Contest Corner: Narrowing the Achievement Gap with C-STEM Curriculum

Debora Kuchey & Michael Flick, Xavier University

Abstract: In this article, we explore an innovative new curriculum, C-STEM, implemented recently in the Northwest School District. Initial results at Northwest Local School District suggest that the approach may narrow the achievement gap for students traditionally underrepresented in mathematics-related fields.

Keywords. achievement gap, contests, C-STEM

1 Introduction

Northwest Local School District was awarded one of the 23 State of Ohio Straight A Grants for the 2016-2017 school year. A total of 143 school districts submitted proposals. At Northwest, part of the funding from this grant was used to implement the computer programming and robotics curriculum developed by the Center for Integrated Computing and STEM Education (C-STEM) located on the Davis campus of the University of California (UC Davis). Computer programing and robotics programs have typically been after school programs or clubs for interested students. This is not the case at Northwest as the school district adopted the C-STEM courses in each of its three middle schools to supplement the intervention mathematics courses for sixth, seventh, and eighth grade students.

2 What is C-STEM Mathematics?

The University of California's C-STEM Mathematics Center trains teachers to implement their technology-based curriculum to extend student learning and provide alternative experiences to students who are not reaching proficiency in the regular mathematics classroom. The objectives of the C-STEM program are to "close the achievement gap by broadening the participation of students traditionally underrepresent in computing and STEM related careers and post-secondary study" and to "develop students 21st century problem-solving skills to tackle real world concerns through integrated computing and STEM education." The goal of C-STEM is to "provide formal computing education for all K-12 students through existing math courses" (C-STEM, 2017).

Harry H. Cheng is an author of the C-STEM curriculum. He is a Professor in the Department of Mechanical and Aerospace Engineering at UC Davis and Director of C-STEM. Dr. Cheng and his colleagues spent over 10 years conducting extensive research to develop the curriculum. Students who engage in the curriculum write computer programs as a means to learn the content of STEM subjects - science, technology, engineering and mathematics.

According to Dr. Cheng "Teaching math with computer programming - either as part of a standard math course or as an elective - can give mathematical concepts context and relevance while still requiring the same amount of rigor as traditional mathematics instruction." An example shared by Dr. Cheng in his article:

Example Coding Task

Write a program for a yogurt shop to process the sale of frozen yogurt. The sale price for frozen yogurt is $0.39 per ounce. The sales tax is 8.25 percent (Cheng, 2016).

Dr. Cheng states: "In a traditional math classroom this would have been a simpler challenge, asking the student to only calculate the cost for one specific amount of yogurt. But by integrating computer programming we can further students' logical and critical thinking skills by developing their ability to identify variable components abstractly, pay attention to the precision of integer and decimal numbers in a program, develop a mathematical model, and create algorithms with patterns. Students also learn to critique the reasoning of others and help each other during the program development for collaborative learning. Not only is this exercise aligned with the state's Common Core standards, it can help make math feel more relevant as students gain a sense of accomplishment for having successfully written a computer program."

The UC Davis C-STEM program is not just about learning mathematics through computer programming. The curriculum also integrates robots (Linkbot and RoboBlocky) to apply coding and mathematical concepts in a concrete way. More than 200 schools in California have adopted the C-STEM curriculum in their classrooms. The results have been very promising. Dr. Cheng related the following statistics in EdSource: Highlighting Strategies for Student Success:

> Hillcrest High School in Alvord Unified School District in Riverside just completed its first full year of using our integrated C-STEM computer programming and math curriculum. Many students in Hillcrest come from low-income families with parents who have not completed their high school education. The school reported pass rates of 94 percent for students using this curriculum compared to a schoolwide average pass rate of 61 percent on the same math examination for the Integrated Math 2 courses. Based on this success and to accommodate student interest, the school has moved from offering one class of the course to offering seven classes of C-STEM Integrated Mathematics this year (Cheng, 2016).

3 C-STEM at Northwest Local Schools

In Cincinnati, with funding from the Straight A Grant, Northwest Local School District was able to train three teachers, one from each of its middle schools. The training consisted of five consecutive days of work from 7:30am - 3:30pm. The three middle school teachers had no previous computer programing or robotics training although all were highly qualified middle childhood math teachers. Each teach two periods of sixth, seventh and eighth grade intervention mathematics.

The curriculum for the middle school consisted of the following three books:

- Cheng, H. (2016). *Learning Common Core Mathematics with C/C++ Interpreter*, Ch.
- Cheng, H. (2016). *Learning Robot Programing with Linkbot for the Absolute Beginner*.
- Cheng, H. (2016). *Learning Computer Programing with Ch for Absolute Beginners*.

According to District Curriculum Supervisor Leslie Silbernagel, Northwest's C-STEM courses are year-long electives. The sixth grade C-STEM course explores mathematical concepts in Ohio's Learning Standards for Math through practical applications with hands-on and fun computing and robotics activities. Students write C/C++ computer programs to control a single robot or multiple robots. Through both personalized and collaborative group computing and robotics activities, students learn and reinforce algebraic thinking with arithmetic operations in whole and decimal numbers, fractions, measurement, variables, data conversion, lines, angles, ratios and proportions. The hands-on computing and robotic experiments help students make meaningful connections between abstract math concepts and their relevance to real-life applications while developing critical thinking and problem solving skills. A total of 115 sixth grade students are enrolled in the C-STEM elective.

Silbernagel states that at the seventh and eighth grade levels, C-STEM courses are also taken in addition to the required Math 7 and Math 8 courses. These C-STEM courses also use computing to develop and expand the students' understanding of topics taught in Math 7 and Math 8. Through the C-STEM curriculum students analyze real life situations, identify given information, formulate mathematics steps to find a solution, and analyze the results for accuracy, all within the context of computer programming and robotics. The logical process of computer programing allows students to organize their approach to problem solving and efficiently analyze and correct their work. Robotic extension activities allow students to reenact physically derived mathematical problems through robotic technologies. Consequently students visualize situations, associate graphs with physical phenomena, predict and identify key features of the graphs with the specific physical situation, and solve physical problems through algebraic means. A total of 119 seventh grade students and 93 eighth grade students are enrolled in Northwest's C-STEM courses.

4 Results at Northwest Local Schools

After only one semester, Northwest School District is already seeing significant gains in the MAP scores of the C-STEM students when compared to the control group students. The District reported a positive percentile gain from the fall to winter MAP scores for student in the C-STEM program. The average percentile net gain of the C-STEM group in

addition to the gains observed in the control group was 5.20% in the 6th grade, 1.0% in the seventh grade and 3.67% in the 8th grade. Even more impressive were the gains in the percent of students scoring above the 50th percentile on the Winter Math MAP assessment. The percent of students above the 50th percentile in the C-STEM program increased by 11.31 percentage points from Fall 2016 to Winter 2017 as compared to an increase of 7.45 percentage points for the control group. The largest increase was observed in the 8th grade, with a gain of 18.8 percentage points for the district.

With such positive results in just one semester, Northwest School District is looking forward to monitoring the effect of the C-STEM curriculum on mathematics achievement. Only time will tell if the integration the C-STEM computer and robotic program with traditional mathematics content can help narrow the achievement gap for students traditionally underrepresent in mathematics related fields. However, the initial results at Northwest Local School District are very promising and future State Tournament of Mathematics competitions may even include C-STEM content.

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Debora Kuchey, Ed.D., `kuchey@xavier.edu`, served as a Teacher Leader in the Kentucky Middle Grades Mathematics Teacher Network for several years. She is currently the College Representative for the Greater Cincinnati Council of Teachers of Mathematics. Dr. Kuchey is an Associate Professor in Early and Middle Childhood Mathematics Education at Xavier University.

Michael Flick, Ph.D., `flick@xavier.edu`, has served the Ohio Council of Teachers of Mathematics as State Contest Coordinator for over 25 years. He has received numerous teaching awards and honors. Dr. Flick is Professor and Executive Director of the Education Centers at Xavier University.