Glass, Bug, Mud

A self-assessment system enables teachers to differentiate elementary mathematics instruction, which boosts both student learning and students' sense of themselves as mathematicians.

By Kimberly J. Grimes and Dannelle D. Stevens

"What do you do first?" I asked Anna as we looked at another long division problem.

"Divide 5 by 3," she replied.

"Correct! See, you know how to do this."

Once again, I went through the steps of long division with Anna. I watched her usually smiling face change at the start of every math lesson and turn to a frown as she became lost again in the steps of long division. It seemed that no matter how many times I worked with her independently or how I addressed the problem, she still struggled. She began to give up, and so did I. She wasn't the only struggling student in my class. I watched students become discouraged and frustrated during math lessons, and their misunderstanding of math was evident when they repeatedly failed math assessments, yet I felt compelled to move through the curriculum swiftly for the sake of advancing students and in order to teach all math content before the year's end. How could I help my struggling math learners?

Anna and other low-performing students weren't the only problem within my math class. A handful of students were ready to go far beyond where I kept them in our math curriculum. Although I challenged advanced students with alternative assignments, I unfortunately created more busy work than valuable challenges for them, and they verbally expressed their disappointment and desire to be challenged, even going so far as to bring algebra problems from an older siblings' math text to class one day.

I wanted to change, and I needed an approach that would motivate all my students to excitedly tackle math problems. What instructional strategy is most effective to make math accessible and comprehensible to all students? How do I meet the needs of students who are low performing as well as high-achieving students? No curriculum or math text gives a how-to guide. Differentiated math instruction was the solution to my predicament.

WHAT IS DIFFERENTIATED INSTRUCTION?

Differentiated instruction is a teaching method used to meet the diverse needs of learners. Teachers implementing this method provide instruction for individuals or groups of students to benefit both those who find academic concepts difficult and those who find them easy. Differentiated classrooms include several common elements: student responsibility (Pettig 2000), student choice (Pettig 2000), peer tutoring (Lawrence-Brown 2004), flexible grouping (Pettig 2000), and modified instruction (Brimijoin, Marquissee, and Tomlinson 2007).

Differentiated mathematics instruction ensures successful math teaching when properly applied. Students who are taught through differentiated methods not only learn mathematics effectively, but they also become motivated students who view themselves as successful mathematicians (Lawrence-Brown 2004). Dif-

■ *KIMBERLY J. GRIMES is currently teaching at her second overseas post in Nairobi, Kenya. DANNELLE D. STEVENS is a professor of curriculum and instruction at Portland State University, Portland, Oregon.*

Photo: JIunlimited/Stockxpert

ferentiated instruction appeared valid and successful, but would it work in my classroom for my students?

DIFFERENTIATED INSTRUCTION IN A REAL CLASSROOM

During the 2006-07 school year, I conducted action research with 22 students in my 4th-grade classroom. I focused primarily on five aspects of differentiation: student readiness, flexible grouping, student responsibility, peer tutoring, and modified instruction. Based on student readiness for each math concept, I applied a differentiated teaching model to my instruction.

I used an assessment tool, known as *glass, bug, mud*, to determine student readiness on a daily basis (Brimijoin, Marquissee, and Tomlinson 2007). *Glass*, *bug*, and *mud* refer to the front of a car windshield.

- *Glass* means the student can see through the windshield clearly and has a strong understanding of the math concept.
- *Bug* is a partially covered windshield, indicating the student's understanding is not completely clear, but there is evidence of knowledge of the subject.
- *Mud* refers to a windshield completely covered by dirt; the student shows no understanding of the concept.

Students became familiar with *glass, bug, mud* and understood the connection between their level of comprehension and each word in the assessment model. They practiced using this assessment tool in a variety of math situations before the research period. I placed students in readiness groups based on their daily evaluations and my analysis of their pretests using the *glass, bug, mud* model.

Students fluctuated between *glass, bug,* and *mud* depending on their daily understanding of the math concept being learned. If a child showed that he or she was *bug* on day one and then gained understanding quickly, then he or she would be *glass* on day two. A student who was *glass* for converting yards to feet may have been *mud* when calculating the average of three numbers. From concept to concept and day to day, I altered students' groups. No student remained in the same group for an entire unit because, as students completed mathematics tasks, they mastered the concepts being taught and moved farther away from *mud.* The goal for each student with every math concept was *glass.*

Students were responsible in two ways in my differentiated classroom. First, they were responsible for correctly assessing their readiness level. To do so, students completed three to six problems involving the current concept. I encouraged them to do their best, but continually reminded them that they were not expected to know every answer. When they completed the problems, I gave them the answers and they corrected their own work. Based on the number of correct answers, students assessed their readiness level: *glass, bug,* or *mud.* I collected their mini-assessments. Using these, as well as results from an initial unit pretest, I evaluated their readiness to determine if students' assessments of themselves were accurate. If a student chose a task that did not correspond to my evaluation of their readiness level, I redirected him or her to the appropriate task.

Students' second responsibility was to complete a task card. Using their self-assessments, students chose a task card, which I created based on student needs. Each task card was labeled "glass," "bug," or "mud." Task cards gave students their assignment for the day and were geared toward each level of readiness. I used the math textbook as well as additional materials to create assignments appropriate for students who were *glass*, *bug*, and *mud*. Sometimes, tasks cards did not correspond to *glass, bug, mud* because students reached the clarity of *glass* but still needed challenge and continual practice of the math concept. In these situations, I gave students task cards after I had evaluated their math abilities. For example, students who found the average of a group of numbers were all at *glass*, but they comprehended division at differing levels. In this situation, I provided task cards that required different levels of division: Task Card A required students to do long division and create a story problem using averages; Task Card B required mental division and creation of a story problem; and Task Card C required mental division and completion of several story problems using averages. All tasks contained more practice of averages, but each challenged students at their own levels of division comprehension.

Peer tutoring was used with task cards. Students helped check each other's work, assisted with solving unknown problems, and created math problems for one another. Students worked together to correct and compare answers. While doing this, students solved problems on which they disagreed and discovered new solving methods by showing each other their work. For example, we used student-created tests for review. Some task cards required students to create a test for a classmate, along with the answer key. Through the creation of a test and answer key, students showed their understanding of each concept. Those taking a peer's test received further practice. Student-created tests were not used as final assess-

ments but only for practicing concepts.

By using *glass, bug, mud* and a variety of task cards, instruction was modified to meet each learner's needs. Those having difficulty with a concept received the needed assistance and instruction with the *mud* task card. Students needing further challenge had their needs met through the *glass* task or other tasks, such as a task card in which students who understood long division were challenged to find the average of larger numbers, while students who were not ready for long division continued to practice averages with smaller numbers. These tools allowed all students to reach *glass*, or mastery, at their individual paces, and students were challenged at their own levels.

DOES DIFFERENTIATED MATH INSTRUCTION REALLY WORK?

At the end of the research period, data showed that students' academic performance increased after I introduced differentiated instruction in my mathematics class. Students who traditionally scored low on math assessments scored as well as their high-performing peers. Among all students, motivation in mathematics jumped. Students were more engaged in the learning process. As their motivation excelled, so did their academic test scores, providing them with an "I can do it" attitude and the belief that they could succeed as mathematicians.

To determine the effects of differentiated instruction on low- and high-achieving students, I first determined the participants of my two groups based on their academic achievement scores before the research period. While using traditional teaching methods for math, I used unit posttests provided by my curriculum as a common assessment tool to identify students' average comprehension of math concepts. The results of these unit tests identified which students performed poorly and which students consistently performed well. Using this information, I placed students into three groups: low achieving, moderate, and high achieving. Low-achieving and high-achieving students were the primary focus of my action research, consisting of the lowest 20% and highest 20% of the class.

LOW-ACHIEVING STUDENTS

Students who consistently scored in the bottom 20% of their class before encountering a differentiated classroom were analyzed to determine the effect of differentiated math instruction on low-achieving students. Their average unit test score before differentiation was 72%. After using the *glass, bug, mud* model, these students' average score was 91%, a 19% increase in academic performance.

Students' academic success correlated with their motivation and self-efficacy, which was determined through student surveys and journal responses. In my differentiated classroom, 75% of low-achieving students were highly motivated in math, saying math was enjoyable and they wanted to improve, which differed from 50% in the class using my traditional teaching methods.

Journal responses identified feelings and attitudes toward mathematics. For five minutes, students wrote responses to the question, "What do you think about math?" Before differentiation, students' journals

stated: "I'm not good at math." "Math is hard." "I don't like math." After the research period, students' responses differed: "I want to get better at math." "Math is fun." "It is one of my favorite subjects." "Math is challenging, sometimes easy and sometimes hard." Differentiated instruction increased not only low-achieving students' academic performance, but also their motivation and self-efficacy.

HIGH-ACHIEVING STUDENTS

High-achieving students also gained understanding of mathematics by increasing from an average of 88% to 99% overall performance. The 20% highest-performing students continued to show successful academic performance, and their motivation to challenge themselves and be challenged in mathematics greatly increased. In my traditional math class, 63% of high-performing students showed high levels of personal motivation. This increased to 88% when I used differentiation, providing a 25% increase. These students' journal responses before differentiated instruction stated that they "love" math and it was their favorite subject despite the type of mathematics instruction administered. However, they also responded that math was a little easy and sometimes boring. After experiencing differentiated instruction, no student responded that way. Statements included, "I am good at math" and "I want to improve in math." The change in responses supports the positive effects related to differentiation for high-performing students.

CONCLUSIONS

Differentiated instruction not only improved test scores for all students, but it also increased students' desire to do math, their desire to improve in math, and their confidence in their math abilities. Because students benefited from a differentiated model, I continue to use differentiated instruction in my mathematics classroom.

Differentiation is a lot of work! Taking the time to constantly assess, reassess, and adapt lesson plans to meet every student's needs can be time consuming. The following strategies will help all teachers successfully implement differentiated math instruction:

- **Teach *glass, bug, mud.*** Explain the meaning of each part of the assessment tool. Give examples. Then have students evaluate their understanding of simple things: their soccer skills, playing an instrument, or how to build a spaceship. Teach them that it's okay to say, "I don't know."
- **Start small.** Differentiate one lesson and see how it goes. As you become more comfortable, apply differentiated instruction to more lessons. This will alleviate burnout.
- **Assess daily.** This doesn't have to be a formal assessment. Use student work from the day's assignment or ask students to write you a note at the end of the lesson stating their understanding. You can use the *glass*, *bug*, *mud* model or other techniques.
- **Use a simple assessment tool.** If glass, bug, mud is not your preference or is too childish for your grade level, apply a different technique. Thumbs up, down, or sideways. Red card, yellow card, or green card. Or ask for a simple show of hands.
- **Keep groups flexible.** Never place a child in a group indefinitely. After each assessment, maneuver students to the learning opportunity that will best suit their needs.
- **Teach when needed.** Sometimes, a whole-class lesson is necessary; sometimes, a mini-lesson for a few students is more applicable. As needs arise, instruct accordingly.
- **Use materials you have.** Don't try to create lessons and task cards completely on your own. Use your math textbook and other materials you already use in your classroom. Students can complete the same assignment whether they are *glass*, *bug*, or *mud*, but the amount of problems or the pace at which they complete them may vary and provide opportunity for further instructional modification.

In a system of diverse learners, teachers must apply instructional methods that make math accessible and understandable to all students. Differentiated math instruction based on student readiness meets the needs of students who are below grade level, as well as those who exceed benchmarks. When applied correctly, differentiation in mathematics ensures student success.

REFERENCES

Brimijoin, Kay, Ede Marquissee, and Carol A. Tomlinson. "Using Data to Differentiate Instruction." In *Educational Psychology 06/07*, ed. Kathleen M. Cauley, James McMillan, and Gina Pannozzo, pp. 137-139. Dubuque, Iowa: McGraw-Hill Contemporary Learning Services, 2007.

Lawrence-Brown, Diana. "Differentiated Instruction: Inclusive Strategies for Standards-Based Learning That Benefit the Whole Class." *American Secondary Education* 32 (Summer 2004): 34-63.

Pettig, Kim L. "On the Road to Differentiated Practice." *Educational Leadership* 58 (September 2000): 14-18.