Understanding the Path to Understanding Math

JANET WALTER AND HOPE GERSON TEACH AN HONORS CALCULUS CLASS THAT DOESN'T LOOK LIKE MANY INTRODUCTORY MATH CLASSES. For one thing, they don't lecture. They validate students' personal agency and facilitate their improvisational inquiries into mathematically challenging tasks. The students don't sit in rows—they sit facing each other in groups. And the students don't just answer questions from a textbook. Instead they work together to apply mathematical concepts to practical, real-world problems, and they often present their work to their professors and classmates.

This approach to mathematics education may sound innovative enough, but that's only the beginning. In every class session, undergraduate mentored students videotape the calculus students as they work. Not only do they set up, operate, and take down the professional-quality equipment, but they also learn to develop an eye for what to videotape. "From the perspective of a researcher you are in a position to be looking in detail at how students learn mathematics, and you gain a much deeper understanding for what learning mathematics is all about," says Dr. Gerson. These mentored math education majors are looking at student learning through the lens of prospective teachers. As they tape the class, they ask themselves, "How are these students learning calculus?"

That "how," Dr. Walter says, is the question that propels the calculus project she and Dr. Gerson have been running for three semesters. "We felt that, especially for our mathematics education majors, our students need to know how one comes to understand mathematics, not just what math is and how we use it." And so the professors teach an honors calculus class that aims to help students from a variety of majors think about mathematics in new ways.

For the calculus students, the class offers a dramatically different learning environment. The teachers are hands-off and let students talk together to solve problems using skills they bring from their varied experiences and majors. "Our philosophy about teaching is that if we give the students good, rich, open-response tasks to work on, which are accessible at an entry point, they have some tools with which they can at least begin thinking about the problem—and they are perfectly capable of developing math that's appropriate for the problem without our assistance," says Dr. Walter. These open-ended tasks, combined with the collaboration that defines the class, help students see beyond formulas and applications to make sense of problem situations.

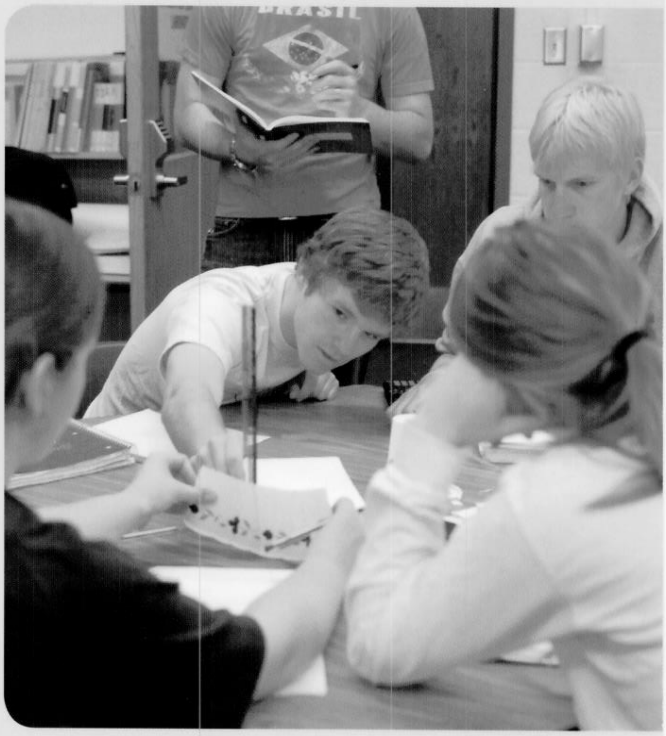
While this novel teaching process guides the calculus class, the undergraduate students that Drs. Gerson and Walter mentor as part of the project begin to look at mathematics education in a new light. "Telling students what to do is not an effective way for them to understand concepts," their teachers counsel. And so a research team that includes eight undergraduate mathematics education majors studies classroom interactions to devise new, more productive ways to teach. The team spends hours in class taping the sessions and then hours more pouring over videotapes, transcribing the conversations and analyzing students' mathematics learning.

Their mentors encourage the students to approach research in mathematics learning with specific questions. They find an element of the classroom interaction that's of interest to them and then pursue that question. Two mentored undergraduate students, Elizabeth Bunch and Tara Rosenlof, are already seeing how that research can shape new philosophies of mathematics education. "I love being in the classroom and watching students," Bunch says. "These students come in from all these different fields,

and they're not told how to solve a problem, so they pull in engineering and physics and they have complete freedom to solve the problem however they can—just like they would in the real world. And they do it!"

Bunch discovered her interest in teaching math through her love for theater. At her high school in Texas she helped fellow cast members comply with her school's "no pass, no play" policy, a rule that required students to pass their academic courses before participating in activities like athletics and theater. "I was amazed," she says. "I was helping people with their homework, and all of these very intelligent students could build beautiful two-story sets with perfect 90 degree angles but couldn't pass algebra, even after taking it three times." The experience suggested to Bunch a gap between the classroom and the real world. "I realized that a lot of teachers don't teach math so that students understand how they can use it in their lives everyday."

And so Bunch decided that she wanted to do just that—give students hands-on experience with mathematics and a sense of the accessibility to the principles and the application of mathematics in daily life. When Dr. Gerson told her about the calculus project, she was interested. "I wanted to see if this really worked," she says. "I wanted to see this philosophy in action." She joined the project in its first semester, observing the calculus class and then formulating her own research question. She's interested in "socio-mathematical norms," or class structures such as small groups and collaboration, that aim to help students learn. Specifically, she's interested in whether or not these structural implementations work—whether the structure really changes what happens in the class and affects how students learn.



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After she graduates Bunch hopes to combine her two loves. She plans to teach high school math and after school head up the technical side of a theater program. Actually, she sees some overlap between math and theater. "I'm seeing a lot of theatrical elements in these classroom interactions, with the roles of student and teacher and the way people act around each other."

Rosenlof appreciates addressing a question prompted by her own relationship to mathematics. "I used to hate math!" she says with a laugh. "But when I took college algebra at BYU–Idaho, I realized that if I worked really hard, I could do it. And then I started to like it." Once she identified part of her trouble with mathematics, she began to wonder if it affected other students in similar ways. "I think one of my problems with math in high school was that I didn't feel comfortable asking questions. I didn't want to look stupid."

Rosenlof believes if students do feel comfortable asking questions, they'll be able to learn mathematics. She considers questioning mathematics principles and concepts a choice and studies how this choice can affect the development of mathematical concepts in the students. As she pursues this research, she takes advantage of the inquiry-based classroom that Gerson and Walter have created. In most classes students expect the teacher to lecture, and the teacher expects the students to take notes. But in this class students can control the session with their questions and come up with surprising ways to think about mathematics.

Right now, Rosenlof is deciding whether she'll pursue an MA after her mathematics education degree or begin teaching school immediately. An MA would help her obtain a teaching position in her home state of California, but she's eager to get started. "I want to teach algebra in junior high," she says. "I love to see students who come in a little more timid in math suddenly realize that they can do it—that they're capable of it. They just have to be dedicated to it." Whether she leaves BYU to teach or to attend graduate school, she feels grateful for the chance she's had to understand the process of teaching and understanding mathematical concepts.

Says Walter, "We want them to envision a student-centered classroom where the teacher is not the teller but part of the learning experience." ■