

Cybersecurity Workforce Generation:

Too Little, Too Late and the Logic Behind Starting in Early Education

Caroline Elyse Burks¹

¹ Caroline Elyse Burks earned her J.D. at The University of Texas School of Law, where she served as a Brumley Next Generation Fellow and a Cybersecurity Fellow. She now works as an associate in commercial litigation at McKool Smith in Austin, Texas. Caroline would like to thank the Strauss Center for International Security and Law Brumley Next Generation Fellowship Program for financial and intellectual support.

Public Education & American Poverty: The Next Great Cybersecurity Threat

As cyberattacks become more prominent in both the public and private sectors, the need for competent and qualified cybersecurity professionals has also increased. With a noted critical shortage in people, cybersecurity jobs and training programs are still attracting primarily white, cisgender males through collegiate education programs. As many individuals choose their career in middle or high school and early skill cultivation is deeply related to future career interests, starting to educate students in cybersecurity skills at the secondary school level would allow new opportunities for workforce development. Such programs could help to cull the labor deficit while providing opportunities for more diversity within the career field.

State of the Profession

There is an overall deficit in the cybersecurity workforce, which is a critical vulnerability. As of February 2021, there were approximately 715,000 cybersecurity professionals and an additional 314,000 unfilled positions in the United States.² The global shortage is an estimated 3.5 million.³ For reference, that is roughly 50 NFL stadiums.⁴ In a survey of eight countries, eighty-two percent of respondents stated they had a shortage of cybersecurity skills, with seventy-one percent of respondents stating that the labor shortage creates direct and measurable damage.⁵ While the eight surveyed countries state the shortage is critical, over half state they

² Matt Donato, *The Talent Shortage Crisis in Cyber Security and How to Overcome It*, CYBER PROTECTION MAGAZINE (Feb. 26, 2021), <https://cyberprotection-magazine.com/the-talent-shortage-crisis-in-cyber-security-and-how-to-overcome-it-2/>.

³ *Id.*

⁴ Steve Morgan, *Cybersecurity Talent Crunch yTo Create 3.5 Million Unfilled Jobs Globally By 2021*, CYBER SECURITY VENTURES (Oct. 24, 2019), <https://cybersecurityventures.com/jobs/>.

⁵ Center for Strategic and International Studies, *Hacking the Skills Shortage*, MCAFEE 1, 5 (Jul. 2016), <https://www.mcafee.com/enterprise/en-us/assets/reports/rp-hacking-skills-shortage.pdf>; Information Systems Security Association, *Cyber Security Skills Crisis Causing Rapidly Widening*

still would require a bachelor's degree despite ranking hands on experience as the best way to acquire skills. Many companies plan to outsource their cybersecurity.⁶ The shortage is created by a multitude of problems. Many of the challenges can be reduced to a lack of investment in early education.⁷

Seventy-seven percent of cybersecurity professionals believe that education fails to prepare students for a career in cybersecurity.⁸ Less than half of the top computer science programs in the United States offer more than three cybersecurity courses.⁹ Only one of the top thirty-six required a course in cybersecurity.¹⁰ Statistics show that “[w]e graduate as many park rangers as . . . computer scientists.”¹¹ Still, companies are hesitant to hire outside of the traditional college graduates pool and then train internally.¹² Yet, much attention is paid to college programs despite their known failures.

Business Problem, CISION PRWEB (Nov. 8, 2017),
<http://www.prweb.com/releases/2017/11/prweb14899778.htm>.

⁶ *Hacking the Skills Shortage*, *supra* note 5, at 12.

⁷ *Id.* at 9.

⁸ *How to Shore Up America's Cybersecurity Deficit*, NATIONAL CYBERSECURITY CENTER (2021),
<https://cyber-center.org/how-to-shore-up-americas-cybersecurity-deficit/>.

⁹ Marten Mickos, *The Cybersecurity Skills Gap Won't Be Solved in a Classroom*, FORBES (Jun. 19, 2019),
<https://www.forbes.com/sites/martenmickos/2019/06/19/the-cybersecurity-skills-gap-wont-be-solved-in-a-classroom/?sh=7ad4a6c01c30>.

¹⁰ Thomas Holt Russell, *Education's Vital Role in Cybersecurity Literacy*, THOMAS HOLT RUSSELL (Aug. 31, 2019),
<https://thrus09.medium.com/educations-vital-role-in-cybersecurity-literacy-e9cc152ea60>.

¹¹ Paulette Perhach, *The Mad Dash to Find a Cybersecurity Force*, NY TIMES (Nov. 7, 2018),
<https://www.nytimes.com/2018/11/07/business/the-mad-dash-to-find-a-cybersecurity-force.html>.

¹² Emil Sayegh, *As The End of 2020 Approaches, The Cybersecurity Talent Drought Gets Worse*, FORBES (Sept. 22, 2020),
<https://www.forbes.com/sites/emilsayegh/2020/09/22/as-the-end-of-2020-approaches-the-cybersecurity-talent-drought-gets-worse/?sh=3902d3f95f86>.

Greater concern should be placed on the dearth of teachers at the secondary and post-secondary level.¹³ Many schools are barely getting by when it comes to cybersecurity offerings, with teachers carrying larger course loads, and with schools becoming creative in who they consider a teacher.¹⁴ Where educators are knowledgeable about the topic, their students are knowledgeable, a vicious cycle leaving remote communities without basic cyber awareness training.¹⁵ Less than half of K-12 students are learning about the subject in school.¹⁶ Even where students can learn about cybersecurity in school, the topics are specific and generally not career oriented.¹⁷ Seventy percent of students learn about cyberbullying and cyberterrorism, but less than ten percent learned about cryptography, systems engineering, AI, or cyber law.¹⁸ If teachers manage to prepare students with skills, career understanding is still low:

[M]ore than 2 out of 3 educators say their students have a low level of awareness of steps they need to take to obtain a cybersecurity job. Rates of awareness are even lower in cybersecurity deserts. Seventy-three percent of educators in these communities say their students' awareness of cybersecurity career paths is low, as compared to 58 percent in areas that do have cybersecurity resources. This finding

¹³ *Teacher Shortage Heightens Need for Industry Experts in the Classroom*, FORT MEADE ALLIANCE (Jul. 2021), <https://www.ftmeadealliance.org/2021/07/teacher-shortage-heightens-need-for-industry-experts-in-the-classroom/>.

¹⁴ *Id.*

¹⁵ EdWeek Research Center, *The State of Cybersecurity Education in K-12 Schools*, CYBER.ORG 1, 3 (Jun. 2020), <https://cyber.org/sites/default/files/2020-06/The%20State%20of%20Cybersecurity%20Education%20in%20K-12%20Schools.pdf>.

¹⁶ *Id.* at 4.

¹⁷ *Id.* at 11.

¹⁸ *Id.* at 7.

suggests that where cybersecurity ecosystems are not yet established, K-12 education is even more critical.¹⁹

The problem is more pronounced in minority schools. In districts where over seventy-five percent of students are low-income, twenty-one percent of students will know nothing about cybersecurity, compared to eight percent in higher-income districts.²⁰ Generally, low-income neighborhoods are cybersecurity deserts and/or rural.²¹ In these neighborhoods, eighty percent of K-12 educators report that there are no cybersecurity resources, such as cybersecurity employers or universities offering cybersecurity programs.²² Exposure at the K-12 level often leads to interest in cybersecurity careers,²³ so the lack of exposure in small, high-poverty districts acts as a wealth hurdle in entering the cybersecurity profession.

In underserved communities of San Francisco (notably not a cybersecurity desert), where forty-five percent of households make less than \$25,000 per year and thirty-eight percent do not speak English, many individuals do not even know of basic cybersecurity concepts, such as phishing prevention techniques like checking the email address or hovering over links in emails (Sultan, 2019).²⁴ In these underserved communities, individuals experience frequent

¹⁹ *Id.* at 10.

²⁰ Joseph Marks, *The Cybersecurity 202: Few students are getting serious cybersecurity training. That's bad news for the U.S. workforce.*, WASH. POST (Jun. 25, 2020), <https://www.washingtonpost.com/news/powerpost/paloma/the-cybersecurity-202/2020/06/25/the-cybersecurity-202-few-students-are-getting-serious-cybersecurity-training-that-s-bad-news-for-the-u-s-workforce/5ef3ec5f88e0fa7b44f67191/>.

²¹ EdWeek Research Center, *supra* note 16.

²² *Id.*

²³ *Id.* at 10–11.

²⁴ Ahmad Sultan, *Improving Cybersecurity Awareness in Underserved Populations*, CENTER FOR LONG-TERM CYBERSECURITY 1, 6 (2019), https://cltc.berkeley.edu/wp-content/uploads/2019/04/CLTC_Underserved_Populations.pdf.

victimization by cyber-scams, creating economic hardship and a distrust in their abilities to self-manage cybersecurity.²⁵

The solution to the lack of cybersecurity professionals could be very well linked to a disconnect between identifying interests and cultivating those interests. Career interests are defined as “patterns of likes and dislikes, and indifference regarding career relevant activities and occupations.”²⁶ Many schools provide career aptitude tests, with some states requiring these tests for middle and high schoolers.²⁷ One of the most popular tests – YouScience – helps students determine which of 17 career pathways is most aligned with their interests. Cybersecurity could fall under a STEM interest or under Information Technology.²⁸ With computer science being a newer program, these tests may be faulty, though, and shouldn’t be extensively relied on or used to sort students into buckets without their input.²⁹ In computer science especially, there is a noted mismatch between innate aptitudes and career interests.³⁰ At the end of the day, hands-on, work-based learning is the best way to help students find a fulfilling career path.³¹

²⁵ *Id.* at 6–7.

²⁶ Sangmi Chai, Sharmistha Bagchi-Sen, Rajni Goel, H. Raghav Rao & Shambhu Upadhyaya, *A Framework for Understanding Minority Students’ Cyber Security Career Interests*, Proceedings of the Twelfth Americas Conference on Information Systems, 2, Acapulco, Mexico (Aug. 4–6, 2006), <https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.557.2812&rep=rep1&type=pdf>.

²⁷ Alyson Klein, *Aptitude Tests Steer Students to Careers. Does That Narrow Their Options?*, EDUCATIONWEEK (Feb. 4, 2020), <https://www.edweek.org/teaching-learning/aptitude-tests-steer-students-to-careers-does-that-narrow-their-options/2020/02>.

²⁸ *Career Clusters*, YOU SCIENCE, <https://www.youscience.com/certifications/career-clusters/> (last visited Oct. 12, 2021).

²⁹ Klein, *supra* note 28.

³⁰ Bridget Fowers, *New data about student “aptitudes” could help fill worker skills gap*, YOU SCIENCE (Mar. 15, 2019), <https://www.youscience.com/new-data-about-student-aptitudes-could-help-fill-worker-skills-gap/>.

³¹ Klein, *supra* note 28.

Career interest and relevant experiences can help to predict career selection, but perceived barriers can dissuade students from choosing a career.³² Barriers can be defined as family, study skills, ethnic identity, or financially related.³³ There are also barriers which fall between these topics, like excessive educational requirements, and perceptions about their preferred work conditions.³⁴ Cultivating interests and skills in a low-pressure environment allows students to believe they can do well in cybersecurity leading to a higher interest in a career in cybersecurity.³⁵ In minority populations, this is more critical. Socio-economic status and ethnic identity can have a negative impact on students' beliefs in their ability to succeed.³⁶ At the end of the day, improvements to secondary offerings could greatly increase students' self-efficacy and outcome expectations, leading to growth of the skilled-labor market in cybersecurity.

Solutions

To cultivate student interest in secondary school, educational agencies should aim to (1) provide programs that both promote learning and offer an opportunity for immediate entry into the workforce and (2) offer and promote extracurricular activities that allow students the ability to apply their knowledge and develop soft-skills.

Provide Secondary Programs That Allow Students to Enter the Workforce.

While determining interests is relatively easy using standardized aptitude tests, eliminating barriers and cultivating interest are more complex and require a variety of programming and structured learning opportunities.

³² Chai et al., *supra* note 27, at 3.

³³ *Id.*

³⁴ *Id.*

³⁵ *Id.* at 2, 4.

³⁶ *Id.* at 5.

Early Entry High School Program.

The University of Hawaii Maui College created the Developing Career and Technical Education cybersecurity career pathway for high school students due to a lack of teachers in public schools who could teach rigorous cybersecurity courses.³⁷ The program offered a two-year program where students took a fully subsidized sequence of four cybersecurity courses (one per semester) covering basics of information security, networking, and computer security.³⁸ The students received a Cybersecurity Certificate of Competence at the end.³⁹ In the first year, eighty-four students participated, with the majority being female.⁴⁰ Twenty-four students had dropped out by the end of the first year, but eighty-eight percent stated they planned to take future classes in cybersecurity.⁴¹ The program study concluded that a more reliable and widespread early college pathway was needed, especially in an online format for rural students.⁴²

In communities where graduation rates and college rates are low, career technical education (CTE) programs are especially useful as a tool to divert students into cybersecurity career fields. Students who participate in CTE programs enjoy higher wages than peers, increased standardized test scores, and higher graduation rates.⁴³ This effect is even greater for low-income students, who are overrepresented in CTE programs and are more likely to not

³⁷ Debra Nakama & Karen Pullet, *The Urgency for Cybersecurity Education: The Impact of Early College Innovation in Hawaii Rural Communities*, 16 INFO. SYS. EDUC. J. 41, 42 (2018), <https://files.eric.ed.gov/fulltext/EJ1188021.pdf>.

³⁸ *Id.*

³⁹ *Id.*

⁴⁰ *Id.* at 44.

⁴¹ *Id.* at 45–46.

⁴² *Id.* at 49.

⁴³ Shaun M. Dougherty, *The Effect of Career and Technical Education on Human Capital Accumulation: Causal Evidence from Massachusetts*, 13 EDUC. FIN. & POL'Y 119, 120–22 (2018).

complete high school.⁴⁴ Where hands-on training is valued by hiring managers and seventy-seven percent of CTE programs offer hands-on experience, offering cybersecurity training in a CTE environment makes sense.⁴⁵

Federal Programs.

The U.S. Department of Education created the CTE CyberNet program in 2020 to increase the number of CTE teachers in cybersecurity.⁴⁶ The program kicked off in the summer of 2020, with teachers attending over eighty hours of professional development and also attending ‘accelerator academies’ through the 2020-2021 school year.⁴⁷ The accelerator focused on bringing resources to teachers, as opposed to requiring teachers to travel, which made the program more accessible and allows the program to address local needs of teachers.⁴⁸ The CyberNet program also engaged private partners such as Amazon and Northrop Grumman to teach the academies.⁴⁹ Currently, the program offers elementary, middle, and high school classes along with dual credit high school/college opportunities in ten states: California, North Dakota, South Dakota, Florida, Indiana, Illinois, Michigan, New York, Ohio and Wisconsin.⁵⁰

⁴⁴ *Id.* at 129.

⁴⁵ *Bridging the Skills Gap: Career and Technical Education in High School*, U.S. DEPT. OF EDUC. (Sept. 2019), <https://www2.ed.gov/datastory/cte/index.html>.

⁴⁶ *CTE CyberNet*, PERKINS COLLABORATIVE RESOURCE NETWORK, <https://cte.ed.gov/initiatives/cte-cybernet> (last visited Oct. 12, 2021).

⁴⁷ *Id.*

⁴⁸ *To build a strong cybersecurity workforce, start with educators*, LUMINARY LABS, <https://www.luminary-labs.com/to-build-a-strong-cybersecurity-workforce-start-with-educators/> (last visited Oct. 12, 2021).

⁴⁹ *Id.*

⁵⁰ John Sands, *CTE K12 Career Pathways for Cybersecurity Study*, CSSIA 1, 8 (2019), https://www.cssia.org/wp-content/uploads/2019/10/CTE_K-12_Career_Pathways_for_Cybersecurity_Study_UPDATED_10-22.pdf.

CyberNet is the latest iteration in the federal initiative to push cybersecurity education in public schools. The Department of Homeland Security offers a multitude of cybersecurity teaching resources – more than any school program could reasonably cover.⁵¹ In Palm Beach, Florida, a school launched a four-year Cybersecurity Academy that allows students to gain certification and enter directly into the workforce.⁵² These programs provide a unique and adaptable solution for public schools but are heavily reliant on outside funding.⁵³ Palm Beach recently accepted a \$750,000 grant to expand the program into another district high school and offer six professional certifications within the program.⁵⁴ The federal government also has plans to provide over \$4B in funding to state computer science programs.⁵⁵ This has increased the number of schools offering AP Computer Science courses to over 114,000 students in 2020.⁵⁶ Students who take AP Computer Science are three times as likely to major in Computer Science and black students who take AP Computer Science are 20% more likely to major in Computer Science.⁵⁷

Cisco Networking Academy.

⁵¹ Melissa Delaney, *High Schools Prep Students to Fill Cybersecurity Skills Shortage*, EDTECH MAGAZINE (Jul. 2, 2018), <https://edtechmagazine.com/k12/article/2018/07/high-schools-prep-students-fill-cybersecurity-skills-shortage>.

⁵² *Id.*

⁵³ *Id.*

⁵⁴ Stephanie Susskind, *Santaluces Community High School prepares students for careers in cybersecurity*, WPTV (Nov. 24, 2020), <https://www.wptv.com/news/education/santaluces-community-high-school-prepares-students-for-careers-in-cybersecurity>.

⁵⁵ *Computer Science for All Fact Sheet*, OFFICE OF ELEMENTARY & SECONDARY EDUCATION (Jan. 19, 2017), <https://oese.ed.gov/stem/computer-science/computer-science-for-all-fact-sheet/>.

⁵⁶ *AP Program Results—A Decade of Expanded Access, Student Success*, COLLEGEBOARD, <https://reports.collegeboard.org/ap-program-results> (last visited Oct. 12, 2021).

⁵⁷ *Id.*; see also *AP Computer Science Principles: Research Findings*, AP CENTRAL (2020), <https://apcentral.collegeboard.org/courses/ap-computer-science-principles/ap-csp-research-findings>.

Another route for schools desiring to offer technical education, without an emphasis on getting a degree, is to become a Cisco Networking Academy.⁵⁸ The benefit of the Cisco Networking Academy is that it comes with funding from Cisco, which has invested \$13M in 28,000 students in Missouri alone.⁵⁹ Students in the academies receive a Cisco CompTIA A+, Security+ or Network+ certification upon successful completion.⁶⁰ The program has been adopted by 10,000 schools and about 50% of graduating students state a desire to work in cybersecurity or information technology.⁶¹ About one million students per year graduate from Cisco's Networking Academy.⁶²

Diversify Program Offerings to Include Extracurriculars

Classroom-based learning is not the best for all students and schools should attempt to provide a variety of non-classroom, extracurricular activities to engage students with Information Technology, Computer Science and Cybersecurity. Participation in leisure and extracurricular activities is shown to be a good indicator for career interests and allows students to develop soft skills related with career readiness, such as teamwork and ethics.⁶³

⁵⁸ *Learning Never Stops*, CISCO NETWORKING ACADEMY, <https://www.netacad.com/learning-never-stops> (last visited Oct. 12, 2021).

⁵⁹ Roger Riddell, *After 2 decades, Cisco Networking Academy's success highlights role of partnerships in CTE*, K-12DIVE (Apr. 30, 2018), <https://www.k12dive.com/news/after-2-decades-cisco-networking-academy-success-highlights-role-of-partnerships-in-cte/>art/522393/.

⁶⁰ Delaney, *supra* note 52.

⁶¹ Alan R. Dennis, Thomas M. Duffy & Hasan Cakir, *IT Programs in High Schools: Lessons from the Cisco Networking Academy Program*, 53 COMM'NS OF THE ACM 138, 139–40 (2010).

⁶² Patrick Moorhead, *Cisco's Networking Academy Trains 1M Students Per Year to Fill 8M Networking Jobs*, FORBES (Jun. 28, 2016), <https://www.forbes.com/sites/patrickmoorhead/2016/06/28/ciscos-networking-academy-trains-1m-student-s-per-year-to-fill-8m-networking-jobs/?sh=59a0f3e5288b>.

⁶³ J. Oliver & C. Elwell, *Effective Competitions for Broadening Participation in Cybersecurity*, 2018 ASEE Zone IV Conference: Boulder, Colorado Mar 25 (2018).

Competitions.

Cybersecurity competitions allow students who lack technical skills to engage in critical thinking in technology policy.⁶⁴ This means that competitions can cast a wider net in recruiting a more diverse set of students.⁶⁵ Competitions can test competitors in a spectrum of skills, such as the more static “perform the exploit” competitions, to the dynamic red team competitions. CyberPatriot, one such competition, attracted over 14,000 students in 2016-2017 alone.⁶⁶ Competition learning can also be implemented inside of a traditional course, such as a competition-based capstone project.⁶⁷

Although designing such competitions may seem easy, proper design to attract long term interest and novices is quite complex. One of the keys to successfully introducing students to cybersecurity through competitions is to ensure the proper ratio of novice competitors to advanced competitors and ensuring the competition is not lopsided and inaccessible to students with budding interests.⁶⁸ For instance, the National Cyber League, hosted by CompTIA, organizes students into brackets based on skill level.⁶⁹ Bracketing by skill level inspires novices “to apply their learning and improve their projects, while advanced students [are] incentivized

⁶⁴ *Id.*

⁶⁵ *Id.*

⁶⁶ Dunn, M., & Merkle, L. D. (2018). Assessing the Impact of a National Cybersecurity Competition on Students’ Career Interests. Association for Computing Machinery’s Special Interest Group on Computer Science Education, 62–67. Baltimore, Maryland.

⁶⁷ Pusey, P., Gondree, M., & Peterson, Z. (2016). The Outcome of Cybersecurity Competitions and Implications for Underrepresented Populations. *IEEE Security & Privacy*, 90–95.

⁶⁸ Oliver & Elwell, *supra* note 64

⁶⁹ Veronica Combs, *Cybersecurity competition: CompTIA seeking high school and college students for hacker and security games*, TECHREPUBLIC (Jul. 7, 2020), <https://www.techrepublic.com/article/comptia-joins-the-battle-to-recruit-high-school-and-college-students-into-cybersecurity/>.

with projects that challenge their abilities.”⁷⁰ This also reduces competition dropout.⁷¹ It’s also recommended that competition hosts and creators think less about attracting skilled students, who will participate without encouragement, and focus more on students who have simply an interest in the subject matter.⁷² This would foster a more welcoming and holistic learning environment.⁷³ Additionally, students without technical skills should be given a place within the competition sphere, even if only to provide comments on the ethical, legal, or policy concerns.⁷⁴

Competitions also offer another perk for students: the opportunity for employment and scholarships. “Hackathons, capture the flag contests, and cyber competitions are increasingly seen as a viable recruiting tool” as this allows companies to tap into new labor pools, such as the self-taught ethical hackers.⁷⁵ Especially in a field that values hands-on experience, competitions morph into a multi-hour or multi-day interview session.⁷⁶ Students can also receive certification course scholarships or compete for millions of dollars in college scholarships.⁷⁷

The problem with relying on competition-based learning is that it generally does not foster diversity.⁷⁸ For instance, the Science Olympiad competitors tend to be male, white, and from a high-income, non-immigrant family.⁷⁹ Minority students can be excluded early on by a

⁷⁰ Pusey et al., *supra* note 68.

⁷¹ *Id.*

⁷² Oliver & Elwell, *supra* note 64.

⁷³ *Id.*

⁷⁴ *Id.*

⁷⁵ Dan Swinhoe, *How cyber competitions can help fill the cybersecurity talent shortage*, CSO ONLINE (Jan. 15, 2019), <https://www.csoonline.com/article/3332685/how-cyber-competitions-can-help-fill-the-cybersecurity-talent-shortage.html>.

⁷⁶ *Id.*

⁷⁷ *Competition*, CYBERSTART AMERICA, <https://www.cyberstartamerica.org/#competition> (last visited Oct. 12, 2021).

⁷⁸ Pusey et al., *supra* note 68.

⁷⁹ *Id.*

lack of resources.⁸⁰ Despite this, competitions have shown some success in increasing diversity. In the CyberPatriot competition, rates of female competitors are twice that of females in the cybersecurity field.⁸¹

Summer Programs.

For students who don't want a competitive learning experience, there are also hands-on summer camps available to explore interests and learn foundational skills.⁸² Many of these are offered on university campuses, which have the added benefit of exposing students to a college atmosphere.⁸³ A non-collegiate summer camp study showed that all participants in the camp, even those previously not interested in cybersecurity, became more interested in cybersecurity at the end of a one-week program focused on teaching the Confidentiality-Integrity-Accountability triad.⁸⁴ These camps can also level the playing field for minority students.⁸⁵ The Citadel, a military university, offers a summer camp that prioritizes students who do not have resources in their community.⁸⁶ Camps can also provide 'field trips' allowing students to visit companies and see the working environment of computer scientists.⁸⁷

⁸⁰ *Id.*

⁸¹ Dunn & Merkle, *supra* note 67.

⁸² Cyndi Reitmeyer, *Learning Cybersecurity: Competitions and Workshops for Teens*, BOSTONTECHMOM (Oct. 14, 2020), <https://www.bostontechmom.com/learning-cybersecurity-competitions-and-workshops-for-teens/>.

⁸³ *Id.*

⁸⁴ Wolf, S., Burrows, A. C., Borowczak, M., Johnson, M., Cooley, R. & Mogenson, K. (2020). Integrated Outreach: Increasing Engagement in Computer Science and Cybersecurity. *Education Sciences*, 10(12), 353–76.

⁸⁵ *Id.*

⁸⁶ *Cybersecurity Inter-disciplinary Training Camp for Middle and High School Students*, CITADEL, <https://www.citadel.edu/root/ceitl-resources/41-academics/stem/25010-cybersecurity-inter-disciplinary-training-camp-for-middle-and-high-school-students> (last visited Oct. 12, 2021).

⁸⁷ Douglas Jacobson, *Computer Security Summer Camp for High School Students*, AMERICAN SOCIETY FOR ENGINEERING EDUCATION 1, 3 (2006), <https://peer.asee.org/computer-security-summer-camp-for-high-school-studentshttps://peer.asee.org/computer-security-summer-camp-for-high-school-students>.

Conclusion

With a significant labor force shortage in cybersecurity and a noted failure of college-based programs in producing enough students with the necessary skills, focus should be turned to providing entry-level educational qualifications and interest building activities to secondary school students. Educational opportunities can be provided through a variety of private, state and federal programs. Extracurricular offerings are even more adept in building skills, both technical and soft, and cultivating student interest. Competitions, when properly developed, are an especially useful skill. Ultimately, the workforce shortage requires educational institutions to get creative to meet needs and private companies have an incentive to assist in this development. Public-private partnership could foster significant entry-level workforce development through the aforementioned educational development methods.