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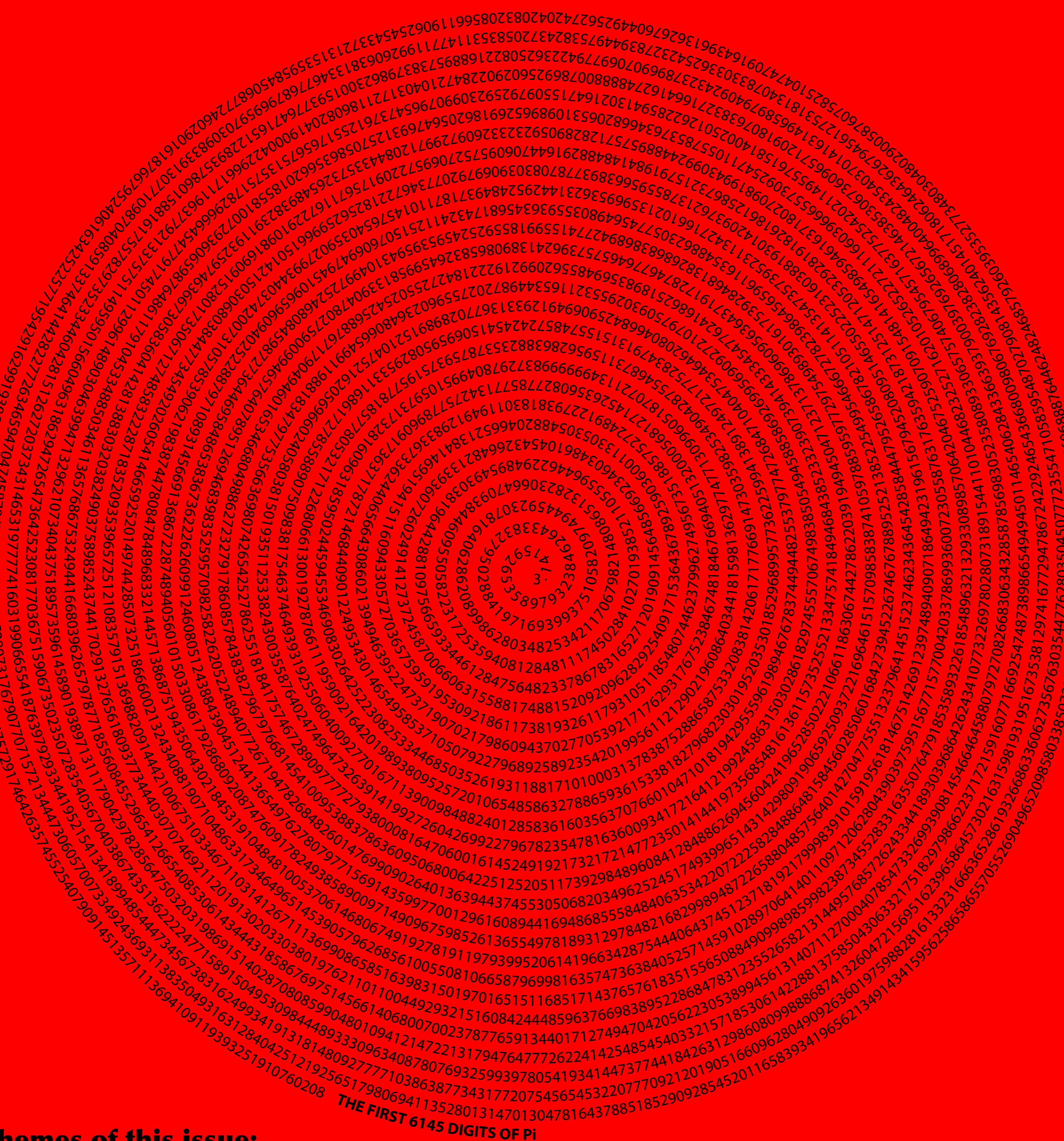

Themes of this issue:

Real World Applications of Mathematics

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Equity and Social Justice in the Mathematics Classroom

Activities Towards Teaching Mathematics for Social Justice

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Introduction

A recent position statement by TODOS Mathematics for All and the National Council of Supervisors of Mathematics (NCSM) described social justice as a key priority in the mathematical education for all students (NCSM and TODOS 2016). Not surprisingly, challenges exist when changing instruction to reach this goal. Teaching mathematics for social justice "demands change in institutional structures, teaching and learning environments, community engagement practices, and individual actions" (p. 1). As teachers of middle school, high school, and university students interested in learning more, we were curious about how teachers could begin this work in their own classrooms. What sorts of activities might allow teachers to teach mathematics for social justice?

The joint position statement describes the importance of using knowledge of students' academic readiness, language proficiency, cultural background, and individual development to plan instruction. We wondered what activities could be used to uncover these types of student knowledge. The position statement also describes the importance of connecting learning accomplished in the classroom to students' prior knowledge, life experiences, and interests. We wondered how we could connect mathematical activities learned in our classrooms to experiences and aspirations of students. In addition, the statement describes the importance of collaborating with colleagues and the broader professional community to support teacher and student learning. We wanted to learn together how to teach without deficit views of race, class, language, and culture, and instead use these differences among students and teachers as sources of inspiration for mathematics lessons.

This article describes our attempts at learning what it means to teach mathematics for social justice in our own classrooms. We present three activities designed to explore teaching mathematics for social justice and document our efforts to recognize this important goal. Although the descriptions of activities come collectively from middle school, high school, and university instructors, we believe these activities may be fruitful for educators interested in exploring social justice in their own classrooms.

Activity 1: Getting to Know You Survey

The first activity assigned to both middle and high school students is called the Getting to Know You survey. The main goal of this survey is to gather insights that will be useful for personalizing instruction. The short survey asks students questions that would be helpful to better understand students, specifically students' views towards mathematics, how previous mathematics classes influenced their views of mathematics, and their thoughts on teacher expectations in the classroom. Since the NCSM and TODOS position statement states that teachers often do not challenge students, we decided to ask students if they felt challenged by their mathematics class. To our surprise, we learned that the majority of our students thought mathematics was important and believed students could get better at mathematics through hard work. We also asked students to rate the extent to which students learned how mathematics was a part of their in- and outside-of- school life and the types of class assignments they would like to complete (e.g. projects, presentations, notes, etc).

We gave the survey to high school students at the beginning of the school year and to the middle school students halfway through the first semester. We noticed that students who described starting the semester with a nega-

tive view on mathematics as perceived by the teacher often told a different story on the mid-semester survey, stating that they now enjoyed mathematics due to how the teacher presented it. By giving the survey at the beginning of the semester, we were able to gain useful information about students. This also allowed students to notice that they contribute to class as we make their voices heard.

Having survey data allowed us to reflect on our practice in a few ways. For instance, we were encouraged to learn that more than 70% of the high school students and 85% of the middle school students rated the importance of mathematics as a 4 or 5 on a 5-point scale. Approximately 29% of high school students and 19% of middle school students responded that they were not challenged or only sometimes challenged during mathematics class. In addition, we learned that approximately 80% of the middle school students and 84% of the high school students surveyed believe that mathematics can be learned with hard work, rather than believing it is a skill a person is born with. Moving forward, we can choose quality mathematical activities that challenge more students. Giving our students these surveys gave them a voice and allowed us to respond to their voices and to tailor our instruction.

The link to the survey is **docs.google.com/forms/d/e/1FAIpQLSeUADYMm-FpBY8h9u-7joXHqXajWAOK8j-Gh2tJo1XAipJp8gA/viewform**. Please feel free to modify it.

Activity 2: Draw Me a Mathematician

A second activity used to target teaching mathematics for social justice is called Draw Me a Mathematician. The main purpose of this assignment is to see how students feel about mathematics. Drawings of Draw Me a Mathematician give teachers a sense of how students imagine what a mathematician looks like and suggest the usefulness of mathematics from students' perspectives. Did they draw someone that looks like them? Were the genders of the mathematicians noticeable and, if so, were there any patterns? Many drawings depicted mathematicians to be female teachers or male teachers who looked like Albert Einstein.

A modified version of this activity is called Draw your Relationship with Mathematics (Druken 2017). In this activity, students are invited to draw what comes to mind when they think about relating to mathematics (***Figure 1***). The usefulness of this activity is two-fold: first, teachers can see the extent to which students personify mathematics and, second, teachers may understand broadly how students describe their feelings towards mathematics. Is mathematics depicted as a set of symbols? What kinds of emotions are depicted in the drawings? Do they tell a story of their changing relationship over time? A majority of the pictures displayed a negative or fearful disposition towards mathematics. Analyzing these pictures can provide teachers useful insights about students' prior knowledge. Teachers can ask students towards the end of the year to redraw their relationship with mathematics and look to see if anything has changed.

Figure 1. Middle school student drawings of their relationship with mathematics.

Activity 3: Research a Mathematician and Scientist Project

The third activity for teaching mathematics for social justice is the Research a Mathematician and Scientist project. Students first learn about a range of mathematicians and scientists, such as Sophie Germain, Hypatia of Alexandria, and Katherine Johnson (***Figure 2***), to examine the history of mathematics. They then select one mathematician or scientist to further research and write a biography. The project attempts to connect mathematics learned in

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Figure 2. Presentation poster for research project on Katherine Johnson.

class to the lives of students, and to highlight mathematicians and scientists as people who achieved success in face of adversity.

Many students researched French mathematician Sophie Germain, who excelled in mathematics despite being hindered from learning by her gender. One student who researched Germain stated, "I chose this mathematician because there really aren't many female mathematicians, and I feel that more females should demonstrate what they are capable of, like Sophie Germain or Katherine Johnson." Another person that students researched was scientist Galileo Galilei. Students discovered that he was silenced for his scientific views that often clashed with the Catholic church, and spent years living under house arrest as a result. Through this project, students are able to relate to mathematicians and scientists' struggles and use it as a source of inspiration for addressing their own challenging circumstances.

One of the reflection questions asked at the end of this project was, "How does researching this person change you as a person?" One student reflected, "Despite your background, or where you came from, you can achieve success if you work hard." Another student reflected about Katherine Johnson:

> The mathematician that I chose is Katherine Johnson. She changed my learning in math because even though she was going through discrimination, she still went on with her skills of math, and also was an engineer and the first African American woman who worked for NASA. That's my dream, to become an engineer for NASA.

Regarding Galileo, one student wrote:

> Before we got into this project, I knew there were mathematicians who invented math, did math, and all that stuff. What I didn't know is how there was more story than that. For example, sure I knew Galileo Galilei was a mathematician and that he did math. What I didn't know was how more things went on in his life other than just math. He wasn't originally a fan of math. He studied medicine. Later he just decided that he could try out a math class. Ever since that, math was Galileo's passion. But it's not just that. Galileo Galilei and other mathematicians died due to their belief of their discoveries.

This project serves as a metaphor to help students deepen their own connections to mathematics and, consequently, provides opportunities for all students to learn mathematics.

Conclusion

Teaching mathematics with social justice in mind requires that all students are supported in learning mathematics. The TODOS and NCSM joint position statement reminds us that this involves engaging teachers in reflections and conversations, as well as changing school structure, teaching and learning environments, and ways of engaging with community. Teaching mathematics with social justice requires having knowledge of students' school and cultural background to plan instruction. The activities presented here suggest practical ways teachers can begin to connect mathematics to their students. For example, the Getting to Know You surveys help instructors become familiar with their students' beliefs about mathematics. The drawings about relationships to mathematics can serve as a metaphor that can be modified and/or built upon throughout the year. The Research a Mathematician and Scientist project helps to connect the mathematics learned in class to people in history that students may identify with and create an interest in learning mathematics.

The three activities presented here—Getting to Know You survey, Draw a Mathematician assignment, and Research a Mathematician project—were used to think about how we might teach mathematics for social justice. By sharing with others, we can rethink classroom activities together as suggested by NCSM and TODOS and make small, yet

meaningful modifications to the ways that students experience mathematics instruction. We hope others may begin to create space for richer mathematics for all students through one of these activities.

References

Druken, B.K. 2017. "Three Activities for Growing New Mindsets in Mathematics." *ComMuniCator* 42 (1): 16–19.

National Council of Supervisors of Mathematics (NCSM) and TODOS: Mathematics for All. 2016. *Mathematics Education through the Lens of Social Justice: Acknowledgment, Actions, and Accountability.* **http://www.todos-math.org/assets/docs2016/2016Enews/3_pospaper16_wtodos_8pp.pdf**.

The Facility Location Problem: Just the Beginning

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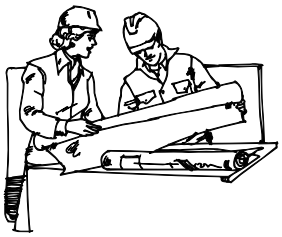

At recent CMC conferences in Asilomar and Palm Springs, educators were introduced to a valuable computer science topic, Computational Geometry (Comp. Geom.) Based upon basic geometric theorems and constructions, Comp. Geom. applies algorithms to solve problems from throughout the centuries.

Identifying the polygonal regions that are equidistant from a set of points, Comp. Geom. solves the facility location problem generated from one of two objectives: placing a hospital or store that services the largest unserved area possible or placing a prison or dump as far from existing facilities as possible. Not only are these problems equivalent, but the solution to these problems is also based upon three concepts: perpendicular bisectors, circumcenter of a triangle, and construction of a Voronoi diagram.

Comp. Geom. has direct application in many middle school mathematics and high school geometry courses. Students can be shown how to use the perpendicular bisector to locate points equidistant from two "facilities." Likewise, students can be supported in identifying equidistance of three points based upon the circumcenter of a triangle. A more advanced area of study would be to construct a Voronoi Diagram, which identifies the polygonal regions that show the service regions for any number of facilities using these circles.

Background

A Voronoi Diagram is the partitioning of a plane with n points into convex polygons such that each polygon contains exactly one generating point and every point in a given polygon is closer to its generating point than to any other. A Voronoi diagram is sometimes also known as a Dirichlet tessellation. The cells are called Dirichlet regions, Thiessen polytopes, or Voronoi polygons. ***Figures 1*** and **2** are examples of these diagrams from Wolfram Math World and/or shared through **reddit.com**.

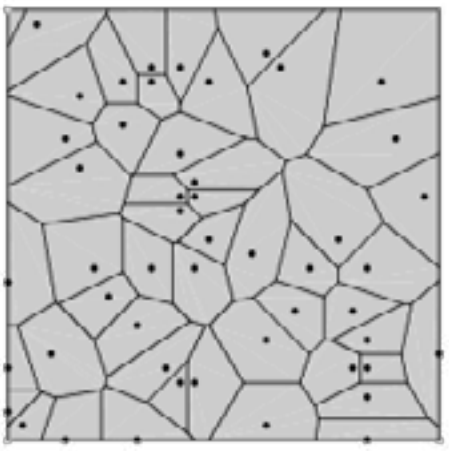

Figure 1

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