tests were graded, and everyone in the class moved on to the next topic, regardless of the understanding of each individual student.

To assess the surface area and volume unit, students were given an activity sheet with ten pictures of rectangular prisms for which they had to find the surface area and volume of each. At the time, I was not concerned with their solution methods. I looked at the numerical answers and assigned a grade. Students did not get a chance to fix any of the ten problems, and the following day we moved on to the next unit, surface area and volume of cylinders.

2007–2008

I began using assessment results to determine future instructional goals and noticed students taking a different approach to my class. They interpreted this technique as demonstrating my desire for them to succeed. I approached this method in many ways, including individual conferences, concept experts, and student self-reflection. Although day-to-day assessment was changing dramatically, summative assessment remained very much the same. I focused on process during class, but form A or form B was still given for the final assessment.

The same ten questions were used to assess surface area and volume as in the previous year, but students had to explain their understanding in addition to giving their answers. They could choose among drawing pictures, writing descriptions, and creating models to explain how they calculated surface area and volume problems. Some students chose to do a mixture of the suggestions, whereas others asked if they could provide descriptions in alternate ways, such as through an instructional video. These explanations provided a wealth of data with which to address student misconceptions.

I also let the students correct their answers after individual conferences with me, making the transition to the cylinder topic easier than in the past when some students had moved on without a strong understanding of the content. A pretest was given before we began the unit to ascertain what the students already knew about the topics. In this case, the students knew relatively little about surface area and volume of prisms, so the lesson proceeded as planned, but I still felt better knowing that I was not wasting time teaching something students already knew.

2008–2009

The quality of my assessments improved in that they probed for understanding. For each exam, only a few questions were asked, but students were expected to show their thinking, processes, and understandings. The class also became more project-oriented, and I built a library of quality tasks that resulted in one solid project-type assessment per concept. Assessing in this manner worked well because my students were more interested and invested. Better results followed. I was able to better determine the depth of my students' understandings by looking at these assessments.

For the surface area and volume unit, I decided to use a project to assess their learning. Working alone or in groups, the students were instructed to design a cereal box from a designated amount of cardboard. The fictitious cereal company would reward with a raise the worker who devised a box that was most cost efficient (surface area), but held the most cereal (volume). Each student or group had to submit three box designs with surface area and volume, along with a description of their numbers. This project also fit nicely into a maximum and minimum surface area and volume discussion, and how one relates to the other. Students were highly motivated to earn the raise and attempted many variations of the cereal box to find the optimal design. I was able to see everything that I could before, with the real-world project providing additional student motivation.

> ***Learning about volume using a textbook only proved problematic because of the difficulty of conveying depth through a two-dimensional picture.***

CURRICULUM AND MATERIALS

Research has shown that textbooks strongly influence what mathematics gets covered and how it gets taught (Riordan and Noyce 2001). That was certainly true for me before my decision to change. Although the scope and sequence held relevance, the suggested implementation and problem sets no longer provided the learning opportunities that I sought for my students. I could not replace the textbook so turned instead to injecting the curriculum with various units. With injection, one problem or activity is placed within a regular unit, like a problem of the day or a mathematical investigation. A replacement unit takes the place of an entire textbook unit. I used both injection and replacement to support the changes I wished to make.

2006–2007

Students read pages from the text and completed problem sets. Problem solving and free exploration did not occur. I used materials suggested in the textbook. This was certainly the easiest path for me, but in retrospect, it was not necessarily what was best for my students.

Students received only paper copies and notes, limiting the opportunities for hands-on exploration. Many students struggled to understand which measurements should be used for various faces of the prisms and why the related computations made sense. Learning about volume using a textbook solely proved problematic because of the difficulty of conveying depth through a two-dimensional picture.

2007–2008

I began to flourish from a curricular standpoint. Through my experiences and ongoing education, I began to understand that students who became problem solvers could apply their knowledge (including individual concepts) to any situation. While time-consuming, I created activities rich in problem solving and discovery in an effort to relate to student interests and real-world applications. I also modified problems from my textbook to make them more thought provoking. The text became a sparingly used resource.

The use of technology was

Table 1 The Iowa Test of Basic Skills (ITBS) and the Northwest Evaluation Association's (NWEA) Measure of Academic Progress (MAP) results tracked students' performance.

Graduating Class	Class Year	ITBS (Average Class of Proficiency)	NWEA MAP (Class Average)
2013	Sixth grade	63.8%	224.6
	Seventh grade	83.9%	227.6
	Eighth grade	84.3%	237.1
2014	Sixth grade	84.6%	225.6
	Seventh grade	100%	236.5

expanded, and wireless carts were used frequently. Various Internet sites, such as the National Library of Virtual Manipulatives (http://nlvm.usu.edu) and NCTM's Illuminations (illuminations .nctm.org), became staples in my classroom. Students seemed to enjoy the technology, and I appreciated the enhancement to the curriculum that the technology provided.

During the surface area and volume unit, curricular improvement stemmed from the questions I could ask. I tried to get past simple queries about calculating surface area and volume and instead moved into "what if" and student-related questions. For example, I asked one group about video game consoles and the factors a company would consider concerning surface area and volume. Other resources used included basic building blocks that snapped together and Internet applets that manipulated surface area and volume with three-dimensional models. The combination of hands-on and online representations helped solidify the meaning behind these topics for the students who needed more than just a flat visual.

2008–2009

I figured out that I did not have to re-invent the curriculum wheel. The previous year, I had spent so much time preparing original lessons that it left little time for anything else. Through graduate courses and the Internet, I discovered various sources of rich problems, which led me to purchase classroom sets of the Connected Mathematics Project (CMP 2004). I used CMP's *Accentuate the Negative* (CMP 2004a) as a unit replacement when I noticed my students struggling to retain integer concepts.

From a technological standpoint, I began using my personal website as a hub of mathematics for my students and located Web-based activities pertinent to the topic of study. Students used laptops every day to discover more about the topics we were exploring.

Along with the project-type assessment for surface area and volume, we worked through CMP's *Filling and Wrapping* (2004b), which contained everything I needed to help all my students (of various abilities) deeply understand surface area and volume. *Filling and Wrapping* was a seventh-grade unit, but at the time it fit better with the sixth-grade standards of our district. I added any potentially helpful links I found to my website so that students would have a choice of what worked best for their own learning of surface area and volume.

MEASURING THE IMPACT

The decision to change the way my students experienced mathematics came with a significant amount of risk. Although I daily encountered evidence that my students were developing deeper understandings, having richer conversations, and enjoying the learning of important mathematical topics, such formative findings would not be meaningful if test scores failed to improve.

In my district, students' mathematical knowledge is assessed using the Iowa Test of Basic Skills (ITBS) and the Northwest Evaluation Association's (NWEA) Measure of Academic Progress (MAP). To measure the impact of my changes, I tracked performance on these instruments for a group of students (the class of 2013) over a three-year period. As previously noted, I served as the sole mathematics teacher for this group of students from the time they entered the sixth grade until they graduated from eighth grade. I have also included data for the class of 2014, as I served as the sixth-grade and seventh-grade mathematics instructor during this time (see **table 1**).

In both cases, proficiency (those reaching the 41st percentile or higher) increased on the ITBS. I also witnessed students who had never been proficient (in any grade) being proficient for two consecutive years. This was a particularly exciting accomplishment because students had to not only grow for the specific school year but also make up for lost time, as other students had passed them by during previous years. Similar increases were also visible on the NWEA MAP Test. Although students' scores are expected to increase on a yearly basis, average growth exceeded norm values. During the third year, when my changes really began to gel, the scores improved dramatically.

WHAT CAN HAPPEN

Although my particular story does not present an adequate sample for generalization, it does provide an example of what *can* happen when a teacher commits to a journey of change that aligns with NCTM's vision for school mathematics. After having taught in essentially the same manner since I first began, the decision to change was difficult, but it had to be made. I had to improve if I wanted my students to improve. My path to change required a lot of hard work, time, and support, but the results have been well worth the effort.

My transformation was drastic, as outlined in my reflections, but also ongoing. The work to improve my assessment, classroom environment, materials, and instruction is ongoing. Significant change does not happen overnight, but such transformation can lead to positive results.

REFERENCES

Connected Mathematics Project (CMP). 2004a. *Accentuate the Negative.* Saddle River, NJ: Pearson Prentice Hall.

———. 2004b. *Filling and Wrapping*. Saddle River, NJ: Pearson Prentice Hall, 2004.

National Council of Teachers of Mathematics (NCTM). 2000. *Principles and Standards for School Mathematics.* Reston, VA: NCTM.

———. "lluminations." http://illuminations.nctm.org.

National Library of Virtual Manipulatives (NLVM). http://nlvm.usu.edu.

Riordan, Julie E., and Pendred E. Noyce. 2001. "The Impact of Two Standards-Based Math Curricula on Student Achievement in Massachusetts." *Journal for Research in Mathematics Education* 32 (4): (July): 368–98.


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