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Teaching math with computer programming can help narrow achievement gap

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Harry Cheng

President Obama earlier this year announced a new initiative, "Computer Science for All," to empower a generation of American students with the computing skills they need to thrive in a digital economy. I believe we can take this a step further by employing computer science to help students do better at math – particularly algebra, which is often referred to as a "gatekeeper" that determines whether a student succeeds in high school and beyond.

My colleagues and I at UC Davis have been conducting extensive research for more than 10 years on how to use computing – solving a problem by designing and writing a computer program – to engage students and help them learn science, technology, engineering and math (STEM) subjects. We are now at a tipping point where we have the tools and opportunity to enable all of California's schools to integrate computer science into their math and science curriculums.

I believe all K-12 schools should provide computer science education for all students in each grade level. But even more urgently, we can use computer science to address the achievement gap in math that schools are still struggling to close. Algebra is often a key stumbling block for students, with research showing that nearly half of California students repeated Algebra I under the old state math standards.

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. For example, the following exercise asks students to write a computer program to solve an algebraic problem:

> *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.*

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.

This is just one example of how computer programming can be integrated to enhance math instruction. At the UC Davis Center for Integrated Computing and STEM Education's C-STEM program, we use computer programming with algorithmic design and robotics to engage students in hands-on learning of math and computer science. With funding from the National Science Foundation and the California Department of Education, through our collaborative research with K-12 partners, we have developed innovative educational computing and robotics technology tools

that are available to schools and students for no cost. Our C-STEM curriculum can be integrated into a school's math program for a month, a semester, a year, or multiple years – or schools can offer computer and robotics classes as electives.

More than 200 schools in California have officially adopted and used the C-STEM curriculum in their classroom teaching, and the results have shown promise in closing the math achievement gap for schools with a large percentage of student subgroups that have historically lagged behind. For example, 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.

And schools don't need to go out and recruit computer science majors to teach these courses! Even teachers with no prior computer programming experience can quickly integrate computing into their classroom instruction after just a brief professional development training.

Teaching math with computer programming presents an unprecedented opportunity to improve the success of all students, regardless of their race, gender, family background, income, or geographic location. Algebraic and computational thinking can reinforce each other. It is a cost-effective way to close the math achievement gap and at the same time provide computer science education for all students without adding teachers or new courses.

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Harry H. Cheng *is a Professor in the Department of Mechanical and Aerospace Engineering at the University of California, Davis, and Director of the UC Davis Center for Integrated Computing and STEM Education (C-STEM).*

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Judy Tan
2 years ago

I have been working with C-STEM for 3 years now. I have integrated the C-STEM curriculum in my math classes. My students are engaged and became better problem solvers. Before integrating the C-STEM curriculum into my Algebra 2 classes, my students were having trouble understanding the concept of domain and range. Through writing codes to generate correct graphs to functions, rational equations, and piece-wise functions, my students mastered the concept of domain and range and ... Read More

Adam Ko
2 years ago

I teach math at High Tech High, a project-based school in San Diego, and C-STEM aligns with our school's values of providing rigorous, meaningful and relevant projects for students to access knowledge and take the project as far as they can. I have been using the C-STEM curriculum for two school years, and it has engaged and challenged my students in such meaningful ways. Dr. Cheng and the C-STEM team at UC-Davis have ... Read More

Anthony Villanueva
2 years ago

This year is my first year implementing CSTEM into my High School Integrated Math 1 class. It was an experiment and I was not sure how programing would fit into teaching mathematics, but it fit right in. Students were immediately engaged with creating programs that would solve and calculate problems for themselves. As a result they were motivated in learning the mathematics necessary to make a generalization that could be programed.

This is Powerful.

Clay Dagler
2 years ago

I have been fortunate enough to work with Dr. Cheng over the last four years of my teaching career. During this time I have taught the UC Davis C-STEM high school mathematics class to English Language Learners, at risk students, and honor students. I can say that my students' engagement and understanding

improved for all the classes I taught using this curriculum. The highlight of my day is watching my students use programming and ... Read More

Naomi
2 years ago

I have been using the C-STEM software that Dr. Cheng is speaking about now for 2 years in my math classroom. The first year I was not able to integrate much, but this year I was able to do quite a bit, especially with my Stratigic class, which is a class for our Math 1 students who struggle and need a second class. This is where I saw the largest benefit from introducing ... Read More

Doug Obrigawitch
2 years ago

Paul, you make some very valid points, however, having taught both AP Computer Science and mathematics for a number of years, I believe that Dr. Cheng's curriculum serves as a needed gateway to more rigorous computer science education. I've had a number of students take AP Computer Science, and, like most California high schools, it was our only computer science course. The students simply did not know what they ... Read More

Paul
2 years ago

Dr. Cheng, as a computer scientist and a one-time K-12 teacher, I agree completely about the benefits of teaching math through computer science. Emmanuel Schanzer's http://www.bootstrapworld.org/ is similar to your initiative. He uses programming to teach algebraic concepts, including the notions of a variable and an unknown. His templating approach, which at its core is like the CPM (College Preparatory Math, not the old programming language) "game" in which students infer functions from tables-of-values, works brilliantly ... Read More