Closing the Gap: Tech Industry Needs and the State of K-12 Computer Science Education
Couragion’s mission is to inspire students to pursue STEM competencies that will prepare them for the many careers they will have in their lives. Couragion is generously supported by the National Science Foundation – with an undertaking to improve the awareness and perception of STEM careers and to meaningfully broaden participation in these fields. Couragion strongly believes that career literacy should be integrally woven into K-12 Computer Science (CS) education to improve relevance, better inform student choice, and increase retention in real-world career paths.

As a part of its research, Couragion took an in-depth exploration into the technology (tech) sector and specifically into K-12 CS education. Our goal with this research is to provide a window into what industry needs and how education is preparing the next generation workforce. In this report, we will address the following:

- The state of the tech industry as a foundation for the imperative to prepare our students for tech jobs
- A look at CS program access and quality, and what it would take to improve programs from both an administrator’s and teacher’s perspective
- An understanding of CS teacher preparation in the context of teacher scarcity, qualifications, professional development and capacity building
- An overview of the range of resources used today to teach CS, including the top teacher favorites
- A deep dive into which programming languages will provide the most employment opportunities, and how that aligns to what is being taught to our students
- A closer look at interest levels in CS, and some insights about how to engage students (especially girls) more effectively
CompTIA recently released Cyberstates™, a guide to the tech sector and tech workforce analytics. The tech sector accounts for more than $1.3 trillion and an estimated 8% of total activity in the U.S. economy. Over the past five years, the IT and software services sub-sector added over 48K new businesses at a growth rate of 24%. More than ever, CS and related jobs are required to innovate across every industry from healthcare to security to education and beyond. Computing jobs constitute the backbone of the U.S. economy both in the tech sector and in tech occupations across all other industries.

CS-Related Worker Shortage

In the U.S., there is a shortage of CS-related workers. According to the National Center for Education Statistics (NCES), there were 527K computing jobs open in 2015 with only 60K CS graduates (NCES, Code.org®). While H-1B visas provide one way to alleviate the shortage of tech graduates, the number of visas allowed does not meet the demand. In 2017, there were 199K applications for the available 85K visas (CNN, U.S. Citizenship and Immigration Services). At the same time, underrepresented participation in the tech workforce remains low. According to a 2016 Taulbee Survey, women make up less than 18% of Bachelor of Science (BS) CS graduates and Latino, African American and Mixed-Race students make up less than 15.3% of BS CS graduates.
Recruiting Woes
Per Cyberstates™, the annualized average wage for a tech industry worker in 2016 was more than double the average national wage, while the unemployment rate in the first quarter of 2017 was almost half as low for tech jobs compared to the overall U.S. labor market. Yet today, tech job openings remain vacant for long periods of time. Per DHI Hiring Indicators and Workable, IT or product management jobs remain open for 50 days while a software quality assurance engineer opening remains unfilled for 121 days - these are significantly higher than the average across all U.S. jobs of 29 days. This results in lost productivity, decreased innovation and exorbitant recruiting fees to pluck qualified candidates from existing jobs or to apply for H-1B visas.

Inspiring the Pursuit of Tech Careers
By inspiring students, especially the underrepresented, to pursue careers in tech we can contribute to solving tech worker shortages and lowering industry hiring costs. Couragion works to better attract and retain tech workers by enabling students to learn about the vast spectrum of tech careers and find careers that support students’ values, interests, and desired work characteristics. Couragion connects the dots for students on the applicability of near term coursework and alternative postsecondary pathways that support students’ future career options. This ultimately leads to a happier and more productive workforce that will boost innovation in STEM and improve our nation’s welfare.
According to 2016 Gallup research, 91% of parents want their students to learn CS and 93% of parents want their children’s school to teach CS. According to the same report, only 40% of administrators report having at least one CS class in which students learn programming or coding. In 2016, Code.org outcomes showed that the proportion of schools with AP CS programs increased 6 percentage points to 21% of schools. While we are seeing improvements, we have a long way to go in improving access in line with parents’ expectations.

Educator Perceptions Around Quality of Programs
Per Couragion’s primary research, when schools do offer CS, teachers and administrators are at odds over the CS program quality and perceived gaps. 45% of CS teachers feel their programs are above average or best in class. This perception is significantly different amongst administrators whereby 37% say their programs are below average. When asked what would improve their programs, teachers state ‘more time in the school day to cover CS’ (47%) and ‘budget’ (44%) as the top two issues. While 78% of administrators share that ‘teachers with appropriate skills and experience’ would take their CS programs to the next level. We will dive more deeply into teacher professional development in the next section.
The Need for Real-World Experiences Like Apprenticeships

Another reason for below average programs from the administrators’ perspective were the lack of real-world experiences. In Couragion’s research, only 3% of CS educators report having apprenticeships and 9% report having internships. These types of initiatives expose students to real-world job environments and help them build marketable skills towards their careers - all while earning livable wages and potential college credit. Partnerships with businesses can help companies build the demand and pipeline for future employees while stimulating interest and preparedness in students. Building on bipartisan support across a broad range of states and industry partners, the U.S. Department of Labor has invested in the ApprenticeshipUSA initiative. The ApprenticeshipUSA Toolkit provides resources to introduce you to the benefits, implementation strategies and models of success.

Couragion + CareerWise Colorado Forging the Way

Colorado is leading the way in building multiple student pathways, highlighting alternative postsecondary options and engaging industry to produce the next generation of talent. CareerWise Colorado is a nonprofit organization building a statewide system of youth apprenticeships that create pathways for students to access high-demand, high-paying careers. Students work toward high school graduation and earn postsecondary credit and/or industry credentials in their chosen career path. CareerWise is shaping the workforce through innovative, business-led apprenticeships that will shift the paradigm of workforce readiness – and is forging the way for other apprenticeship programs across the nation. Couragion has partnered with CareerWise. Together the organizations will deliver career exploration that illuminates potential pathways and supports students in their apprenticeship selection processes. Couragion inspires students by featuring diverse industry role models in their actual work environments while mapping the relevance to the classroom and coursework. With this new-found self-awareness and knowledge, students can translate their passions into project-based learning initiatives, volunteerism, internships, apprenticeships, and industry certifications. This modern career exploration improves apprenticeship experiences and helps lead to meaningful careers.
Per the **Information Technology and Innovation Foundation**, a major barrier to increasing the quantity and quality of CS courses offered to high school students is teacher certification - whereby many teachers who end up in CS classrooms are either uncertified or certified for another subject. In Couragon’s findings, many CS teachers lack appropriate qualifications: 23% report having a CS bachelor’s degree, 13% report having a CS master’s degree, 27% report having CS certifications, while 37% report having no CS degree or certification.

**CS Teacher Deficits & Goals**

We need to build teacher capacity for the computing and tech fields, while also creating scaffolding to traditional classroom practice. There are some notable efforts to increase teacher capacity like the **Blow Minds. Teach STEM.** initiative, powered by 100Kin10, to enrich U.S. classrooms with 100,000 excellent STEM teachers by 2021. Per the **Information Technology and Innovation Foundation**, the U.S. should aim to have high-quality CS courses as common in high schools as calculus courses and to do so there is a need to train and certify 10,000 more CS teachers. The outgoing Executive Director of the Computer Science Teachers Association (CSTA) recently talked about his tenure on **LinkedIn**. He noted that the organization has grown to 26,000 members across more than 145 countries. He also talked about how many might be surprised to learn that most CSTA members do not identify themselves as ‘CS teachers’, but rather as ‘teachers of CS’ – as only 1 in 9 of his members have taken a college level course in CS and only 5 – 7% have a degree or certificate in CS.

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CSTA members identify as ‘teachers of CS’ not ‘CS teachers’.

37% CS teachers with no CS degree or certification.

10K new CS teachers needed to match access to calculus.
CS Professional Development Opportunities

Couragion’s research shows that 50% of CS teachers receive less than 10 hours of CS professional development (PD) each year. Per research from the CSTA, a lack of formalized PD for K-12 CS teachers endangers the U.S.’ ability to compete in the global economic arena because it results in limited or lagging digital learning for K-12 students. Since it is difficult to locate and access high quality PD programs and resources, CSTA built a pipeline for K-12 CS teachers which includes access to resources, the ability to earn micro credentialing badges, connections with other CS teachers and online tracking. You can learn more about this new initiative, known as the Continuing Professional Development Pipeline here. Another resource is Code.org, which is recognized by the College Board as an endorsed provider of teacher PD for AP® CS Principles. They offer a free online curriculum guide and a CS Principles Professional Learning Program for in-person and online PD. There are also state and university programs available depending on your region. More information about the student resources from Code.org are covered in the next section.

Professional Development Focused on Tech Career Literacy

These evolving opportunities are key to increasing the number of CS teachers and the quality of CS instruction. CS career literacy woven into K-12 CS education enables educators to bridge the needs between industry and education – and in due course be better mentors to students. To that end, Couragion has developed teacher workshops designed to boost CS career literacy and develop micro credentials around tech career occupational and essential skills – all with the intent to help educators improve teaching and learning.
Of the CS teachers Couragion surveyed, there were two resources that rose to the top of list of the most commonly used for K-12 CS education – and those were Code.org (83%) and Hour of Code™ (88%). These same two resources were also at the top of the pile in being most highly recommended by teachers with Code.org having a 98% recommendation rate and Hour of Code having a 96% recommendation rate. These recommendation rates are consistent with those published by Code.org in that 99% of surveyed teachers recommend the Code.org intro CS curriculum. While these two integrally bound programs are widely known and understood amongst educators, we will take a minute to cover some highlights.

**Code.org** is a non-profit organization dedicated to expanding access to CS and increasing underrepresented participation. Code.org organizes the annual **Hour of Code** campaign and provides the leading K-12 CS curriculum in the U.S. Code.org is also known for its bipartisan coalition of corporations and nonprofits who work together to establish federal and state policies to expand and sustain access to K-12 CS. Hour of Code is a grassroots global movement that has served nearly 450 million people. It began as a way to prove that anybody can learn the basics of CS and to broaden participation in the field. It is an integral part of CS Week which takes place each December. The 2017 CS Education Week takes place December 4-10.
Top Resources Focus on Coding
Of the top ten most used resources, all of them were focused on learning to code as a central thread. As coding becomes increasingly more critical as a foundational skill, the next section focuses specifically on which programming languages will provide the most employment opportunities for students and how that aligns to what is being taught by schools.

Couragion Tech Career Literacy Resources
As previously noted, Couragion strongly believes that career literacy should be integrally woven into K-12 CS education to improve relevance, better inform student choice, and increase retention in real-world career paths. Couragion helps students understand that technical jobs require skills and professional certifications to prepare them for the future. Many of the fastest growing and exciting tech careers in data science, cyber security, and user experience (UX) offer alternative pathways that might not require a traditional degree path. Couragion helps students build skills that make them more employable and create an online portfolio to track and communicate those strides.
Those responsible for setting or influencing the strategy for STEM, CS, or Career and Technical Education (CTE) curriculum might struggle to understand what industry needs and exactly how to prepare students for the workforce. As coding becomes increasingly more foundational, educators must decide which programming languages will provide the most employment opportunities for students, especially when there are so many opinions out there about the most popular technologies. To that end, Couragion has conducted research, spoken to our partners, and found additional studies to help answer this question.

**Programming Language Skills Required by Industry**

While there are several studies regarding which programming language skills hiring entities want, Couragion looked to the 2016 study conducted by New Relic and Indeed, due to its huge sample size. In this study, Indeed reviewed 16 million job openings to determine which programming languages were mentioned most frequently as job requirements. Java was the clear winner - with 2,992 mentions per million listings - and this is more than the next 9 mentioned programming languages combined. According to Terence Chiu, vice president at Indeed, “It is not surprising that Java is such a popular programming language. It’s been around for a long time, runs in many computing environments and has advantages of readability, scalability and robustness”.

![Java Clear Winner Across 16M Job Openings](chart.png)
Key Technologies Used by Developers on the Job

Job demand is one way to understand key technologies, but another important view is what developers are using on the job. Stack Overflow conducted a Developer Survey in 2016 that included responses from over 50K developers across the globe. The survey asks developers about what they build, which technologies they use, which jobs they hold and the education they have received. Interestingly 69% of developers today are self-taught! As Stack Overflow puts it “JavaScript is the most commonly used programming language on earth”. JavaScript emerged as one of the three core technologies of the World Wide Web for content production. Initially only utilized by Front-End developers, even Full Stack and Back-End developers are more likely to use it than any other language today.

Access to These Top Programming Languages

Couragion wanted to understand what secondary schools are teaching today, and we were encouraged to find that Java and JavaScript were the two most popular programming languages being taught by our CS educator respondents. Unfortunately, Couragion’s research shows disadvantages in access among regions with higher proportions of students of color or poverty levels. Here is what we learned in numbers:

- 53% of schools offer Java, while 42% of schools offer JavaScript
- 57% of private schools and 52% of public schools offer Java
- 45% of public schools and 32% of private schools offer JavaScript
- Regions with higher populations of students of color offered Java 6% less
- Regions with higher populations of students in poverty offered Java 17% less
Java In K-12 Schools

- 53% Teaching Java
- 52% Public Schools Teaching Java
- 57% Private Schools Teaching Java

JavaScript In K-12 Schools

- 42% All Schools Teaching JavaScript
- 45% Public Schools Teaching JavaScript
- 32% Private Schools Teaching JavaScript

Poverty & Access

- 60% 55% Low Poverty Regions Teaching Java
- 50% Higher Diversity Regions Teaching Java
- 38% High Poverty Regions Less Likely To Offer Java
- 40% 30% Delta Low Poverty
- 44% 48% Delta High Poverty

Diversity & Access

- Regions With Higher Diversity Less Likely To Offer Java
- 54% Higher Diversity Regions Teaching Java
- 50% Lower Diversity Regions Teaching Java
Java & JavaScript Resources for Students & Educators

Based on this research, Couragion recommends teaching your students Java and JavaScript. To learn more about teaching these programming languages, here are some curriculum resources and considerations:

1. **Oracle** has a great website with several resources and recommendations for younger learners.
2. **Greenfoot** offers free software, a book and an instructor community, focused on teaching and learning Java.
3. **BlueJ** is a free Java Development Environment designed for beginners.
4. If you are looking for JavaScript resources, check out Khan Academy’s offerings.
5. Keep abreast of reports that give insight into what hiring entities are looking for and what developers are using in their day-to-day jobs. Look not only for the most frequently mentioned languages, but also consider the year-over-year growth rates. A programming language with a large growth rate may indicate an up and coming language that will be very important in the future. In recent reports, PHP appears to be falling out of favor (especially in the enterprise) as programming languages like Node and Angular emerge.
Increasing CS Interest Among Girls

According to the National Center For Women In Technology (NCWIT), while women make up 56% of the overall workforce, they make up just 26% of the computing workforce. And in 2015, although 57% of bachelor’s degrees were awarded to women, only 18% of the bachelor’s degrees in Computer and Information Sciences were earned by women. There is much work to do to increase interest in CS among girls. Couragion’s co-founders have dedicated our careers to building software apps – and we have seen firsthand the lack of diversity in tech. As such, we have personal missions to help boost that diversity. We would like to offer insights and advice to others like us who want to help girls see the opportunities that CS provides. Here are ideas based on Couragion’s CS-related career data and our key partnerships:

1. **Help Girls See the Applicability of CS in other Fields – Especially Science-Related Fields.** When asked to select the STEM category of greatest interest, Science is first with 43% of girls choosing it. That compares to 22% of girls choosing Technology, 19% selecting Math and 16% opting for Engineering. With Science being such a strong choice among girls, it may be helpful to share examples of how Science relies upon CS. For example, our Climate Researcher role model shared that she needs to use the programming language Python to better study the effects of global warming on coral reefs. She expressed regret that she did not take CS courses in college and instead had the tough path of teaching herself programming while also juggling the responsibilities of a full-time research job.
2. **Integrate other Technology-Oriented Programs.** While school districts have rushed to add coding to their curriculum to embrace computational thinking, very few schools have incorporated other technology-oriented programs. The only exception would be robotics. Recent Google-Gallup studies have shown that robotics offerings in schools grew 12% year-over-year. We get it, robots are cool and they demonstrate how written code translates to action and movement in the robots. In Couragion’s research, we asked educators which CS concepts were offered at their schools. Of the schools surveyed who offered CS, 55% offered robotics in the classroom, whereby less than 15% of schools taught UX or product management concepts. Couragion data also shows that middle and high school girls have limited interest in robotics, so these subjects might not be the best route to spark CS interest in girls. For example, one of Couragion’s featured role models is a Robotics and Computer Vision engineer. This is a popular career among boys with it being on the ‘top 5 list’ of most selected careers. Clearly robotics is a compelling and worthwhile approach to introduce computing as a high percent of high school boys (56.4%) also find that career is a best fit for their interests, values and desired work characteristics. But among girls, only 7% are interested enough to select the robotics career and of those experiencing the career, less than a third find it to be a best fit.

For boys, the Robotics Engineer is among the top 5 most selected careers. 55% of boys find that the career is a best fit for their interests, values & work preferences.

Among girls, only 7% select the Robotics Engineer career. Less than a third of girls find the career to be a best fit for their interests, values & work preferences.
3. **Select CS Projects that Focus on Helping People, Animals, or the Environment.** Couragion data shows that 96% of all students want a job with greater purpose - compare that with the 28% of today’s workforce who state they have a greater purpose in their job (Hurst 2015). In studying girls versus boys on this topic, girls rate work purpose as ‘extremely important’ while boys rate it as just ‘important’. This trend remains true at the individual job level. In looking at Couragion’s tech-related career preferences among females, the data shows the Chief Technical Officer (CTO) with the highest percent of best fits - 67% of girls found the CTO career a fit for their interests, values and desired work characteristics. Notably, this CTO works at a startup that mobilizes resources to help find lost children. To spark CS interest in girls, focus on projects that incorporate a greater purpose.

4. **Equip Change Leaders with Resources for Recruiting, Retaining and Advancing Girls’ and Women’s Meaningful Participation in Computing!** NCWIT is the only national non-profit community of nearly 900 universities, companies, non-profits and government organizations working to increase girls’ and women’s meaningful participation in computing. NCWIT equips change leaders with resources for recruiting, retaining and advancing women from K–12 and higher education through industry and entrepreneurial careers. There are more than 160 NCWIT research-based resources to raise awareness, increase knowledge and build capacity for individuals and organizations to reach out to critical populations and implement systemic change. These resources are easy-to-use, free and available in both electronic and print. Couragion worked with NCWIT to create a curated collection of the top K-12 resources just for you!
About the Research

This research was conducted by Couragion with generous support from the National Science Foundation. Couragion has been working with students since 2015 to measure the awareness and perception of STEM careers. Couragion’s technology has been tested in authentic K-12 learning settings to drive student achievement. Student indicators prove that increased exposure to Couragion boosts the intention to pursue STEM careers. Of the population served, 50% of students are female and 75% are from communities of color. Couragion encourages every student to succeed in STEM by helping them to uncover career opportunities that fit their unique STEM identity – work preferences, interests, and values.

In Q1 2017, Couragion conducted primary research about K-12 CS education. The survey has a margin of error of +/- 7% at a 95% level of confidence. Reach out to Couragion at info@couragion.com with any inquiries.