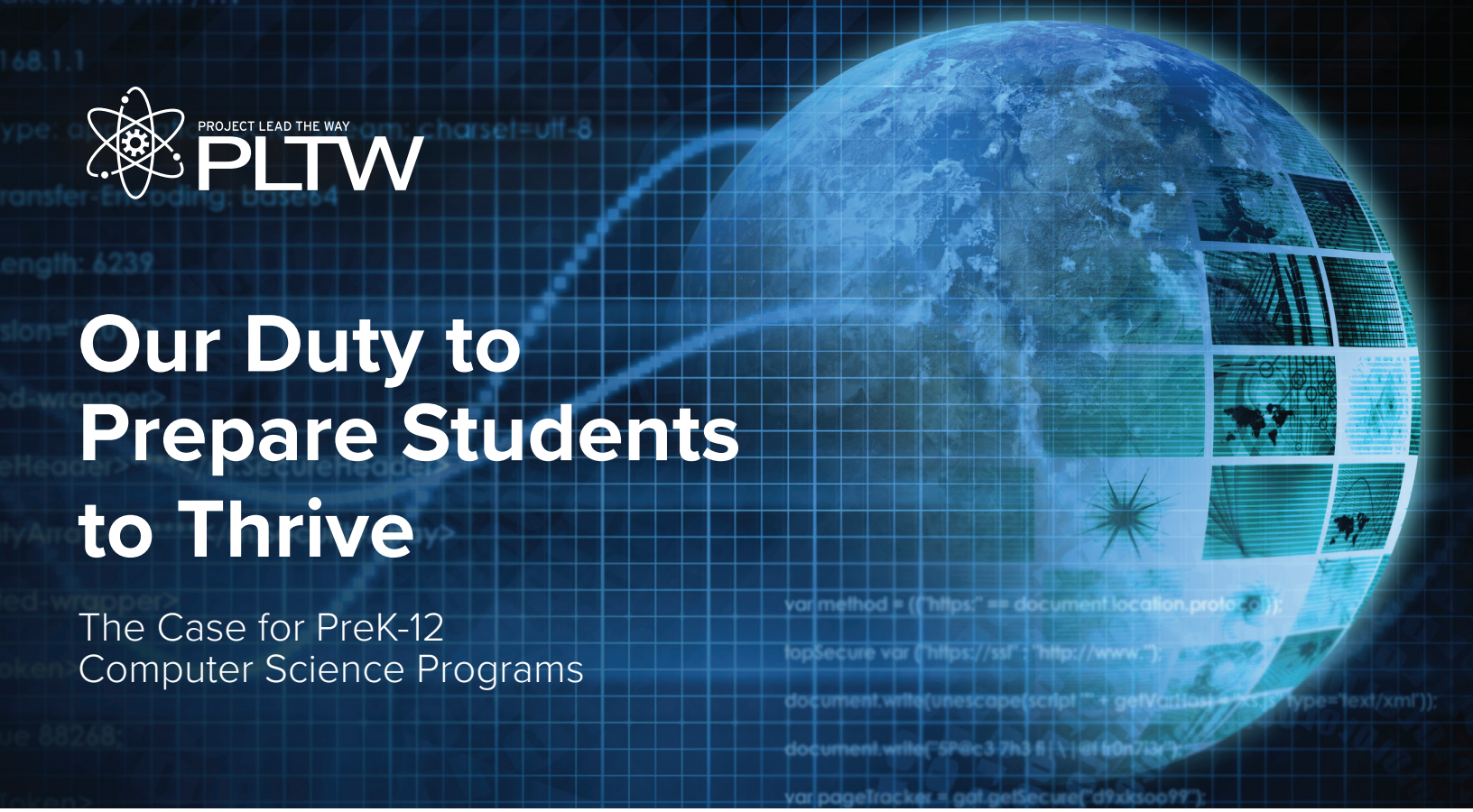


# Our Duty to Prepare Students to Thrive

## The Case for PreK-12 Computer Science Programs

In Miss Schemanske's third-grade class, students arrive bursting with excitement and anticipation, wondering what they're going to learn.

Their challenge today: Think like computer scientists. Gathering around a life-sized game board, they direct a classmate through a maze by giving commands in the right order and creating a working "program."

The students discover that computers do exactly what they're told and that sometimes they have to fix their commands in order to complete the maze. They're learning not only the fundamentals of computer science and coding, but also the importance of perseverance and the value of growing through challenging experiences and thinking like a computer scientist.

A group of middle school girls in North Carolina is learning this, too, and gaining confidence that they can do and be whatever they want. With the freedom to explore, collaborate, and make mistakes, these students have seen new doors of opportunity open and are inspired to envision their future careers.

One of them has developed a love for computer science and the problem-solving process, describing her favorite moments in class as those in which she finds and fixes a problem in her code – equating the experience to conquering Mount Everest.

More than the satisfaction of solving problems, she says computer science gives her the opportunity to create technology that can make an impact – and that's precisely what a group of high school students in Missouri set out to do.

Applying the knowledge and skills they gained through their computer science education, the students created a one-stop-shop mobile app for both iOS and Android devices after leaders from their district struggled to find the right solution to engage parents and teachers.

Taking on this real-world problem meant working together, communicating with the "client" and other district stakeholders, overcoming obstacles, listening to feedback, and using their problem-solving skills to design a solution that would have a real impact on the community.

Whether exploring new things, embarking on a quest to make an impact, or collaborating to solve a real-world problem, these students are gaining invaluable knowledge, skills, and experience that will serve them on any career path they choose – and it comes from their computer science classrooms.

***However, their experiences are the exception to the rule; the reality is that three-quarters of schools in the U.S. don't offer these computer science learning opportunities, and access is limited even further for groups of underrepresented populations.***

**Computer science is more than just programming or learning to code.**

By definition, computer science is the study of computers, computer systems, and algorithmic processes including their principles, hardware and software designs, implementation, protection against unauthorized access, and impact on society; and the practice of formulating problems so that their solutions can be represented as computational steps or algorithms to be executed by a computer.

Computer science focuses on computational thinking as a problem-solving process and the study of skills like logical thinking, pattern recognition, and abstraction that can be applied in many contexts.

Programming, coding, software development, and graphic design are to computer science what algebra, geometry, and calculus are to mathematics.


The importance of computer science education cannot be underestimated. A growing number of professions rely on computer science, making it more important now than ever for students of all ages to have the opportunity to gain computer science knowledge and skills.

> ***By 2024, there will be more than 1 million open computing jobs in the U.S., but far fewer skilled workers with the computer science training necessary to fill them.[1]***

Beyond positions directly related to computer science, jobs of all types are becoming more digital.[2] Across sectors, employers are willing to pay big premiums for people with computer and data science skills.[3]

There's clear value and urgency in preparing students for those opportunities, and district and school administrators are in a position to drive the change needed to impact their students' futures.

They can help expand access and close the nation's widening computer science skills gap by identifying and implementing the right computer science program – one that spans the PreK-12 continuum and helps students develop the knowledge and skills they need to thrive in an increasingly digital world.

## A CALL TO EXPAND EARLY ACCESS

The importance of computer science and its role in PreK-12 education has gained attention in recent years, with dozens of states allowing computer science courses to fulfill other credit requirements and some legislatures passing measures to increase access across the PreK-12 continuum.

However, even positive progress remains slow, leaving most students across the country without access to these important learning opportunities and contributing to the computer science skills gap.

An integral part of the solution lies in introducing students to computer science at a young age – as early as PreK – when they exhibit a natural curiosity to make sense of the world around them.

The early childhood years are a particularly defining time for these young learners. It is during this time that they experience the most critical point in neurological and brain development and demonstrate an innate drive to observe, explore, and discover.[4]

These natural abilities, coupled with the nation's growing workforce gap, have driven educators, policymakers, and organizations like Project Lead The Way (PLTW) to advocate for earlier introduction to computer science experiences for young learners.

> *"Engaging students as young as 4 and 5 years old in computer science learning experiences is critical in fostering their interest and confidence and setting the stage for how they approach problem-solving in the future," says PLTW Senior Vice President and Chief Programs Officer David Greer. "We don't wait until high school or college to teach students English or history; why would we wait to teach them how to think like computer scientists?"*

Providing these learning opportunities early in students' education also directly addresses the issue of students self-selecting out of computer science. At a young age, students begin telling themselves that they're good or bad at certain subjects based on what they know and experience, but earlier exposure helps them build confidence and interest that can have a lasting impact.

This is especially important for female, Hispanic, and black students, as they are overwhelmingly underrepresented in computer science. In fact, only 17 percent of students graduating with a bachelor's degree in computer science are female, only 9 percent are Hispanic, and only 8 percent are black – and this trend continues in the workforce.[5]

**"Our strategic plan calls for three focus areas – academic excellence, creative problem-solving, and social and emotional learning – to be implemented across the PreK-12 continuum. By expanding our PLTW program to PreK, we're bringing high-quality STEM learning experiences to our youngest learners, an important part of our strategic vision."**

– ***Dr. Travis Bracht,*** *Superintendent at Affton School District*

**"Many of our students come to us in PreK and kindergarten already familiar with technology, but often this familiarity is on the level of a simple consumer, passively absorbing content from a screen. The PLTW Launch computer science modules in the early grades allow students to express their individuality through programming and apply their knowledge creatively to solve problems, while acquiring important skills such as sequencing, critical thinking, and how to work collaboratively."**

– ***Chris Reynolds,*** *Principal at Darnaby Elementary*

Structural and social barriers in both exposure and access to computer science education have created disparities in opportunities to learn computer science and contribute to the continuing perception that computer science is only for certain groups.[6]

### *It's time to make a change.*

Early exposure can help solve this issue over the long term – but only if the program is responsive to students' backgrounds, cultural perspectives, traditions, and knowledge. Programs that encourage an equitable approach to computer science include the following characteristics:

- Elicit and value students' prior experiences, providing them a sense of belonging in the classroom.
- Encourage students to work in groups to learn and value diverse perspectives.
- Allow student choice regarding relevant projects and problems, providing all students with opportunities to contribute to the learning experience.
- Provide adequate support to meet the learning goals of the curriculum, helping students of all backgrounds and learning levels build knowledge, skills, and understanding.

By providing students with early exposure to these important learning experiences, schools can reach and engage more students, driving interest in computer science and ultimately working to close the nation's skills gap.

**17% Female**

**9% Hispanic**

**8% Black**

*Percentage of students graduating with a bachelor's degree in computer science*

## QUOTES FROM PLTW CLASSROOMS

**"What's notable is that many of the children who benefit the most from this program are the ones who may not typically have academic success. My best builders and doers, for instance, are often children who can't sit still for long periods of time. This program is truly Computer Science for All."**

– ***Angela Canham,*** *PLTW Launch (PreK-5) Teacher*

**"When time comes for them to have to return the computers, there's this sense of, 'Aw, really?' That, to me, is a good class, when time's up and they don't want to leave my classroom."**

– ***Angelica Gunderson,*** *PLTW Gateway (6-8) Teacher*

**"The PLTW Computer Science Principles curriculum (being offered as AP CSP) has changed the way students view computer science. It is no longer a subject that is reserved solely for the intellectual elite of the school. Word of mouth – that this course is for students who are curious about technology, and that it is welcoming of all abilities – has made it one of the most sought-after AP classes this year."**

– ***Nimmi Arunachalam,*** *PLTW Computer Science (9-12) Teacher*

## PREPARING STUDENTS THROUGHOUT THE PREK-12 CONTINUUM

Broadening exposure and access to computer science learning opportunities is essential in engaging all students in the subject and equipping them with the tools necessary to thrive. Not only should schools offer these learning experiences as early as PreK, but they should also provide throughout the PreK-12 continuum computer science education that progressively prepares students for more challenging, higher-level work.

Not all computer science programs are created equal. A comprehensive PreK-12 curriculum that is well-organized and purposefully designed to facilitate learning ensures that students remain interested, gain knowledge and skills, and have the opportunity to develop deep understanding and mastery of computer science concepts and practices over time – some of the many values of a vertically aligned curriculum.

Among other benefits, a vertically aligned curriculum:

- Ensures continuity of instruction across lessons, classes, and grade levels.
- Follows standards and age-appropriate and developmentally appropriate practice, while preparing students for assessments.
- Maximizes teacher and student time by reducing inconsistency of what has been taught.
- Minimizes student boredom and fosters student engagement by offering new, novel ways to acquire knowledge and skills.

"Vertical alignment presents many clear benefits for students as they progress through the PreK-12 continuum, building not only their understanding but also their confidence in the subject matter," says PLTW Director of Curriculum and Instruction Jason Rausch. "It's important to note, however, that while PLTW's computer science curriculum is vertically aligned to scaffold knowledge and skills, it also provides 'entry points' and flexibility for teachers to engage students who may not have progressed through the entire PreK-12 pathway."

**Vertical alignment** is the organization of curriculum from one grade level or content area to the next to support students' progressive development of skills and knowledge over time.

**Elementary**
*Visual programming*

Students are introduced to fundamental concepts of computer science in an engaging and approachable manner.

**Middle school**
*Block programming*

Students dive deeper to solve real-world problems that matter to them by applying computer science principles.

**High school**
*Text-based programming*

Students unlock the power of text-based programming to solve relevant problems.

Integral to a vertically aligned PreK-12 curriculum is an instructional approach in which students learn by doing – one that empowers students to own their learning, provides appropriate scaffolding, and prepares students to tackle real-world challenges.

An activity-, project-, problem-based (APB) instructional approach helps students become active and engaged learners by creating student-centered learning experiences in which teachers act as facilitators, rather than lecturers. In this environment, students begin to lead their own discovery as they work through hands-on activities, projects, and problems that become increasingly open-ended as they progress through the curriculum and more challenging as they advance to higher grades.

With appropriate scaffolding and guidance from teachers, students are able to achieve higher levels of problem-solving than they would otherwise.[7] By creating an environment in which learning is not too challenging, not too easy, but at just the right level of difficulty when given the right support, students are empowered to think deeply, apply their learning, and overcome challenges.

These hands-on, problem-based, applied learning experiences give students the opportunity to demonstrate evidence of their learning as they find solutions to open-ended, real-world problems. When immersed in such experiences, students learn both content and thinking strategies[8], building knowledge, skills, and understandings they can apply to unique situations, rather than simply answering a question on a test. In other words, they're putting their learning into practice.

The APB approach not only makes learning more relevant, but also empowers students to develop both technical and in-demand skills that are valuable and transportable across all industries.

"PLTW's computer science pathway uses our APB instructional approach that brings career awareness and relevancy into the classroom," says Greer, PLTW's senior vice president and chief programs officer. "It empowers students to develop problem-solving strategies, to think creatively and critically, to develop grit and perseverance, and to work together to create innovative solutions. These are skills that are extremely valuable and transportable into college and career, no matter what field a student chooses to pursue."

## PLTW'S ACTIVITY-, PROJECT-, PROBLEM-BASED (APB) INSTRUCTIONAL APPROACH

**Activities**
empower students to develop knowledge and skills they'll use to navigate a real-world project and problem. Activities are structured hands-on learning experiences.

**Projects**
help students explore a real-world challenge and make meaningful connections. Students draw on the preparation provided in the previous activity to identify and propose solutions.

**Problems**
challenge students to apply what they've learned through the activity and project. They reflect real-world challenges and are open-ended, with no one "right" answer.

## THE VALUE OF INDUSTRY IN CREATING STUDENT CURRENCY

To prepare students for a career and a life of economic prosperity, schools must ensure students gain the knowledge and skills employers are seeking.

Collaboration between education and industry is critical, says Don Kleoppel, vice president and chief security officer of Cerner Corporation, a global leader in health care technology. "We want to make sure that schools are focusing on the right skill sets. We're looking for associates who have computer science experience or a technology background, but we're also looking for those who are problem-solvers, self-motivated, and able to work as a team."

Close ties to and engagement with industry are signs to look for when choosing a high-quality computer science program – one that signals both technical and in-demand skills to future employers while creating currency for students.

"Our close connections with industry help us continuously validate that the skills we are building are the ones employers are seeking," says Vanessa Stratton, PLTW's vice president of programs. "Our engagement with industry extends beyond the classroom – most recently with our new high school assessment and the resulting student score report, which highlights students' subject-matter knowledge and mastery of transportable skills."

With a comprehensive computer science program that not only helps students gain technical and transportable skills but also measures them, students are better equipped for their futures and have a tool to prove their potential.

"For years, we've sought graduates who have mastered the types of skills PLTW students gain through their coursework, but have faced increased challenges in identifying those who are ready to hit the ground running in the workplace," said Brian Krinock, Toyota Motor North America senior vice president, vehicle plants. "By giving businesses a tool to validate these skills, PLTW is making it possible for employers like Toyota to recognize and hire the top talent we need to drive our business forward."

Beyond lending insights to inform computer science curriculum and assessment development, industry leaders play an important role in driving career connections for students. By partnering with education to offer field trips, internships, apprenticeships, competitions, or other special programs, industry can provide invaluable opportunities for students to explore career paths and take their learning beyond the classroom.

As students dream about their futures, it is essential that they have access to these real-world experiences that illuminate the computer science career paths and possibilities available to them.

"Students can't be what they can't see," Greer says. "If they don't know what to strive for, they can't actually strive to achieve it. If we can show them what they can be – and build a scaffolded PreK-12 pathway for them to actually achieve that – then the sky's the limit for these students."

**Working Together to Expand Access to Computer Science Education**

PLTW partners with industry and workforce development organizations to expand access to computer science education and create an ecosystem of support for students and teachers, engaging them in learning and equipping them with tools, resources, and experiences that connect the classroom to business and industry.

As a result of these partnerships, PLTW awarded more than 780 schools over $9.6 million in grants to fund computer science education during the 2017-18 and 2018-19 school years.

“By 2020, a huge percentage of jobs will require technology skills. Yet today, millions of American students lack the tech literacy and computer science skills they need to succeed in the digital world,” says Justina Nixon-Saintil, director of programs for Verizon Innovative Learning. “It’s imperative that all children have access to technology and computer science education because they deserve the opportunity to achieve their potential and to realize a brighter future for themselves, their communities, and the world.”

Industry partners also support computer science education by offering mentoring, internships, and career-related opportunities, validating the knowledge and skills students gain to ensure that PLTW programs are the standard for career learning, and advocating for PLTW programs to give more students access to real-world learning experiences.

## EMPOWERING STUDENTS TO THRIVE

PLTW ALUMNI SHARE THE IMPACT OF COMPUTER SCIENCE EDUCATION

For PLTW alumni Ruby Rios and Jacob Kinsey, PLTW's computer science curriculum illuminated career paths they didn't know existed.


### RUBY RIOS

Affectionately nicknamed a "STEMinist," Rios is a standout advocate for girls in computer science, whose efforts and passion to engage girls in tech have led to her being recognized on Kansas City's "30 Under 30" list, in various articles, and on stage as a featured speaker at events such as TEDxYOUTH.

Her passion for computer science began early – after she attended an app development camp for girls in fifth grade – but it wasn't until she took PLTW Computer Science that she found the intersection of her hobby and her future.

"Those [PLTW] classes gave me the opportunity to take the skills I'd been honing by myself and expand them in an enormous way," Rios says. "I was able to take the stuff I was doing as a hobby and turn it into something I could do as a career."

Rios, who is currently dual-majoring in computer science and business administration at the University of Missouri-Kansas City, says access to computer science education in school is necessary to encourage and motivate kids to pursue it as a career path.

"For kids who are really interested in writing, being able to do writing assignments in class gives them that sense of fulfillment they need to continue onward and the confidence that they're capable of doing this. When you don't have computer science or engineering in schools, there's nothing motivating students to continue pursuing it."


### JACOB KINSEY

Kinsey – who is studying computer science at the University of Arkansas and completed a software engineering internship at Cerner Corporation during summer 2018 – attributes much of his success to the skills and knowledge he gained from his PLTW classes.

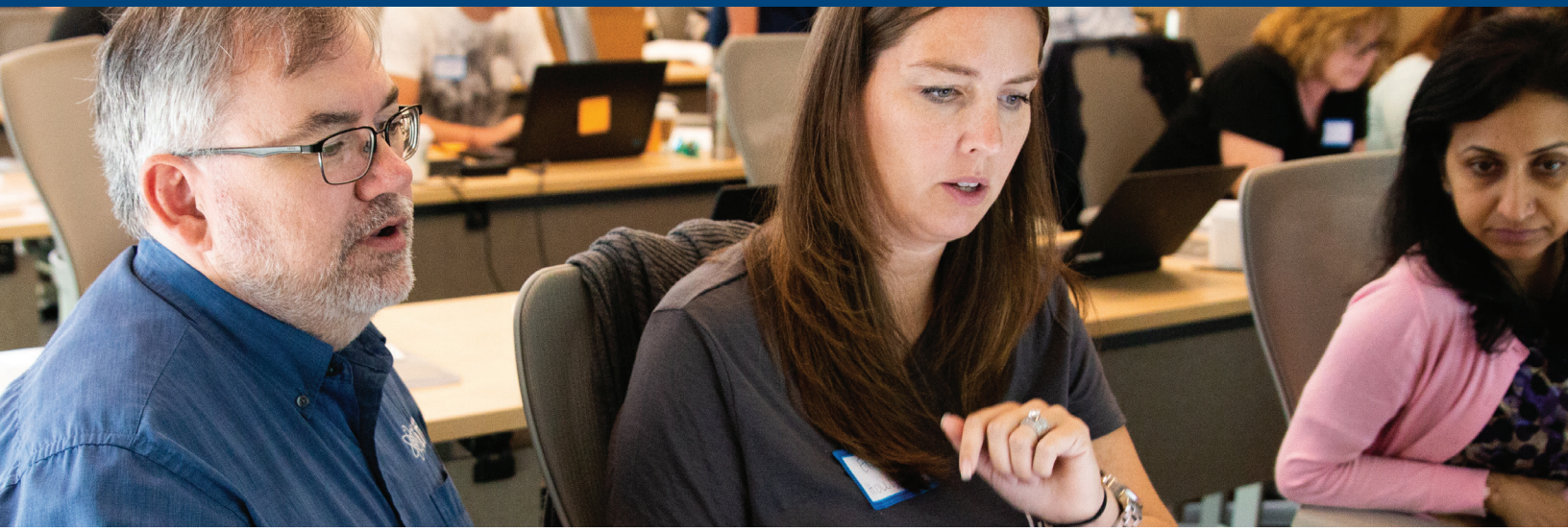
"When I first started, I didn't know what a computer scientist looked like. I didn't know what someone in the industry could do. How did you get there? What did that job look like?" Kinsey says. "PLTW really gave me that insight into, 'Here's a job path for you; here's how to get there.' PLTW showed me that path that I had no basis for before."

His experience with four PLTW high school courses helped him develop both the technical and transportable skills he used every day at his internship.

"I would say that my job is 50 percent programing, 50 percent explanation," he says. "If you don't have the ability to explain your thoughts, they're not worth much in this industry. You have to be able to work with people. You have to able to explain. It's not just about the end goal. It's about how you're getting there."

More than anything, the skills and knowledge needed to perform his work required confidence in himself – and Kinsey believes this came from PLTW.

"Without PLTW, I wouldn't have the confidence that I can do this. I will forever be grateful for this program and the opportunity it gave me," he says.



## EMPOWERING TEACHERS TO FACILITATE COMPUTER SCIENCE EDUCATION

Central to computer science education and student success is the teacher who facilitates these learning experiences. However, many believe that only teachers who have advanced degrees or backgrounds in computer science are equipped to effectively facilitate the curriculum.

"Teachers new to computer science often feel intimidated or lack confidence in teaching the subject due to their limited knowledge and experience," says Bryan Kind, vice president of programs at PLTW. "Our computer science teachers come from a variety of educational backgrounds – ranging from library science, physical education, and theater to music, biology, history, and more. Some are first-year teachers, while others have more than 30 years of teaching experience."

This makes it essential to find the right computer science program – one that offers robust professional development that supports and prepares teachers to confidently bring computer science to the classroom. Such professional development should:

- Meet teachers' varied backgrounds and learning styles by offering different delivery options and flexibility in how teachers participate in computer science training.
- Create an environment that challenges teachers to look at their classrooms in a new way and immerses them in the role of the student.
- Incorporate industry experiences that empower teachers to bring career connections and inspiration back to the classroom.
- Build skills and confidence around activity-, project-, problem-based learning.
- Prepare teachers to gain the ongoing pedagogical and content knowledge necessary to be expert facilitators of student learning, rather than lecturers at the front of the classroom.

**"PLTW does a really good job of scaffolding ideas and building that foundation for the students and for the teachers. It didn't feel like this huge monstrosity I had to learn in order to conduct the class. The way PLTW has set up the curriculum makes me more of a facilitator than the only person who holds all the information for that computer science course."**

***– Justin Delos Reyes,*** *PLTW Computer Science Teacher*

A strong professional development program that builds confidence among all teachers, regardless of their backgrounds, and prepares them to facilitate the classroom experience is essential; however, finding the right teachers is also key.

Teachers' attitudes and predisposition to the subject can greatly impact their ability to successfully facilitate the curriculum. Those who exhibit the following qualities are better positioned for success in a computer science classroom:

- Excited and curious
- Enthusiastic about using and teaching technology
- Willing to learn new things and learn alongside students
- Comfortable acting as a facilitator of the learning experience and empowering students to lead their own discoveries

***"When you find the right teachers and provide them high-quality professional development, computer science is no longer an intimidating subject," Kind says. "That's what we've seen at PLTW, and we believe it's a result of the immersive PLTW Professional Development experience, in which teachers gain the training, resources, and support they need to engage students in relevant, true-to-life learning."***

## IT'S TIME TO ACT

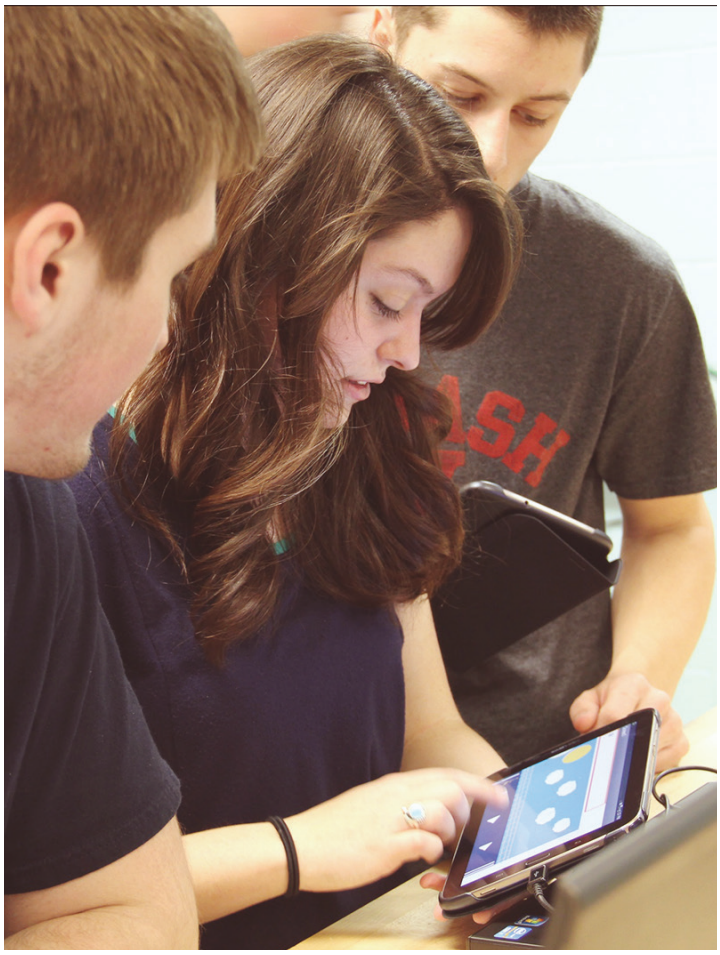
"Computer science is everywhere. Data is everywhere. Information is everywhere," says PLTW Computer Science Teacher Anjali Nanda. "The world is moving toward computer science in every field."

Today, 7.7 million people in the U.S. use complex computing in their jobs[9] – and this number will only rise as technological advancements and the associated workforce demand continue to elevate the importance of computer science knowledge and skills.

Unfortunately, many PreK-12 students today have limited opportunity to learn about computer science and to understand how it influences not only their daily lives but also their future careers.

By some estimates, only one in four K-12 schools in the U.S. teach computer science, leaving three-quarters of students ill-equipped to enter the modern workforce and leading to a growing computer science skills gap.[10] Access is further limited for groups of underrepresented populations, including female, black, and Hispanic students.

***Our students deserve better.***




**1 in 4**

**K-12 schools in the U.S. teach computer science**

All students deserve the kinds of learning experiences offered to third-graders at Carpenter Elementary who were learning to think like computer scientists, middle school girls at Coulwood STEM Academy who discovered how computer science is key to their careers, and seniors at Pattonville High School who solved their district's real-world problem as professionals would.

All students deserve to realize a brighter future in which they're prepared to thrive – and we have a duty to ensure this happens. That means:

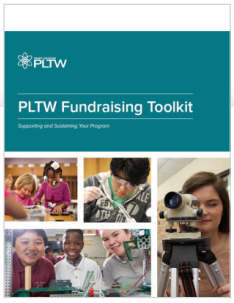
- Providing computer science education to students as early as PreK.
- Offering a program that progressively prepares students for more challenging, higher-level work throughout the PreK-12 continuum.
- Ensuring access to learning experiences that support student ownership of learning, provide appropriate scaffolding, and prepare students to tackle real-world challenges.
- Inspiring career confidence by offering students the opportunity to see and explore career paths.
- Collaborating with industry to validate knowledge and skills and providing students with a tool to prove their potential.
- Empowering teachers to facilitate computer science learning experiences.

***By implementing a comprehensive PreK-12 computer science program that is purposefully designed to empower students to thrive, district and school administrators have the opportunity to drive change and profoundly impact their students' lives – and now is the time to act.***

## About Project Lead The Way

*Project Lead The Way (PLTW) is a nonprofit organization that provides a transformative learning experience for PreK-12 students and teachers across the U.S. PLTW empowers students to develop in-demand, transportable knowledge and skills through pathways in computer science, engineering, and biomedical science. PLTW's teacher training and resources support teachers as they engage their students in real-world learning.*

*Continue the conversation with PLTW to discover how you can prepare your students for the future and drive the change needed to close the nation's computer science skills gap. Email* ***CSedu@pltw.org*** *to connect with our experts, who can help you take advantage of the opportunities that high-quality computer science education can provide your students.*




Need help funding your computer science program? Check out PLTW's Fundraising Toolkit, available at **pltw.org/pltw-fundraising-toolkit**.

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