The Way We Teach Now

A PUBLIC + PRIVATE MASHUP FOR COMPUTER SCIENCE EDUCATION

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By Kevin Wang

Getting called into the boss's office isn't always fun. Memories of trips to the school principal's office flash through your mind.

But the day last year that I was called in to meet with our division vice president turned out to be a very good day. Executives at my company, Microsoft, had noticed the program I created in my spare time to train and place industry professionals as volunteer computer science (CS) teachers at local schools. They thought it was a great idea that needed to grow. So I was offered the chance to run the program full-time, with backing from the company.

Thus the Technology Education and Literacy in Schools (TEALS) program was "officially" born. But the program had begun unofficially three years earlier, in 2009, when I taught a first-period computer science class at a Seattle high school in the mornings before I went to work. While some thought it was a strange way for me to spend my early mornings, it was actually a very natural thing for me to do. After earning an electrical engineering and computer science degree from UC Berkeley, I taught computer science for three years in California and then went to Harvard for a master's degree in education. I joined Microsoft to work on Office365 and soon discovered a serious gap affecting both education and the technology sector.

PHOTOS COURTESY OF TEALS

Jonathan Guerin, Microsoft SQL database program manager, helps students code on smart phones in an Intro CS class at Rainier Beach High School.

Steven Edouard, a software test engineer at Microsoft, teaches AP CS at Rainier Beach High School.

Sam Gensburg, software design engineer in the Microsoft Excel group, teaches at Ranier Beach High School.

All technology companies have problems finding qualified candidates for technical job openings, and our public schools don't have the resources to teach students the computational thinking skills to launch them towards those careers.

When some of my Microsoft peers heard about my "moonlighting" in the schools, several expressed a willingness to do the same. In 2010, there were 10 of us in four schools. A year later, there were 35 in 13 schools. That's when the company took notice of what we were doing and decided to help expand it exponentially with staffing and resources.

This school year, we have 110 TEALS volunteers—mostly from Microsoft, but with about 20 percent coming from other technology companies—working with teachers in 37 high schools to teach computer science to more than 2,000 students. Some 300 of those students are enrolled in Advanced Placement Computer Science (AP CS) classes.

The program operates primarily in Puget Sound-area schools, but now extends from coast to coast, with participating schools in California, Utah, Minnesota, Washington, DC, Virginia, North Dakota and Kentucky.

Today, we identify schools that are committed to offering computer science instruction to their students but can't find enough appropriately trained teachers to provide this instruction. We then work with the school administration, guidance counselors and teachers to develop a plan for offering first period CS classes. After a 100-hour, 12-week long summer training program taught by me and other professional educators, these volunteers begin their workdays by heading into the classroom to co-teach with certificated classroom teachers.

It's a symbiotic relationship in which classroom teachers help our volunteers hone their instructional abilities, and our volunteers provide state-of-the-art content knowledge and help build the classroom teacher's capacity to teach computer science.

Half of our TEALS volunteers have graduate degrees, and 70 percent come from the top 20 CS programs in the country—places like UC Berkeley, Brown and MIT. Equally important, given the demographics of the technology industry, 25 percent of our volunteers are women or underrepresented minorities—figures well above tech industry employment averages. Seeing industry professionals who look like them in the classroom provides real-world inspiration to young people who traditionally have not pursued technology careers.

Even more exciting is that three schools have now "graduated" from the TEALS program and offer full-scale computer science programs to their students. This means that CS classes are offered during the entire school day by in-service teachers.

Student demand for these classes almost always outstrips expectations. The experience at Mount Si High School, in the community of North Bend, east of Seattle, was typical. School administrators thought that about a dozen students would sign up for AP CS and around 18 would enroll in our introductory class. Instead, 29 students signed up for the AP

Brad Smith, executive VP and general counsel, Microsoft: Four decades after Bill Gates and Steve Jobs were teenagers, we still live in a country where you have to be one of the fortunate few to be exposed to computer science at an early age … even though computer science is to the 21st century what physics was to the 20th.

Janai Skiles, Lake Washington District student: [My TEALS teachers] showed me I can be passionate about computer science when I never expected to be interested in the subject. Learning about the culture of computer science … and being able to express my creativity through the programming were fascinating to me.

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Dennis Wright, Issaquah School District CTE director: As a result of our partnership with TEALS, Issaquah School District increased the number of students enrolling in computer science coursework … While partnering with industry is not a new educational concept, the timeliness of the TEALS program is clearly appropriate for our students, schools, communities and economies.

Rubaiyat Khan, TEALS Intro CS teacher, Microsoft program manager: I have led a very blessed life, and the least I can do is give back by teaching some of the things I have learned. I also just really like it when a student's eyes light up because they now know something about how the world around them operates that they didn't know before.

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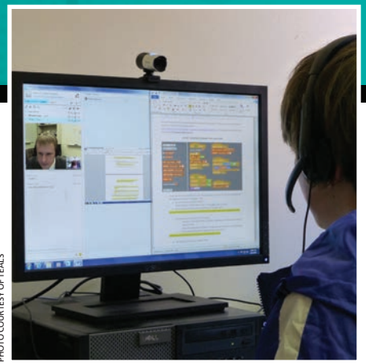

PHOTO COURTESY OF TEALS

Student in rural Lee County, Kentucky, working through a CS problem with TEALS teacher Isaac Wilson, a software design engineer at Microsoft.

section, and we had two Intro classes with 34 students apiece.

The ultimate goal of the TEALS program is to become truly nationwide; to leverage the passion and skills of high-tech professionals while keeping their day job; and to bring in-service teachers up to speed on the latest in computer science and the impact of it on their students' daily lives. Eventually, more in-service teachers will be able to teach multiple sections of CS classes on their own, building a sustainable computer science program at the high school.

It's a small, but growing, step in addressing a major problem facing our public schools, our industry, and our nation: the lack of computer science education opportunities at the high school level.

The Time for Computer Science Is Now

Schools today are asked to prepare graduates to succeed in an increasingly complex, globally competitive and technologically driven world. However, the talent pool for both industry and teachers in those areas has not been able to keep pace.

So it's no wonder that business and educational publications alike routinely report that we simply don't have enough students prepared for the jobs being created in the 21st-century economy, especially in fast-growing fields like health care, engineering and information technology. Political, educational and business leaders all have declared that we must increase the quality and number of graduates in the STEM (science, technology, engineering and math) disciplines.

Some of the best employment opportunities are found in the field of computer science. Various fields within CS provide virtually full employment, with an average starting salary that's 47 percent greater than the average undergraduate starting salary, and some starting compensation packages that include stocks and bonuses reaching into six figures.

In light of these extraordinary economic opportunities, it's surprising that we face a serious workforce gap in our industry. This gap constrains the continued growth and success of the whole technology sector, and threatens our nation's economic health. It's an issue for national defense and security which depend on home-grown technical talent. And it limits the economic opportunities for young people across the country.

Approximately 1.4 million new computer specialist jobs will be created by 2018, but at today's graduation rates, only 29 percent of those openings can be filled by U.S. graduates. Moreover, the country's production of CS degrees—particularly among women and students of color—is actually decreasing.

Research indicates that this problem starts in middle and high schools, where students build foundational skills for their future studies and develop their initial college or career interests. And while students now use computers and computing devices in their lives every day, most aren't exposed to the computational ideas behind it. The average high school student can't explain big ideas in computer science, such as how encryption enables us to send information securely on the internet or how search engines work. This is no less disastrous than if students are unable to explain how gravity works, especially in the information age. Even if they don't become computer scientists, it is important for the students to be technology literate.

Despite the need and strong student interest, the low number of teachers with CS backgrounds means that relatively few high school students actually have access to more intensive courses like AP CS. Of the more than 42,000 public and private high schools in our country, only 2,100 offered AP CS. As a result, computer science represented only 0.63 percent of all AP exams administered in the United States last year—in fact, that figure is actually down from 1.6 percent a decade ago. The more rigorous AP CS AB exam had to be discontinued for lack of participation.

We need a national commitment from both the public and private sectors to make computer science as ubiquitous as calculus or biology in the high school curriculum, and to increase the number of computer science majors in our colleges and universities.

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No one has ever learned computer science from just listening to someone talk in front of the class. Lab time is crucial. All classes are structured around a 10–15 minute lesson, followed by a 45-minute lab for mini- or multi-week projects. TEALS supplies volunteer lab teaching assistants (TAs) to keep the student-to-teacher ratio at approximately 12:1 to match the individual attention that students receive in college CS labs.

The UC Berkeley Beauty and Joy of Computing curriculum used in our Intro course is more than just a one-semester survey course on the big ideas in CS like

abstraction, design, algorithms, computational thinking and programming. The course broadens students' perspectives by showing applications of what they are learning and how computer science has changed the world. During the semester, we have readings and discussions on social implications of computing, as well as current, relevant topics about the technology environment that students live in. In addition, the course uses a graphical programming language where programs are "written" visually by putting blocks together. This allows students to focus on the big ideas without worrying about programming syntax.

For example, one TEALS teacher introduced the concept of abstraction by first showing students various art masterpieces and how great artists abstract ideas and then demonstrated how computer scientists do the same. The rest of his class was taken up by discussion on building functions as a way to abstract away layers in programs. To finish the class, the teacher had students apply these concepts to a program they have been working on.

AP CS is a more intensive, year-long course equivalent to a first-semester college CS course for CS majors. Over 75 topics are covered in a span of 30 weeks. The concepts in AP CS are actually relatively easy compared to other AP science courses like physics or calculus; the key is that students invest the time needed to adapt to how computer scientists think. The class is heavily project-based, and during second quarter, students have the chance to build the very first killer app for the PC, a spreadsheet called VisiCalc.

In addition to purely academic topics, both classes also invite industry experts to come in and talk about majoring in CS in college, internships, and various career paths they have taken during and after college in the tech sector. We also host field trips to the Microsoft campus so students see for themselves how fun and interesting working in technology can be. The AP CS students even spend an afternoon in mock interview sessions with industry software engineers to prepare them for their own internship and job interviews.

Our immediate goal is to increase the number of high school students who are able to take a CS course; the longer-term goal is to build a sustainable CS program at all our partner high schools. While we are teaching the students, the partner in-service teacher is also learning along with the students. As time goes on, in progressive iterations of the course, the in-service teacher takes on more and more of the curriculum and teaching responsibility. The first step is to take on the role of a lab TA, then a co-teacher, and finally teaching on their own while the TEALS teacher's role fades into that of a lab TA, before the entire CS curriculum is handed off.

A Look Ahead

If there's one thing my experience in education and my tenure in the technology industry have taught me, it is that complex problems need to be attacked from many different angles. Accordingly, TEALS and Microsoft are a part of a consortium of like-minded organizations that has actually started policy discussions about high school computer science education at the national and state levels.

We can't let another generation of students move through high school without exposure to computer science. That's why career and technical educators must play a key role in giving every high school student the opportunity to take a computer science class. It's also why dedicated TEALS volunteers will continue playing a role in high school classrooms across the country and why we will continue to grow the program as quickly as we can while maintaining the quality of the experience for the volunteer, the classroom teacher and the students.

TEALS works because the entire school ecosystem comes together to make computer science classes available to students. It requires supportive administrators, counselors and in-service teachers committed to developing these critical skills in their students. It also requires a flexible employer and a volunteer who is willing to dedicate at least 300 hours per year for an experience that they will carry for the rest of their lives, and at the same time, become an advocate for CS education.

I look forward to the day when computer science is offered at every single high school in the U.S. That day is still somewhere in the future. But it's getting closer. T

Kevin Wang is the founder of TEALS, a grassroots program that recruits, trains, mentors and places high-tech professionals in high school computer science classes in a team-teaching model with in-service teachers. He is a former high school computer science teacher, as well as an engineer at Microsoft. The TEALS program at Microsoft was recently featured on the front page of the *New York Times* business section. Kevin can be reached at Kevin@tealsk12.org.

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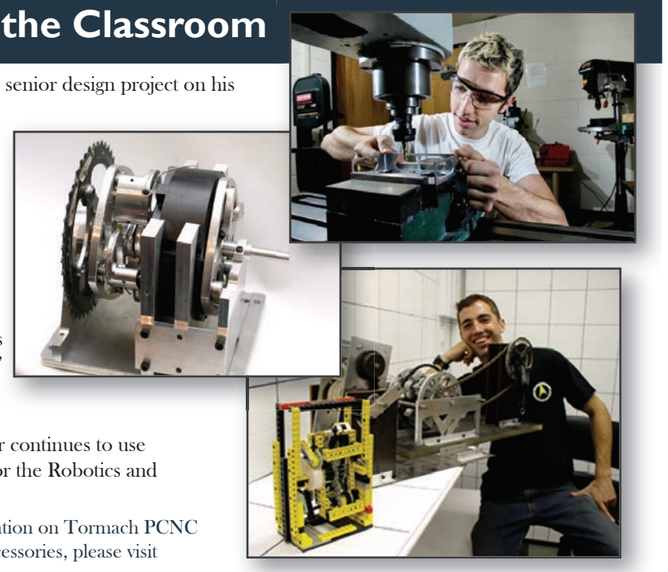
Using Real World Tools in the Classroom

Virginia Tech engineering student Derek Lahr made his senior design project on his graduation present, a Tormach PCNC mill.



"One of my research projects at Virginia Tech was to make a continuously variable transmission (CVT) for a bicycle. To get continuously variable ratios out of the transmission, one of the parts in the cam changes shape along its length. I needed a 4th-axis CNC with a rotary table to get it done. While I was researching ways to solve the problem on the bicycle design, I discovered the Tormach mill and saw that it had 4th-axis capabilities, was economically priced, and the right size."

For the Future

While pursuing advanced degrees at Virginia Tech, Lahr continues to use his Tormach CNC mill, making award-winning robots for the Robotics and Mechanisms Laboratory (RoMeLa) program.

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