

Thinking Like Archimedes

Causing learning, studying learning: a glimpse of the classroom

Half of a Grade 9 mathematics class is working in small groups, comparing the area of circles with the area of “radius squares,” and wondering about the shape of the graph they have drawn. The other half of the class has covered a circle with a coil of string, and then cut the coil of string along a radius. As students stretch out the cut coil, a triangle appears, with a base as long as the original circle’s edge, and a height equal to the circle’s radius. But what does that have to do with πR^2 ? Later, the class will compare their experiences. Then they will write about their inquiries, and either their teacher (Evan Janzen Roth) or “the guy from the university” (Dr. Ralph Mason) will write back to each of them.

The value of the last seven classes has been that I have really been able to understand circles and the origin of π . Through my different math classes I’ve only been told that you multiply π by radius squared to get the area. But now I understand why. This has been a great time. (Jessica, Grade 9)

The Research Project

Evan and Ralph’s classroom project is an example of *design experiment research*. Design experiments develop and refine curriculum for use by others, and during the developing and refining process the experimenters use research procedures to pursue richer understandings of student learning. Through this project, initiated in 2005, the researchers are developing a unit of instruction for academic students in Senior Years mathematics that enables them to understand mathematical formulas more richly and purposefully. Research data included the students’ products from each lesson and interactive writing between the students and the teacher/researchers. Data analysis will enable Evan and Ralph to address a specific research question focusing on how students learn formulas in Senior Years mathematics.

Doing this research thing, I’ve had more fun in math than I ever had. I have also learned some new things about squares and circles and graphs. I didn’t know before how to compare circles and squares, and tennis balls and tubes. I think learning to draw a hexagon was cool. Now I can draw geo art at home. (Sandra, Grade 9)

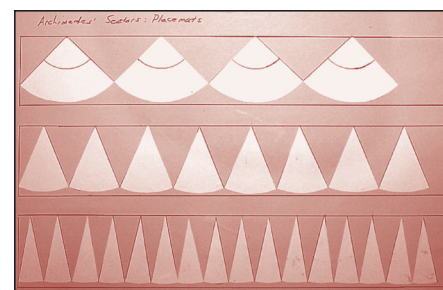
The instructional design will continue through three cycles of refinement, but it began with attempting to bring the thinking of Greek mathematician Archimedes about the geometry of the circle into Senior Years mathematics. Over a period of seven classes, students graphed relationships among radius, diameter, circumference, and area of circles. They circumscribed and inscribed regular polygons to approximate π . Readings from historical accounts of the life of Archimedes were interwoven throughout the unit. Overall, the instruction reflects principles of inquiry-oriented learning to make students’ engagement with content more thoughtful and rewarding.

Sometimes it’s easier to understand once you’ve been told what those people did to find out. You can actually find out. (Rayna, Grade 9)

Evan Janzen Roth is a teacher of mathematics at Silver Heights Collegiate in the St. James-Assiniboia School Division. Evan graduated from the University of Manitoba in 2003, winning the Gold Medal for academic achievement in the Faculty of Education. He began teaching in 2003 at Silver Heights and has taught primarily pre-calculus at the school. Evan received a grant to present at the International Institute on Units of Historical Presentation in Science Teaching held in Germany and Hungary. Presenting with Dr. Ralph Mason from the University of Manitoba, this conference laid the foundation for Evan’s current research with Dr. Ralph Mason.



In a pivotal experience, students constructed a geometric representation of the calculus-like thinking of Archimedes. This process involved progressively subdividing a circle into more and more sectors, and rearranging the sectors into a rectangle each time (see student work below). Then, as a “thought experiment,” students imagined the results if the number of sectors approached infinity and the base of each sector approached the infinitesimal.



A narrative-inquiry process brought to light the different ways in which students approached formulas and pointed to factors that helped students reorient their efforts toward understanding the relationships within the formulas. One clear outcome was an increase in students’ ability to explain mathematical concepts through the processes of active inquiry and interactive writing. The students’ ability to make sense of formulas as relationships also became apparent.

Evan and Ralph recently returned from the 8th International History, Philosophy and Science Teaching Conference in Leeds, England, and are currently developing an article to share their experiences and research results with others. For providing financial support and more, the researchers are grateful to the Imperial Oil Academy for the Learning of Mathematics, Science, and Technology, the University of Manitoba Faculty of Education, and St. James-Assiniboia School Division.

For more information, contact

Evan Janzen Roth
Mathematics Teacher
Silver Heights Collegiate
Telephone: 204-837-1321
Email: ejroth@sjsd.net

Dr. Ralph Mason
Faculty of Education
University of Manitoba
Telephone: 204-474-9086
Email: masonr@ms.umanitoba.ca