

SOLD!



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Math Design Collaborative

SOLD!



Introduction:

	My Mathematics Design Collaborative Experience	1
i.	The Five Key Strategies of Formative Assessment	5
ii.	Content and Planning	10
iii.	The Pre-Lesson Assessment	12
iv.	Providing Effective Feedback	14
v.	Maintaining a Productive Learning Environment	17
vi.	Collaboration with Other Teachers	19
	Final Words	20

Introduction: My MDC Experience

Before I received training on formative assessment in mathematics, much of my teaching consisted of giving students step-by-step instructions and tricks for solving specific problems. I assumed that my role as a math teacher was to determine the most efficient way to solve a problem and then teach my students how to mimic my procedures. I thought I was teaching mathematics, and making the subject easier for my students, but in

reality I wasn't helping them at all. I was simply teaching them to follow a recipe without thinking about what they were doing.

As Ann Shannon, who led my school district's professional development sessions, told us, "It's not the students' job to figure out what is in our heads; it's our job to figure out what's in theirs." This idea has transformed the way I teach. I realized I had not been paying attention to how my students were making sense of the problems. The training taught me to question my students in order to understand their thinking, which would lead them to solve the problem in a way that made sense to them.

During our first training sessions, the mathematics teachers in my district began to replace our lessons with new lessons that engaged the students in the practice of doing mathematics. We learned how to engineer discussions, select student experts, and build a classroom environment where thinking and the exploration of various solution paths were more important than just simply imitating me.

As I began integrating some of the lessons and formative assessment strategies into my instruction, I discovered that my students were actively



engaged in thinking about mathematics for an entire class period! They began discussing ideas with each other and even volunteered to present their work in front of the class. At times the classroom was loud, but almost every student approached the problems differently. They were more invested in their work than they'd ever been.

We also learned about the Shell Centre's Formative Assessment Lessons. The Formative Assessment Lessons (also known as Classroom Challenges) have been a great resource for me to understand what student mastery of a cluster of the Common Core State Standards should look like. They have provided me with a structure to analyze how my students are actually thinking about a task or activity within a unit, which in turn has helped me to understand their misconceptions. I now allow class time for discussing those misconceptions during one of the collaborative activities within the lesson.

This past year I have worked as a Mathematics Design Collaborative (MDC) building coach in my high school, helping my fellow teachers to implement Shell's Lessons. I model lessons and assist during collaborative activities. I've also shared my successes and failures with MDC by participating in the training of teachers in other districts and states. Changing the way I enact formative assessment in my classroom has redefined my teaching, and I only hope MDC will do the same for yours.

Where can you find the Shell Centre's Formative Assessment Lessons?
www.map.mathshell.org/materials

i. The Five Key Strategies of Formative Assessment

When I began my career, my lessons followed a definite script: I wrote sample problems on the board and expected my students to copy everything into their notes, review their notes at home, and learn the content. I chose to teach this way because when I was a student all of my instructors used this method; I assumed it was what a good mathematics teacher should do. Soon I realized my students were not really learning. They were leaving many questions on quizzes and tests blank. I thought that perhaps my lectures were not clear enough and that I needed to make the math easier.

My initial solution was to provide them with a list of step-by-step instructions on how to solve a particular problem. During the lecture I asked them to copy down the procedure and a set of example problems. As I worked through the examples, I asked the students questions such as "What is the next step?" When it seemed like they understood the procedure, I asked them to work out similar problems on individual whiteboards.

As I followed this routine, I was feeling good about my teaching abilities. My students were following the steps I gave them and getting the correct answers. However, whenever I asked them to apply the same skills in a slightly different way, they became stymied—and I became frustrated. I remember saying to my colleagues, "If my students would just *think* about it, then they would get it, but they just will not *think*!"

Looking back, it occurs to me why the students weren't thinking.



I had been teaching them *not* to think! I had spelled out everything for them. No wonder they didn't know what to do when I gave them a different task. They were waiting for me to either do the work for them or give them a procedure for solving the new problem.

At the formative assessment training, we learned that memorization tricks do not help our students to learn mathematics at all; they provide an illusion of learning. For students to learn mathematics, they must be actively engaged in a balanced array of math lessons. We learned to use five key strategies for formative assessment.

1. Clarifying and sharing learning intentions and criteria for success
2. Engineering effective discussions, questions, and tasks that elicit evidence of learning
3. Providing feedback that moves the learner forward
4. Activating students as owners of their own learning
5. Activating students as instructional resources for one another

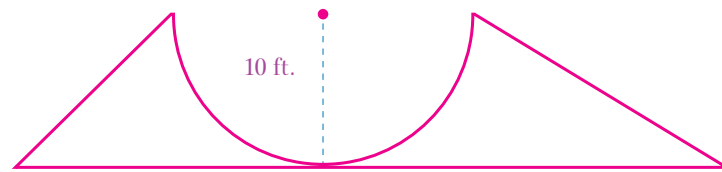
We discussed models of what each of these strategies might look like in a classroom setting. We watched a video of a visiting teacher modeling an enactment of these strategies in a classroom of struggling students. Sometimes it seemed she was having trouble getting the students to think on their own, but she stuck to the strategies, never telling them how to do anything. By the end of the lesson the students were participating and taking charge of their learning. I was inspired to give her suggestions a try in my own classroom.

We had some time at the end of the session to develop a lesson using the formative assessment strategies. I was teaching a geometry unit at the time that required students to apply ideas from previous units, and this had been a struggle for them. I decided this would be a perfect opportunity to change my approach with the help of the five strategies. I worked with a few other teachers in my district who were teaching the same unit. We wanted to develop a lesson that had multiple solution paths and required the application of several geometry topics.

Eventually we produced a lesson that required the students to calculate the area of the cross-section of a skateboard half-pipe with ramps. They would need to apply their knowledge of the properties of several geometric shapes, as well as trigonometry skills and reasoning.

Half-pipe with ramps

Below is a cross section of a skateboard half-pipe with ramps. Find the area of the cross section.



I knew the task would be difficult not only for my students to complete but also for me to teach. I couldn't show them how to solve the problem; I could only guide them toward the solution. Would they try? Would they give up? Would I finally give in? What if each of their approaches was different? How would I monitor each student's progress while maintaining order in the classroom? How would I keep them motivated?

The following week I enacted this lesson to one of my general geometry classes. The class consisted of about 25 sophomores who often asked, "When are we ever going to use this skill?" I began the lesson by telling the students, "Today you are going to figure out what to do when you don't know what to do" (strategy #1: clarifying and sharing learning intentions and criteria for success). As I handed out the assignment, I asked the students not to solve the problem but to spend one minute reading the prompt and describing the diagram. Realizing the skills my students had accessible to them, I knew they would have to find the area of the cross-section by breaking it up into smaller geometrical shapes. Since the cross-section could be divided in several different ways, I needed to know how my students were looking at it.

Then I asked them to spend another minute sharing their description of the diagram with the person sitting beside them. This way I would be able to walk around the room and get a sense of what each student was thinking. This time allowed the students to run their ideas past their classmates and gain confidence before sharing their ideas in front of the entire class.

Next, I asked the class to talk about their descriptions as a group. I learned that some students were viewing the half-pipe as a trapezoid with a semicircle removed. Others saw the half-pipe as a combination of triangles,

rectangles, and a semicircle. On the board I wrote the name of each student who had spoken and his or her idea (strategy #4: activating students as owners of their own learning).

Then I reminded my students that the task asked them to find the area of the cross-section and asked them still to not start solving the problem but to spend another minute coming up with a starting point. I wanted to make sure that they had a good amount of think time before starting the problem. After all, wasn't I the one complaining about my students not thinking?

At the end of the minute, I asked the students to once again share their ideas with each other in pairs. As I walked around the classroom, I heard some great ideas, and I made mental notes to call on these students during the classroom discussion. Again, I wrote these ideas on the board along with the students' names.

After a student had shared an idea, I asked another student to say that the student's idea was a good one and explain why it was helpful. We had learned that this would help students to become more comfortable sharing ideas in a group. Once I began recording names beside ideas, more students began raising their hands. The students were actually excited to see their names on the board for ideas they had figured out.

As the list grew, I noticed that some ideas were great and others were less so, but all of the ideas came from the students. I had not told them anything; they had done all the thinking. The class didn't have a list of step-by-step instructions, but they had created a list of places to start in completing the task.

I finally set the class to work. As I walked around the room, I noticed a persistently low-achieving student staring at her paper. We had learned a strategy to motivate low-achieving students called "creating an expert." The idea is to prove to the student and to the class that the student is capable of doing the work. I approached this student and began to ask her about her thinking. At first she kept repeating that she "had no clue" about how to do the problem. I told her that I knew she had to be thinking *something*, because if she wasn't, she wouldn't know she was stuck in the first place! I pointed to the board and said, "Whose approach are you using to start this problem?" (strategy #5: activating students as instructional resources for one another). I continued to ask questions about her thinking that eventually led her to a vital piece of information for solving the problem.

After a few minutes my students started to lose focus. Several got stuck along their solution paths and began talking to each other about other topics. I called the attention of the class to discuss everyone's progress so far.

I asked some students to share their work under their document camera to show what they had figured out and where they were still struggling. I also called on the usually low-achieving student. Her classmates were impressed by her work and began to see her as a contributing member of the class. I then returned the students to the problem solving. Amazingly enough, the discussion had reengaged them; they were motivated to try again. We continued on like this until the end of the period (strategy # 2: engineering effective discussions, questions, and tasks that elicit evidence of learning). I could hardly believe that my class had spent an entire class period thinking about math and working on a complex task. They hadn't finished the problem, but they had made progress. I collected their work to take home and later wrote comments and questions, as I wanted to provide only feedback that would encourage their learning (strategy #3: providing feedback that moves the learner forward).

The students used my feedback the next day to complete the task. To close the lesson, I asked some of them to share their mistakes and how they had corrected them. I realized that my students did not need me to guide them in each step; they were in fact quite capable of thinking mathematically and generating multiple correct solutions.

After this lesson, I was sold! Implementing the five strategies instead of just telling them what to do had helped me to empower my students to become engaged in mathematics. The students were no longer asking me why they had to do math. I began to redesign my lessons to require the students to become more active learners. Developing these new lessons was time-consuming. Sometimes a task had an easier solution path than I wanted; other times the lesson failed because I had selected a task a little beyond their productive struggle zone. But overall, my classroom environment had completely changed as the students adjusted to my new expectations of working and thinking.

When I had a chance to look at some ready-made Formative Assessment Lessons from the Shell Centre, I was thrilled. Finally I had a quality resource to support the changes to my instruction. However, learning how to use these Lessons has provided a different challenge.

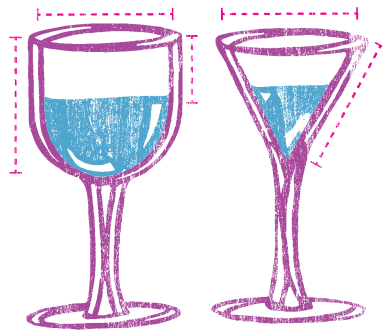
ii. Content and Planning

When I received my first group of Formative Assessment Lessons, I was a bit overwhelmed. The lessons seemed long and quite different from the problem-solving tasks I had been using in my classroom. I decided to begin with one titled “Calculating Volumes of Compound Objects.” I planned to enact it in a geometry class, following the unit on calculating area and before the unit on calculating volume. I thought that this placement would give me a sense of how the students might apply the skills they’d learned in the area unit.

Unfortunately, enacting this Formative Assessment Lesson at this place in the unit was too big of a leap for my students. I’d assumed that my students had gained at least a conceptual understanding of volume in earlier grades, but they hadn’t. How could I ask them to calculate the volume of a compound object if they did not really understand what volume was?

In my experience, the success of a Lesson has been directly related to its placement within a unit. I have found it works best to enact one toward the end of a unit. Formative Assessment Lessons are designed to give teachers a picture of how their students are thinking about what you have been teaching them. Teachers usually have a good idea of how students *should* be thinking about the unit, but students do not always think about mathematics the same way that their teachers do!

I have found it helpful to decide on the placement of the Formative Assessment Lessons before I even begin teaching the unit. I work through the lesson and think about all of the skills that should be covered before it can be enacted. Remember, the Formative Assess-



ment Lessons are meant for you see how students are thinking about the math that you have been teaching them, not to teach new material.

Since the Formative Assessment Lessons are aligned with the Common Core, they give you a glimpse of what mastery of a particular standard should look like. For this reason, it may be a good idea to keep them in mind when teaching the material leading up to the lesson, as it may offer insight into how to approach certain concepts within the unit. Just be careful not to teach to it, as this may lead to an illusion of learning.

Where can you find the Common Core State Standards?

www.corestandards.org

iii. The Pre-Lesson Assessment

The Formative Assessment Lessons incorporate a pre-lesson assessment that reveals student misconceptions about the material and prepares teachers for how to respond, so they are not put on the spot during the lesson. I find that I can also use these pre-lesson assessments to sort my students into groups for the collaborative portion of the lesson.

When I pass out the pre-lesson assessment on the day before the Lesson, I make sure to tell my students that although I will not assign grades to it, I will be using the pre-lesson assessment to help them better learn the content of the unit. If they show me what they know, then I can know where to help them know more. Telling students this motivates them to try their best. I also encourage them not to leave anything blank, as this prevents me from determining what they are thinking about that item.

Since the students usually work hard on the pre-lesson assessment, I come away with a good set of data to analyze before enacting the Lesson. I make a list of the number of students making different types of mistakes to determine which are most common. Knowing this can help me plan the focus of the plenary discussions. Shell's script does a great job at predicting some of the difficulties students will have and gears the plenary discussions accordingly, but I need to know what issues my particular students are having and find a time to address these during the lesson.

The pre-lesson assessment gives me some time to think about how to bring misunderstandings to light and what types of questions I can ask students to guide them. Without this time to reflect, I often found that I was telling the students how to do something rather than giving them the opportunity to think for themselves.

The Formative Assessment Lessons require students to work collab-

oratively in small groups. Students question each other and justify their own reasoning. Rather than grouping higher-achieving students with lower-achieving students, which often lead to the higher-achieving student doing all of the work, I use the results of the pre-lesson assessment to group students according to their misconceptions. If two students made the same mistake on the pre-lesson assessment, I put those students together. This way, students can help each other learn.

I urge you not to skip the pre-lesson assessment. Though placing the Formative Assessment Lessons correctly in the unit had a big impact on my teaching, I also found the pre-lesson assessment invaluable.

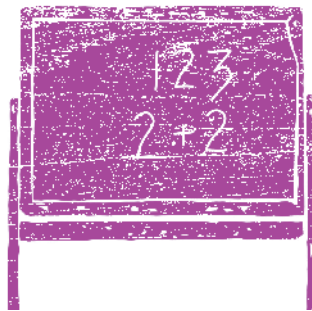


iv. Providing Effective Feedback

One of the five key strategies of formative assessment is providing feedback that moves the learner forward. The Formative Assessment Lessons require teachers to give feedback in two forms: as a set of formal feedback questions and through oral questioning when the students are collaborating in groups. As I work to improve my feedback, I like to remind myself that its purpose is to encourage learning; the feedback should not simply encourage them to be satisfied with what they have already done. Sometimes when students receive a graded assignment, they focus on the grade rather than on improving their work. I want my feedback to motivate them to do more, not to settle for what they have produced.

1. Feedback Questions

When I write my feedback questions, I focus on the most common misconceptions revealed by the pre-lesson assessment. For example, I enacted the Formative Assessment Lesson “Forming Quadratics” in an Algebra II class. One of the tasks on the pre-lesson assessment asked the students to identify the y -intercept of a quadratic equation written in factored form. Many students incorrectly identified the y -intercept for the equation $y = (x - 6)(x + 8)$ as $(0,8)$. I thought back to my instruction and realized why my students might be confused. They’d been working on identifying the y -intercept of a quadratic equation in standard form, such as $y = x^2 + 5x + 6$, and had had no trouble correctly identifying the y -intercept, in this case $(0,6)$. I looked at the similarities between the two forms of the equation and realized that they were assuming that the last number in



a quadratic equation, regardless of the form, was the y -intercept. To address this misconception, I made sure that one of my feedback questions asked the students, “What is the value of x at the point where the graph intersects the y -axis?”

Developing a set of feedback questions was not as difficult as getting the students to use them as they are meant to be used. Though they are intended to help the students reflect on their work, they seemed to view them as yet another task they needed to complete before they could leave class.

The Formative Assessment Lessons suggest addressing the feedback questions specific to each student’s misconceptions by writing them on that student’s paper. This helps them to focus on what they could do to improve their own response. For my small class, this approach was practical. However, whenever I enacted a Formative Assessment Lesson in more than one section of a class, I ended up spending hours writing the questions for each student. This prospect could lead a teacher to avoid implementing them altogether!

As an alternative, I created a short list of feedback questions for the entire class. This has proved much more feasible. I have been able to develop a set of quality feedback questions to address the major misconceptions shown in the pre-lesson assessment.

I usually choose to project only about four or five feedback questions, addressing only the major issues raised by the pre-lesson assessment. I keep other student misconceptions in mind as I teach the lesson and address them as the opportunity arises.

I also make sure to establish a structured time (about five minutes) for the students to read, think about, and answer the feedback questions.

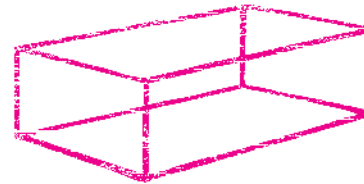
The feedback questions are not the only time student misconceptions should be addressed, however. It is up to me to enact the Formative Assessment Lessons in a way that will continue to bring them to light.

2. Oral Questioning

I use the pre-lesson assessment to determine not only class-wide issues but also individual student challenges. As students are working on a collaborative activity, I walk around the classroom and look at their work individually. My questioning is often as simple as pointing to something a student has written and asking, “Can you tell me about this?” If students seem a little uncomfortable, I try to ask about something they have done correctly, so my questioning doesn’t shut them down.

If they respond correctly, I ask for an explanation of how they know the answer is correct, how to check the answer, or how to prove that the answer is correct using another method. If the students respond incorrectly, I continue to probe into how they are thinking about the math until they do arrive at the correct answer.

V. Maintaining a Productive Learning Environment



Enacting a Formative Assessment Lesson demands a specific classroom environment. The students talk as the teacher spends a lot of time circulating among groups of students. Because of this, there are many opportunities during a Formative Assessment Lesson for students to lose their focus. Here are some strategies I have implemented to limit distraction.

1. Clarify the learning target, so that when students are working collaboratively they know exactly what they are doing and why they are doing it. Shell provides a set of projector resources that list the directions for each collaborative activity. When you post these, the students always have something to reference. Simply providing verbal instructions may not be sufficient.
2. Form pairs of students who are thinking about the task in the same way. None of the students should be more knowledgeable than their partners (and therefore should not be able to do all of the work for the group). Even though it may be easier to circulate to fewer, larger groups, having large groups often encourages a few students to do most of the work while the others chat.
3. Be aware that about ten minutes into a collaborative activity, the students may begin to lose focus and begin talking to their partners about something other than the task. When this happens, I call the class together for a whole-group mini-discussion. This is a good time for some

of my “expert students” to share what they have figured out or how they corrected their mistakes. This change of focus often reengages students in the task.

4. Have another teacher in the room whenever possible to check student work, question student thinking, and improve the overall flow of the lesson. I have found that inviting another teacher who is enacting the same Formative Assessment Lesson in his or her classroom is helpful for both of us, as we can discuss what worked and what didn't.

Finally, consider each enactment of a Formative Assessment Lesson as a learning experience and reflect on how it can be improved the next time.

vi. Collaboration

Collaboration with my colleagues and administrators has been essential in changing the way I teach. Before enacting any Formative Assessment Lesson, we meet to work through the lesson as if we were students. We discuss how our students might think, what difficulties they might have, and what arguments they might use when defending their reasoning. This helps us to mentally prepare for enacting the lesson.

My administrators have been wonderful at finding ways to cover our classes, so we can observe what is effective and what can be improved in our own classes. At the same time, we can assist each other in oral questioning during a collaborative activity.

I have also found it valuable to have my administrators in the room during a Formative Assessment Lesson. This allows them to see how my teaching methods are changing—and to realize that all the noise coming from my classroom is not due to distracted students, but from students engaged in learning!

Final Words



Over the past three years, my teaching has changed. I no longer want my students just to sit back and quietly take notes. I want them to think for themselves and truly understand concepts. As I continue to figure out how my students are thinking about mathematics, the five strategies for formative assessment and the Formative Assessment Lessons are becoming increasingly valuable. I see the impact that formative assessment is making in my classroom as my students are more willing to present their work and learn from their own mis-


takes more than ever. Changing my instruction has taken a lot of work, but my students are responding well, and as long as they are learning and engaging in mathematics, I will continue to do what is best for them.

I hope this guide can offer you some insight into helping your students learn and retain their learning. I hope that my experiences and advice will be helpful to you as you plan to implement the Formative Assessment Lessons into your curriculum so that you can see, as I have, that your students are brilliant and absolutely capable of higher level mathematics. Who knows, they might even like it!

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