

Governor's Workforce Development Board  
Task Force on Cybersecurity and Information Technology

A photograph of students in a computer lab, overlaid with a dark blue semi-transparent filter. In the foreground, a young woman with glasses and a grey hoodie is smiling at the camera. Behind her, another student is working on a laptop. Several laptops are open on wooden desks.

# Computer Science Education and Professional Development Findings Report

LEAD AUTHOR: ANDREW COY

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# Computer Science Education and Professional Development Findings Report

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June 2018

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## Executive Summary

Technology is, and will continue to be, the driving force behind every industry. There is a critical need for Maryland's future students to understand computer science, computer engineering, and the process by which computer applications are created. Along with reading, writing, and arithmetic, computer science education should be considered a foundational skill.

Maryland benefits from a diverse, robust workforce trained in computer science, cybersecurity, and information technology (IT). To remain economically competitive, Maryland must bolster current efforts and implement new initiatives to advance computer science (CS) education.

In accordance with Executive Order 01.01.2017.27, Computer Science Education and Professional Development, the report provides recommendations on how Maryland can more fully develop a workforce that meets the current and future demands of Maryland employers, and provide opportunities for all Marylanders to succeed.

During the community-driven process to create the report, the Governor's Workforce Development Board (GWDB) engaged nearly 200 professionals from industry, education, government, and nonprofit sectors. The report contains high-level findings, characterizations, recommended frameworks, and key action areas for understanding the current status and future direction of computer science education and related employment in Maryland.

Recommendations from the report are top-level and in sequential order based on short-term and long-term goals. These recommendations include:

- » Host and promote computer science public events;
- » Recognize formal and informal pathways to computer science careers;
- » Increase mentorship and coaching opportunities for youth;
- » Increase access to computer science courses;
- » Grow computer science participation and interest among women and minorities;
- » Develop a tech extension partnership program;
- » Create a Maryland computer science fellowship program; and
- » Increase awareness among parents and students of the United States Government security clearance process.

Through the implementation of the recommendations contained within the report, Maryland will continue to be a national leader in CS-related fields by providing a strong vision and distinct guidance for CS, thereby increasing workforce capacity and engagement, and enhancing Maryland's economic competitiveness.

## Overview of Report Structure & Contribution Process

### Executive Order 01.01.2017.27

On November 2, 2017, Governor Larry Hogan issued Executive Order 01.01.2017.27, Computer Science Education and Professional Development, directing the GWDB to engage workforce development partners and stakeholders to make specific recommendations on how Maryland can more fully develop a market-ready workforce and provide equitable opportunities for all Marylanders to succeed.

The executive order directed the GWDB Task Force on Cybersecurity and Information Technology (Task Force) to:

- a. Study opportunities to grow Maryland's economy associated with the computer science and IT industry;
- b. Focus on developing pathways that meet identified workforce needs in computing fields;
- c. Determine the skills needed in and challenges for Maryland's talent pipeline;
- d. Encourage employer partners to invest in Maryland's IT workforce; and
- e. Create innovative and sustainable ways to address gender and racial disparities in the Science, Technology, Engineering, and Mathematics (STEM) and IT fields.

### Community Engagement Process

The GWDB and Task Force engaged an inclusive community of more than 200 professionals from industry, education, government, and nonprofit sectors to participate in the creation of the report. These individuals participated in multiple listening tours and writing sessions, and had the opportunity to contribute valuable insights, data, and ideas that have been integrated into the report.<sup>1</sup>

### Report Structure

The following sections contain recommendations, findings, and recommended frameworks for understanding the current status and future direction of CS education and related employment in Maryland. If not explicitly otherwise stated, such as with published research, the statements in this report express the opinions of multiple contributors. Most importantly, this report contains concrete recommendations for action that, if taken, will position Maryland as a national leader in the CS Education movement, creating a robust constellation of opportunities for today's youth to develop the skills, awareness, mindsets, identity, and interest to pursue careers serving the technical needs and opportunities of our state, our country, and in businesses across a full range of industries.

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<sup>1</sup> See Appendix A for a list of active report participants and contributors.

## Report Recommendations

### Host and Promote Computer Science Public Events

Throughout the year, the Governor and business leaders should host various events to focus appropriate attention, reward dedicated efforts, and publicly celebrate those who are working in the interest of advancing inclusive CS education and employment. These events should recognize alternative pathway supports, technology, CS-related college scholarships, and other financial or in-kind resources supporting CS education efforts. An extraordinary commitment from individuals and businesses should be publicly recognized to include awards such as: CS Teacher of the Year, CS Administrator of the Year, CS Informal Educator of the Year, CS Champion of the Year, CS Volunteer of the Year, CS Outreach Business of the Year, and CS Champion of Diverse Hiring Practices of the Year.

### Recognize Formal and Informal Pathways to Computer Science Careers

Individuals who have not gone on the traditional pathway to a CS-related career can possess the necessary skills to obtain a job, learn, and thrive in a CS-related career. To recognize informal pathways into CS-related employment, a comprehensive and inclusive database that includes asset, skill, and pathway mapping should be created and further expanded on to clearly articulate the alignment between the three key stakeholders. These stakeholders are employers, job seekers (inclusive of both current students and transitioning workers), and education providers (both formal and informal). The map should include identification of professional development opportunities for informal CS educators. This mapping should create increased understanding through use of common language descriptions of the skills (as dissected from individual job postings or course offerings), be real-time and up-to-date, and use data to increase transparency for each stakeholder group. Recognizing both the formal and informal CS pathways will significantly increase the quantity of qualified employees and open new pathways to CS careers, where employees can build skills in jobs like manufacturing that will prepare them for CS. This will also increase the rapid-response capabilities of the educational ecosystem which will empower organizations across Maryland to adapt to future CS-related needs.

### Increase Mentorship and Coaching Opportunities for Youth

Promote a statewide effort to encourage CS-related professionals to engage as mentors and coaches into the classroom, either in-person, or as virtual mentors through technology. There should be an emphasis on recruiting mentors that are women, minorities, people with disabilities, and those of lower socioeconomic status in order to increase diversity in CS-related fields. Experiences could include shadow days, field trips to multiple tech companies spanning various industries, support for tech related extracurricular activities (such as competitions), career guidance opportunities for business to come into schools and advise (short and long term options available both in-person and virtually), or host or support a statewide and/or regional gatherings for guidance counselors and PTA's to educate and inform high school guidance counselors and parents on the opportunities and pathways in CS.

### Increase Access to Computer Science Courses

Rigorous CS courses should be offered in every Maryland high school, including Advanced Placement (AP) offerings and Career and Technology Education (CTE) pathways for CS. Course offerings should be aligned to nationally accepted standards and taught by teachers qualified through training or industry experience to teach these specific courses. Computational thinking and CS instruction should be required in all elementary schools, middle schools, and

high schools, whether as integrated content, stand alone courses, or CTE programs of study.

### **Grow Computer Science Participation and Interest Among Women and Minorities**

To overcome existing inequities and a lack of diversity in CS-related fields, a robust and concerted effort is needed to elevate existing diversity within CS-related workforce and grow both recruitment and retention efforts of traditionally underrepresented groups. To accomplish this, the state should create incentives, score applications higher on state requests for proposals, and/or allocate a percent of technology expenses to projects that make diversity in CS-related fields more visible. Businesses and agencies with staff of diverse backgrounds should engage in personalized mentoring through video-conference, coaching in team competitions, and actively participating on Local Advisory Councils (LACs) and Program Advisory Committees (PACs) in CTE program pathways. Relationships between school personnel such as guidance counselors, tech teachers, and CS teachers with Maryland firms who hire CS, IT, and Cyber employees should be developed so students from diverse backgrounds can develop connections, mentorships, and relationships with role models at these firms.

### **Develop a Tech Extension Partnership Program**

In recognition of the critical role technology plays in our modern society, Maryland should create a new class of educational opportunities modeled after the Cooperative Agricultural Extension. This Tech Extension would focus on technology education through partnerships with multiple higher educational institutions, community-based municipal and private spaces, and public-private partnerships with nonprofit and businesses. The GWDB should convene representatives from across public and private sectors to develop a design and action plan for piloting a Tech Extension program in Maryland. This extension would seek to transfer knowledge gained through research and education directly into communities through educational programs, demonstration spaces, and events seeking to create positive outcomes. These efforts would focus on higher-level thinking and serve as both places for research and development of new approaches to technology education.

### **Create a Maryland Computer Science Fellowship Program**

Maryland should be the first state in the country to create a computer science fellowship that will serve the public. These fellows will spark innovation within government and deepen the understanding of policy implications related to CS. The fellowship would consist of two types of service – one that encourages technology professionals to give a “tour of duty” by serving the public good, and one that encourages educators to enhance their industry experience by giving a summer “tour of duty” embedded in CS-related teams within companies, organizations, or state agencies. Managed through the GWDB, these embedded fellows would enhance the capabilities of State Government offices and Local Education Authorities to elevate and assist CS education efforts as well as create cohorts of committed individuals throughout the state who have deeper understanding of policy processes and needs within Maryland.

### **Increase Awareness Among Parents and Students of the United States Government Security Clearance Process**

A significant portion of the region's workforce is either directly employed by the US government or businesses that support the government (including The National Security Agency [NSA], the Defense Information Systems Agency [DISA], the United States Army Communications-Electronics Command [CECOM], the Naval Air Systems Command [NAVAIR], and U.S. Cyber Command [USCYBERCOM]), and the vast majority of jobs within this workplace requires a background investigation resulting in a US Government-granted Security Clearance prior to employment. Maryland should explore a mechanism in partnership with the federal government through which the processing time could be shortened from the average delay of over eighteen months, including developing support materials and coursework to educate students and parents on security clearance process, including behaviors to avoid in order to receive a security clearance. We believe this to be of critical importance and that it will have an immediate positive impact if developed.

The above recommendations were developed by studying opportunities to grow Maryland's economy. The report focuses on developing pathways that meet identified workforce needs in computing fields. Moreover, the report explicitly identifies opportunities to create innovative and sustainable ways to address gender and racial disparities within CS educational pathways and the current workforce.



## Executive Order 01.01.2017.27 Report Findings

Executive Order 01.01.2017.27 called on the GWDB to study and report on the following items.

### Study opportunities to grow Maryland's economy associated with the computer science and IT industry

To remain economically competitive, Maryland must develop a robust workforce trained and educated in CS, cybersecurity, and IT. Maryland must maintain current efforts and develop and implement new initiatives to bolster the CS workforce.

#### Address Critical Shortfalls in Maryland's Workforce

Despite consistently ranking in top-tier positions for measures of growth of the technology as well as STEM-related jobs and education levels<sup>2</sup>, Maryland is facing a critical workforce shortage. As noted by the Maryland Department of Commerce, "In the cybersecurity industry, the most significant barrier to growth is a critical mass of expert, experienced, and talented cybersecurity professionals at all skill levels."<sup>3</sup> This shortfall is a major contributing factor to the currently estimated 21,350 open computer jobs (4.9 times the average demand rate in Maryland). Even more, the average salary for a computing occupation in MD is \$100,812, which is significantly higher than the average salary in the state (\$56,120)<sup>4</sup>. The existing open jobs alone represent a \$2,152,336,200 opportunity in terms of annual salaries.<sup>5</sup>

This report recommends concrete steps to address these shortfalls but it is critical to acknowledge the depth of the challenge and the exacerbating effect that growing demand and decreases in existing workforce due to normal attrition such as retirement will have on the economy. Figure 1 on page 8 represents the most in demand tech occupations in Maryland in 2017.

#### Promote and Improve Computer Science Opportunities

For Maryland to be best positioned to meet the growing needs and opportunities related to the CS,

Cybersecurity, STEM, and IT fields, both public and private entities from across the state will need to collaborate on, share, expand, improve, and create additional pathways from the K-12 and higher education classrooms into high-growth careers.

Additionally, it is important to recognize that virtually every company is increasingly a "tech company," since every industry has come to rely on technology infrastructure to grow productivity and reach, expand automation, distribute digital marketplaces, and build a connected workforce. These findings are applicable across major sectors of Maryland's economy, including but not limited to Education, BioHealth & Life Sciences, IT & Cybersecurity, Advanced Manufacturing, Military & Federal, Aerospace & Defense, Financial Services, Energy & Sustainability, and Agribusiness.

### Focus on developing pathways that meet identified workforce needs in computing fields

With technology changing every industry on the planet, computing knowledge has become a critical need for a well-rounded skill set. While basic technology literacy is a requisite baseline, it is essential to fully appreciate that computer science is far more than just technology use. In other words, CS is the process

<sup>2</sup> See Forbes "The Best Cities for Tech Jobs", and WalletHub's "2018's Most & Least Educated States in America".

<sup>3</sup> See "Maryland's Unique Cybersecurity Workforce, A White Paper," Maryland Department of Commerce, February 2018, p. 2.

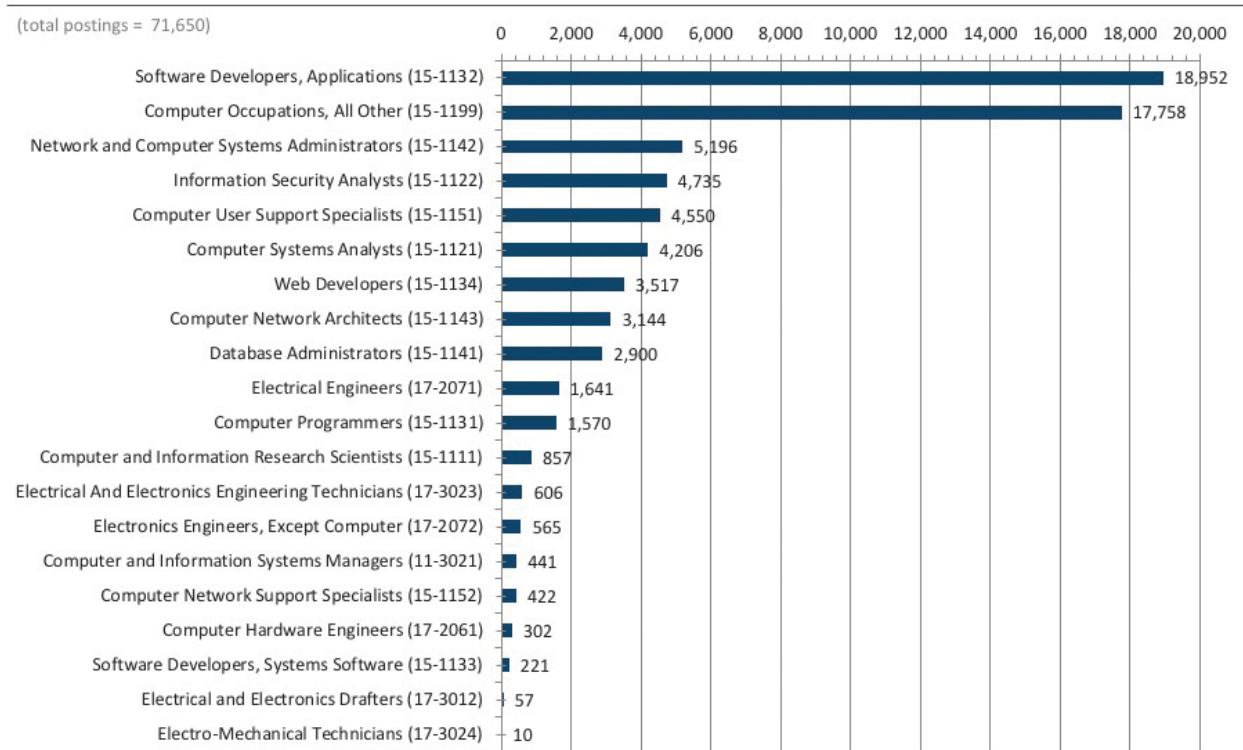
<sup>4</sup> See <https://code.org/advocacy/state-facts/MD.pdf>.

<sup>5</sup> IBID





**Figure 1 – TOP TECH OCCUPATIONS IN DEMAND IN MARYLAND, 2017**



Source: Burning Glass Technologies' Labor Insight™ Real-time Labor Market Information tool. Analysis by Greater Washington Partnership.  
Postings reflect job postings in Maryland for full year 2017.

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through which technology is created, not just used, and it is about more than learning to keyboard or use computer applications. Computer science education should be considered a foundational skill in the same way that reading, writing, and arithmetic are critical underlying skills, and should similarly involve far more than basic use of tools such as penmanship or ability to use a calculator. Students of all ages benefit from being exposed to computational thinking, programming, and digital creation for reasons that go far beyond preparation for a specific job. CS is a new essential literacy for participating and contributing in an increasingly technological world.

### Expand Career and Technology Education

In addition to the need as a basic literacy, computer science education is critical to the future of our State's economy. According to the U.S. Department of Labor statistics, the number of unfilled cybersecurity jobs is projected to be more than 1.5 million across the nation

by 2019, growing 12 times faster than the overall job market in the U.S. This is particularly important for Maryland because the state is home to:

- » More than 12,000 IT and cybersecurity companies;
- » 60+ government agencies tasked with protecting our nation from cyber-crime, including the NSA;
- » The National Cybersecurity Center for Excellence;
- » The U.S. Cyber Command; and
- » 17 higher education institutions that have been designated National Academic Centers of Excellence in Cyber Defense.

One way in which Maryland is responding to this need for an increased pipeline of CS and IT employees is through CTE pathway programs, which provide high school and community college students the opportunity to pursue a sequential technical and academic program of study leading to advancement

in a career field. In the 2017-18 Academic Year, 10,699 students participated in IT pathways at 21 local school systems offering pathway program in 143 schools across the state. While overall IT pathway enrollment has increased 46% since 2015, current IT pathways are comprised of 70% male students with 41% of enrollees identifying as White, 33% as African American, 13% as Asian, 8% as Hispanic, 4% as Multiracial, and less than 1% as Pacific Islander. The gender and racial statistics are moving in the right direction but a significant amount of work needs to be done to ensure the gaps continue to decrease in order to build a diverse and talented pipeline of CS professionals that adequately addresses workforce needs.<sup>6</sup>

A collaborative effort among key stakeholders is needed to support existing CTE pathways and to develop new pathways that incorporate emerging technologies, such as artificial intelligence and augmented reality. It is imperative that ongoing communication occur among leaders from business, industry, labor, and formal and informal education so that existing and new pathways meet workforce needs. Educators in both secondary and postsecondary CTE programs engage with the employer community through LACs and PACs, which allows for ongoing dialogue for continuous pathway program improvement. Further coordination is necessary, however, to increase the role of businesses and industry from advisory to active engagement in development. This is particularly necessary for the CS and IT sector, where technology changes at an exponential rate.

Early experiences in CS-related content coupled with academic and career development is key to helping students understand their skill sets and interest, and should then be matched to career fields of interest. The Maryland State Department of Education (MSDE) already requires that school systems provide students with a systemic instructional program in career development and decision making where school systems "ensure that before grade 9, each student shall develop an individual academic and career plan and update it in subsequent years".<sup>7</sup> Based on the Career Development Framework, the instructional program includes the following six standards: Self Awareness, Career Awareness, Career Exploration, Career Preparation, Job Seeking and Advancement, and Career Satisfaction and Transition.

It is not enough, however, to just improve existing pathways or partner with the employer community through LACs and PACs, it is imperative that new pathways are developed. These pathways should leveraging all the places and spaces (both formal and informal) in which students learn to create sufficient opportunities for sustained engagement.

CS-related educational efforts are particularly challenging as there are not enough teachers with the appropriate skill sets to teach in needed pathway programs. Thus, as more pathways programs become available, meaningful attention should be given to both proven methods and to developing new strategies that both identify and develop CS teachers.

### **Create a Responsive Education Framework**

To address the needs of more teachers in CS-related courses, and in addition to investments in CTE-specific programs, Maryland requires an integrated system of educational solutions through which professional development for educators will become more integrated, industry will provide targeted and timely feedback, instruction will become more responsive, and student recruitment more engaging.

### **Update Teaching Methods to Meet the Changing Nature of Computer Science Education**

Existing mechanisms for curriculum approval, training, and distribution in formal educational systems were designed for knowledge that is relatively constant or that changes only slowly from one generation to the next (such as English, history, sciences, and math). The state of the art in CS, however, pushes boundaries exponentially and at an accelerating rate. As technology capacity doubles repeatedly in the future, the release of more powerful operating systems, languages, and structures will make many older systems obsolete.

The differences between these two types of knowledge are not fully appreciated by the systems of practice. In other words, the processes in place for proposing, reviewing, and adopting new curricula (which are very appropriate for generational knowledge) produce suboptimal outcomes and result in persistently outdated instruction when applied to rapid-cycle knowledge. Unless new approaches are developed, approved, and given appropriate provisions, this structural gap will lead to perpetual problem of

<sup>6</sup> Data provided by Maryland State Department of Education.

<sup>7</sup> See COMAR 13.04.10.01.

being out-of-date almost from day one.

### **Expand Apprenticeship Opportunities**

Maryland is embracing traditional apprenticeship models to create alternative career paths into technical fields. A Registered Apprenticeship program allows an apprentice (employee) to earn a salary while learning necessary skills to succeed in a high-demand career. Employed from day one of the apprenticeship, apprentices receive on-the-job training and job-related instruction.

Additionally, the Youth Apprenticeship program is expanding statewide in order to engage a new generation of workers and employers to ensure that Maryland remains open for business. Apprenticeship Maryland is a new State program that gives business the unique opportunity to train, influence, and shape high school students into top-performing employees who are invested in an employer's business. The program requires that Eligible Employers hire Apprenticeship Maryland participants in Eligible Career Track occupations related to manufacturing industry or science, technology, engineering and math (STEM) and provide paid compensation thus creating an "earn and learn" opportunity. Eligible Employers must also be located in close proximity to the local school systems selected to participate in Apprenticeship Maryland and must have expected future entry level job openings in the Eligible Career Track occupations.

Currently there are four registered apprenticeship programs in cybersecurity (TranZed Apprenticeship Services, UMBC Training Centers) and IT (NPower, and the Education Foundation for Baltimore County Public Schools). Businesses should support the expansion of Apprenticeship Maryland. "Parents, students, school counselors and officials, and business all play key roles in developing a successful youth apprenticeship opportunity. True business investment in the pipeline of talent, future workforce, and community is vital. Without businesses the apprenticeship opportunity does not exist. School counselors and officials are needed to connect the right students with the right opportunity. Additionally, parents and students need to understand the importance of obtaining real-life experience in the 'world of work.'"<sup>8</sup> Apprenticeships are a win-win for the business and apprentice alike. By establishing apprenticeship opportunities, turnover costs are reduced, job satisfaction increases, and employee productivity increases, making apprenticeships good for

business.

### **Expand Internship Opportunities**

Maryland is currently already working to improve the internship. The Department of Commerce created the Internship Network of Maryland (inMD), a web-based program, managed by the Department of Commerce in partnership with the Maryland Tech Council to connect employers who have internship opportunities with individuals students seeking internships.

## **Determine the skills needed in and challenges for Maryland's talent pipeline**

The Task Force's assessment of the business community representatives surveyed for this report indicates that the business community has several areas of significant concern around the needed skills for Maryland's talent pipeline.

### **Quantity of Technical Talent Pathways**

Throughout the listening sessions and writing process, employers expressed more concern about the overall number of students interested in pursuing technical employment than they did about the current technical skill of those students. These businesses acknowledge that regardless of previous training, there is a high likelihood that an individual will not know specific systems, languages, or other processes relating to their line of work. Of critical concern is the willingness and aptitude of individuals to learn those skills in as efficient and effective a manner as possible. The overall number of candidates ready and able to learn matters far more than the precise certifications or training already attained. Two specific skill areas raised through the listening sessions included System Engineering and Agile Development, both of which require the employee's ability to employ a process for approaching a multitude of problems rather than a specific language or skill set. There is a highly relevant need to foster significantly increased CS interest among primary, secondary, post-secondary students, and graduates from a diverse and expanded range of backgrounds and fields to develop an interest in pursuing CS and IT employment pathways into Maryland's business community.

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<sup>8</sup> See <https://www.dllr.state.md.us/employment/appr/youthapprannrep2017.pdf>.

## Employment Skills

The area of concern that was voiced most clearly by the business community was the need for employees to enter the workforce better prepared with so-called “soft skills” which we will refer to as employability skills, and include key characteristics such as:

- » Working collaboratively in teams;
- » Clear multi-channel communications;
- » Interpersonal human interaction;
- » Strong and demonstrated work ethic;
- » Demonstrate leadership skills;
- » Capacity for creative problem solving;
- » Perseverance; and
- » Willingness to innovate, adapt, take initiative, explore, and troubleshoot.

The aforementioned skills are inherent in everyone but must be developed and exercised. The formative education years are critical in this process as they develop initial patterns of behavior. Afterschool and summer programs are an effective space to further develop these transferable reflective, relational, and applied skills students need.<sup>9</sup> Business leaders expressed concerns that current interview processes are not sufficiently in-depth to gain insight into longitudinal patterns. Employers often use proxy measures or look for candidates similar to existing successful employees, both of which commonly have the direct consequence of reducing the applicant pool and eliminating traditionally underrepresented populations from full consideration. Some employers have moved away from a recruiting process centered around human resources departments and recruiter-based interviews and put hiring managers directly in the interview process with candidates. The companies that have made this transition reported increased success in the recruitment of underrepresented populations into their workforce. The hiring managers are better able to explore the candidate's skills (including the more difficult to assess employability skills) and the candidate gains a better understanding of the work environment they are considering at the company.

## Technical Skills

Along with employability skills, the business community voiced the need for technical skills.

Figure 2 on page 13 represents the top skills employers requested in 2017 for digital tech hires in Maryland, while Figure 3 represents the experience by education employers requested in 2017 for digital tech jobs.

## Lifelong Learning

The rapidly evolving nature of CS is projected to continue or increase in the future. As a result, CS professionals will need to continually develop new skills at an increasingly rapid rate throughout the course of their 30-40 year careers. The pace of change is consistently increasing and businesses have expressed concern that employees are not prepared to continuously evolve with new technology. Numerous employers were not enthusiastic about students graduating high school with certain certifications (such as Cisco or Microsoft), noting that the longevity of the tested knowledge from these certifications was short-lived. Instead, the employers stressed that the ability to learn on the job, coupled with the grit and perseverance required to develop new skills, was significantly more important in an employee.

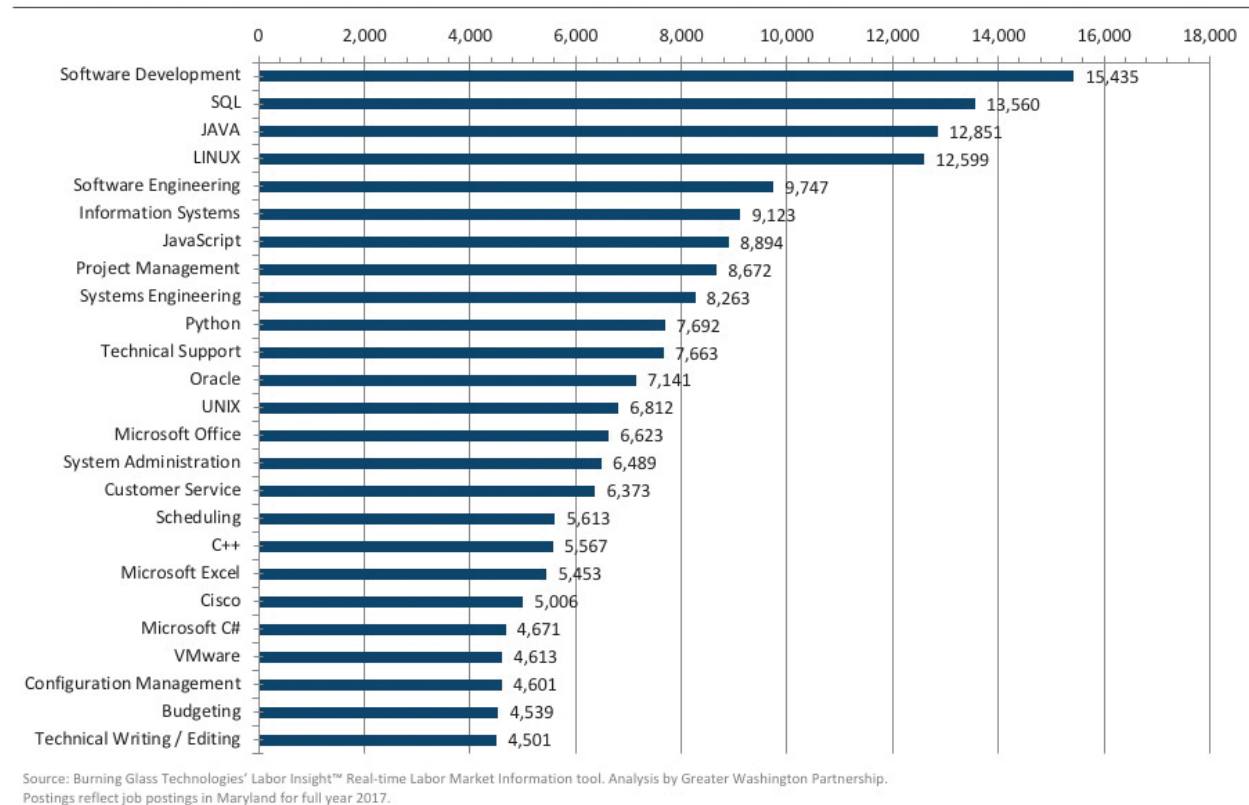
The meaningful exception to this, and a point that many employers voiced, was the need for those with security clearances. This certificate is not, however, as much a verification of specific knowledge that has a short shelf-life but a classification of status that is directly tied to potential for work on government projects. Figure 4 represents the top certifications that Maryland employers requested for digital tech hires in 2017. As the chart indicates, an individual obtaining a security clearance is the highest ranked of all of the certifications.

## United States Government Security Clearance

There is a significant portion of the region's workforce that is either directly employed by the US Government or businesses that support the government. Making individuals available to the government sector with the necessary skills and security clearances is of critical importance to our regional workforce ecosystem. Among Maryland's largest employers are NSA, DISA, CECOM, NAVAIR, and USCYBERCOM. All of these Department of Defense entities maintain large technical staffs in Maryland and are supported by a large number of private contractors. This grouping of defense contractors is the largest employer of computer science, information technology, and cybersecurity talent in Maryland. Virtually all

<sup>9</sup> Afterschool Alliance. 2017. Building Workforce Skills in Afterschool

**Figure 2 – TOP SKILLS REQUESTED FOR DIGITAL TECH HIRES  
BY MARYLAND EMPLOYERS, 2017**



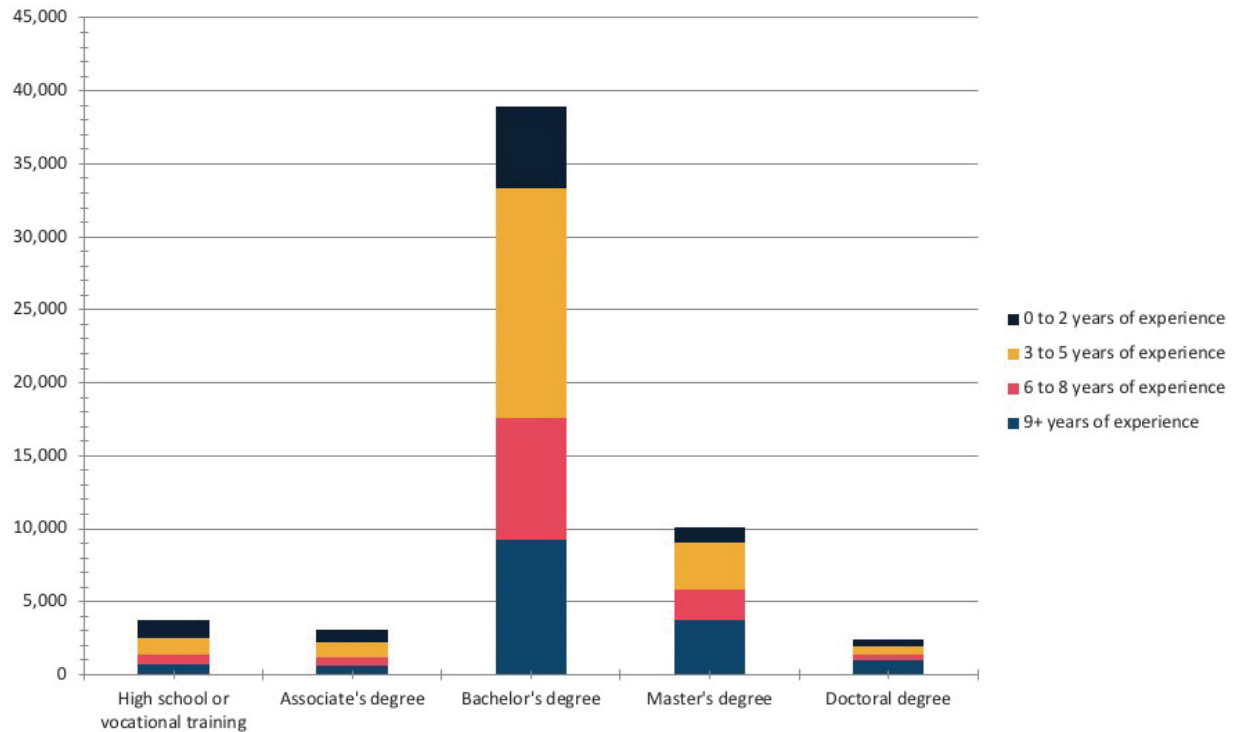
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jobs within this workspace require a background investigation resulting in a US Government-granted Security Clearance prior to employment. For various reasons, the time required for a person to acquire a clearance has steadily lengthened over the past decade, now stretching on average to over eighteen months. At any given time, thousands of jobs go unfilled because new talent is waiting for a clearance. This delay results in many qualified workers taking positions in the commercial sector elsewhere, with many leaving Maryland to pursue other opportunities, all while job positions are unfilled here. Developing mechanisms that will shorten the cycle time for obtaining security clearances is essential to growing this sector and will dramatically increase employment opportunities available to Marylanders. Additionally, a course should be created to educate students and parents on how to fill out the security clearance forms and behaviors to avoid in order to receive a security clearance, ultimately shortening the process.

## Digital Citizenship & Ethical Behavior

An area of concern raised by numerous voices from the business community is related to digital citizenship and ethical behavior of the prospective employees. As highlighted above, a significant portion of the potential jobs in the CS and IT fields in the state of Maryland require the employee to pass a background investigation and/or have a Security Clearance. Many youth today regularly create a "digital footprint" through the use of social media and sometimes the seemingly inconsequential decisions they make can create unintended future issues for them passing a security clearance/background investigation. Forthcoming Maryland K-12 Computer Science Standards include Impacts of Technology as one of the five major concepts. Under this concept, ethical use of computing resources is addressed. As these standards are reviewed this summer, it is necessary to ensure that a clear understanding of potential consequences of a

**Figure 3 – EXPERIENCE BY EDUCATION REQUESTED BY MARYLAND EMPLOYERS FOR DIGITAL TECH JOBS, 2017**



Source: Burning Glass Technologies' Labor Insight™ Real-time Labor Market Information tool. Analysis by Greater Washington Partnership. Postings reflect job postings in Maryland for full year 2017.

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negative digital footprint is emphasized for youth as early as appropriate. More direct mentorship is needed to create an increased awareness of the importance of digital citizenship and ethical behavior on future job opportunities and increase understanding of the risks inappropriate social media use presents to a student's future.

## Encourage employer partners to invest in Maryland's IT workforce

Many resources already exist within Maryland that encourage employers to partner with and invest in Maryland's growing IT workforce; however, awareness of and access to these resources is fractured. A comprehensive organization that has the capacity to meet the requirements and demands associated with analyzing the needs of the IT workforce does not

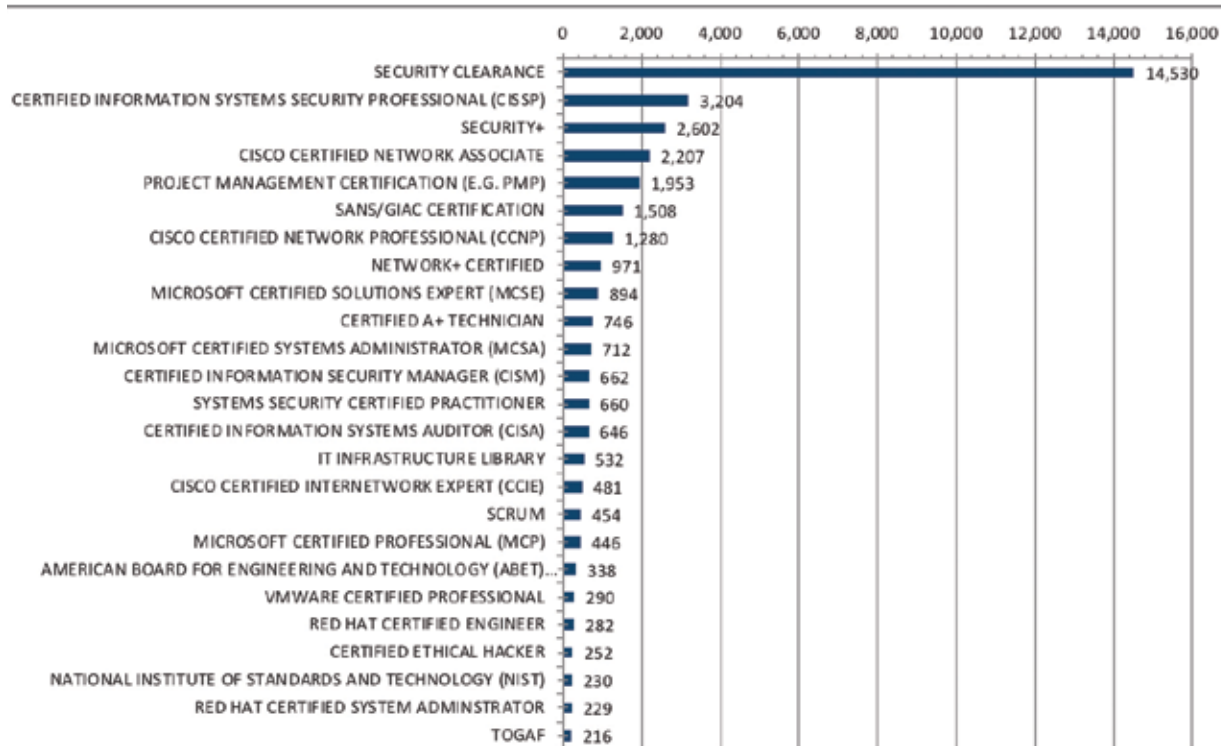
currently operate in Maryland. This task should not fall solely to a single entity but is best served through a coalition approach with a transparent process for effective evaluation.

## Develop a Computer Science and Information Technology Coalition

Engaging, connecting, and providing feedback to employers are key functions that will make this initiative successful. A Coalition could provide key routing capabilities including a single starting point for an individual or organization in Maryland interested in resources or pathways relating to CS and IT jobs available to them as businesses or individual job seekers. Currently, as a state, we lack a central protocol that allows for members of a coalition to parse and disseminate centrally stored information. Additionally, online access of information must be matched by consistent in-person community engagement that meets the current needs of individuals.



**Figure 4 – TOP CERTIFICATIONS REQUESTED FOR DIGITAL TECH HIRES BY MARYLAND EMPLOYERS, 2017**



Source: Burning Glass Technologies' Labor Insight™ Real-time Labor Market Information tool. Analysis by Greater Washington Partnership. Postings reflect job postings in Maryland for full year 2017.

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A comprehensive coalition that effectively and efficiently route information would significantly add to our ability to capture existing dollars, programs, initiatives, and incentives already in place from Federal, State, and private sources intended to assist in solving for the shortfalls facing industry.

### Increase Pathway Supports

The current understanding and acceptance of alternative pathways into technology sector is suboptimal. The common practices of human resources departments are often not aligned to the needs of the technical teams, but instead default to more restrictive external indications of an individual's technical ability (such as a degree or credential). This, in turn, narrows the field of potential candidates for existing positions. The CS field would be well served by better defining an increased number of nontraditional pathways and providing more formal recognition to more informal learning experiences.

To accomplish this, more robust alignment between the three key stakeholders of employers, job seekers (students, transitioning workers, etc.), and education resources focused on increasing the common language of skills as dissected from individual job postings or course offerings. Partnerships should engage with the existing educational pipelines (including but not limited to elementary and secondary schools, tech centers, community colleges, 4-year colleges and universities, career centers, workforce development agencies, teacher preparation initiatives and advocacy organizations, and other organizations that provide technology-related education to both traditional and non-traditional students), work-to-learn opportunities (such as internships, apprenticeships, train-to-hire, or on-the-job training programs), and career advancement efforts (inclusive of rotations, fellowships, special projects, formal mentorships, professional development, or tuition reimbursement).



As these demonstrate, an essential core need for this field are collaborations among businesses, educational entities, supporting organizations, and the State of Maryland to enhance engagement through robust feedback and implementation strategies that serve to increase the effectiveness and efficiency of all CS-related initiatives.

### **Increase Public Awareness**

While the public is aware of the pervasive opportunities to consume technology, a much smaller subset of the population is familiar with specific opportunities for employment in the tech industry. Additionally, the presence of large media outlets in other states and regional markets (which are less prevalent in Maryland) provides those states with a much louder amplification mechanism for publicly highlighting investments and success stories of businesses engaging in workforce and community development efforts. These facts have led to lower investment from businesses and the government as well as lower engagement from the general public in the State of Maryland than would otherwise exist. In other words, more employers would likely participate in workforce development efforts (such as supporting non-traditional pathways, sponsoring college scholarships targeting technology and cybersecurity fields, and financially supporting high school programs) and those who already are engaged would engage even more if there was more public recognition and celebration (including by the state) of these efforts and the associated individual success stories.

### **Increase Public Engagement**

Numerous public school systems and private schools have events (including code competitions, cybersecurity capture-the-flag events, and others) throughout the K-12 environments, many of which depend on volunteers to judge or assist students. These events provide real technical growth opportunities to students, encourage them to continue on a technical career path, and give access to positive role models of successful technology professionals. Furthermore, these public engagements are meaningful forms of community service for employers. Ensuring a diverse pool of volunteers as judges, coaches, and mentors is also critical to fostering more diversity in the computing workforce.

## **Create innovative and sustainable ways to address gender and racial disparities in the STEM and IT fields**

Addressing racial, gender, and socioeconomic disparities will require sustained, intentional efforts over a prolonged period of time. To directly address these imbalances in the CS-related fields, we must identify and invest in best practices that promote opportunities for all Marylanders. To assist in this, Maryland may create a community of practice through which identified and vetted organizations could support others seeking to focus on better engaging underrepresented populations. By documenting and sharing best practices, more organizations will learn from those who have a strong track record of results and whose best practices could now expand in their reach. For many students and individuals, aptitude, ability, and aspiration are not the primary barriers to obtaining the requisite skills and credentials to enter CS-related fields. Instead, for many, poverty is the barrier to a career in CS. Radical inclusion should be integrated into this work to achieve the gender parity and overcome the historic racial and socioeconomic gaps referenced earlier.

According to a report published by Science Magazine titled, Gender stereotypes about intellectual ability emerge early and influence children's interests, "Common stereotypes associate high-level intellectual ability (brilliance, genius, etc.) with men more than women. These stereotypes discourage women's pursuit of many prestigious careers... Specifically, six-year-old girls are less likely than boys to believe that members of their gender are 'really, really smart.' Also at age six, girls begin to avoid activities said to be for children who are 'really, really smart.' These findings suggest that gendered notions of brilliance are acquired early and have an immediate effect on children's interests."<sup>10</sup>

Underrepresented populations are hampered by additional barriers that keep them out of computer science workforce. For instance, "blacks who studied science and technology were less likely than white students to stick with their majors when they felt they were underperforming. Those who did stick with their majors were less likely to apply for technical jobs"<sup>11</sup> due to negative perceptions about the culture at tech companies.

<sup>10</sup> See <http://science.sciencemag.org/content/355/6323/389.full>.

<sup>11</sup> Maya A. Beasley, "Opting Out: Losing the Potential of America's Young Black Elite," 2011.

The research findings indicate that some of the barriers regarding gender and underrepresented populations entering CS professions are cultural and can potentially impact participation in pathway programs at both the secondary and postsecondary levels. Solutions to address the culture gaps include providing students with experiences that start in kindergarten and progress through high school allowing them to gain the needed confidence to persist in doing the challenging work that is a hallmark of STEM education generally; direct and intentional recruitment; and authentic engagement of families and community leaders are thought and implementation partners.

### **Assist in Identity Information**

Research has clearly shown that children become, or aspire to become, what they see.<sup>12</sup> Common places where children observe adults around whom to form their identities are at home, in their neighborhoods, in their schools, on television, and in movies. Access to informal opportunities to visit, observe, and interact with individuals in professional settings is not evenly distributed between socioeconomic groups. Disparities that emerge from barriers such as parent/guardian's social networks or accessibility to transportation further widen the digital divide. Without a focus on inclusion, even the most well-meaning programs such as job shadowing and mentoring will serve to widen the digital divide and create opportunities primarily for those who already have both means and connections.

Furthermore, it is important to distinguish by race, gender, and disability status when identifying models around whom children can shape their identities. African-American youth need to see African-American men and women in CS roles and careers; Hispanic youth need to see Hispanic men and women in CS roles and careers; youth with disabilities need to see professional men and women with disabilities, such as blind, deaf, or mobility impaired, in CS roles and careers. Without the presence of these direct role models, unconscious bias and/or stereotype threat unintentionally reinforce preexisting expectations that CS pathways are not welcoming to everyone.

Instruction should cover contributions to the field made by the contributions of members of minority groups, women, and people with disabilities. These contributions to innovation and technology should

be fully recognized throughout the school year in integrated, balanced, and equally weighted accounts. Including such history will require deliberate efforts to identify the "hidden figures" of innovation history, including those from sources authored by non-majority culture to avoid further perpetuating potential unintended and inherent bias in historical recounting. It is as equally important for non-minority students to see women and minorities in technical roles to decrease unintentional bias.

An important consideration for addressing underrepresentation is parent engagement. Youth in the early grades look to their parents as they form their identities.<sup>13</sup> Activities like Family Code Nights, Family Maker Nights, Hour of Code events, STEM Festivals, and leveraging the afterschool and summer hours help parents to understand the opportunities available. The Governor should issue a proclamation, perhaps during CSEdWeek, encouraging all Maryland schools to host an event like this.

### **Increase Mentorships and Coaching Opportunities for Youth**

As highlighted in the above section, access to informal mentors and coaches is disproportionately benefiting those of wealth, means, and social connections. Deliberate efforts should be made to create equivalent opportunities for traditionally underrepresented populations, including women, minorities, people with disabilities, and those of lower socioeconomic status, as a critical step in addressing the disparities that exist in the CS workforce. Efforts to create authentic opportunities for individualized interactions should be prioritized (such as shadow days, technology coaching, and one-on-one career guidance) with secondary efforts in group experiences (such as classroom visits, group field trips, and presentations) as beneficial ways to identify those interested and ready for the more involved experiences.

On average, the number of girls interested in STEM across Europe doubles when they have a clear role model to inspire them.<sup>14</sup> Engaging role models through the introduction of applied CS in as early as elementary school could provide significant encouragement to traditionally underrepresented youth to become more involved and pursue CS as subject of interest or lifelong career. The above research further shows that:

<sup>12</sup> See <http://parenthood.library.wisc.edu/Popenoe/Popenoe-Modeling.html>.

<sup>13</sup> See Parents Role in Career Selection: [http://www.qualifax.ie/index.php?option=com\\_content&view=article&id=179&Itemid=207](http://www.qualifax.ie/index.php?option=com_content&view=article&id=179&Itemid=207).

<sup>14</sup> See <http://parenthood.library.wisc.edu/Popenoe/Popenoe-Modeling.html>.

- » Women already working in STEM fields are the most influential for driving girls' interest to STEM;
- » Girls with role models are also shown to have more belief in themselves; evaluating themselves as higher performers across STEM subjects;
- » Over half of the girls with role models can imagine a future career in STEM; and
- » A vital factor for engaging girls with STEM is the use of real-world examples to spark a passion and interest.<sup>15</sup>

Providing direct role models to offer tangible guidance and one-on-one consultation will open new possibilities and aspirations that may otherwise go untapped. Utilization of technology that has proliferated in practices such as telemedicine could dramatically increase the ability to provide individual mentoring not limited by geographic proximity and could increase time spent in direct engagement (as opposed to travel). Additionally, a cascading mentoring approach in which professionals and entrepreneurs mentor college students, who then in turn mentor high school students, who then mentor middle school students, who then mentor elementary school students would be beneficial. Regardless their background, all mentors should be trained in strong youth development principles and bias reduction.

### **Provide Exploratory Experiences for Every Middle School Student**

Participation in CS classes in high school and college among certain groups is significantly low; females and minority students do not enroll in numbers representative of their proportion of the population.<sup>16</sup> Middle school has been identified as a key stage in STEM education. There is significant research relating specifically to early exposure for girls in the computing pipeline. 69% of the growth in the computing pipeline would come from changing the path of the youngest girls – especially those in middle school. The study found that the main factors that influence interest

in computing tend to be positive for girls in middle school and college, and tend to be negative during high school years.<sup>17</sup> Experience of computing in their middle school years means that girls are 18% more likely to show interest in computing throughout their high school and college years.<sup>18</sup> Children can benefit greatly from exposure to engaging, culturally relevant, and high-quality CS and other STEM instruction. The only way to provide truly equitable access is to provide a high quality experience that is interesting, motivating, and rigorous for every student. Studies confirm that black students are less likely than white students to have classes dedicated to CS at the school they attend, and most students who have learned CS did so in a class at school.<sup>19</sup>

### **Promote and Enhance Informal Opportunities**

In the efforts to provide every opportunity and advantage possible, families of wealth and means spend an estimated \$8,000 more per child per year for access to informal learning opportunities such as summer camps, tutoring, after-school clubs, competitive teams, and other informal learning opportunities than lower socioeconomic families.<sup>20</sup> Additional activities, such as unpaid internships, college visits, travel experiences, and other explorations are supported by those who can afford them for the express purpose of creating every advantage possible.<sup>21</sup> Similar experiences to those mentioned above should be supported and highlighted for those from lower socioeconomic situations who are interested in pursuing CS-related fields in order to create similar opportunities and pathways. Across the state, there is a shortage of afterschool and summer learning opportunities; 36% of the state's children would participate in an afterschool program if one were available to them.<sup>22</sup>

Additionally, deliberate thought should be given to expanding the format and topic of competitions in order to become more appealing and financially accessible to more diverse students. Potential developments could include expanding design beyond current competitions (which traditionally are dominated

<sup>15</sup> See <https://news.microsoft.com/europe/features/girls-in-stem-the-importance-of-role-models/>.

<sup>16</sup> See [code.org](http://code.org).

<sup>17</sup> Accenture, 2016.

<sup>18</sup> IBID.

<sup>19</sup> Google Inc. & Gallup Inc. (2016). Diversity Gaps in Computer Science: Exploring the Underrepresentation of Girls, Blacks and Hispanics.

<sup>20</sup> See <https://www.russellsage.org/publications/whither-opportunity> With Opportunity: Rising Inequality, Schools, and Children's Life Chances, Duncan & Murnane, 2018.

<sup>21</sup> See The Atlantic, The Activity Gap, 2015, <https://www.theatlantic.com/education/archive/2015/01/the-activity-gap/384961/>.

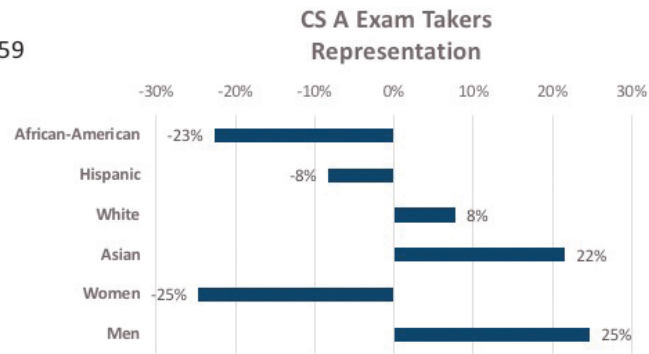
<sup>22</sup> See America After 3PM, 2014. <http://www.afterschoolalliance.org/AA3PM>.



**Figure 5 – MARYLAND AP COMPUTER SCIENCE –PARTICIPATION IN 2017**

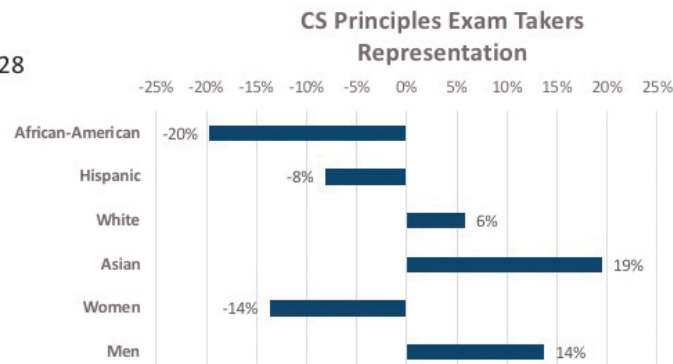
### CS A

Total Exam Takers: 1,459



### CS Principles

Total Exam Takers: 1,628



Source: Greater Washington Partnership Analysis of CollegeBoard Data and Maryland Student Enrollment.

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by male and Caucasian participants), or to explore different structures that highlight different types of learners (such as formats that move away from strict time-based pressure performances), or other thoughtful changes (such as programming-based video editing or code visualization). Out-of-school time (OST) programs could be leveraged to provide more credit and certificate bearing opportunities, mentorship, and paid work experiences in the CS-related fields.

### Increase Access to Technology

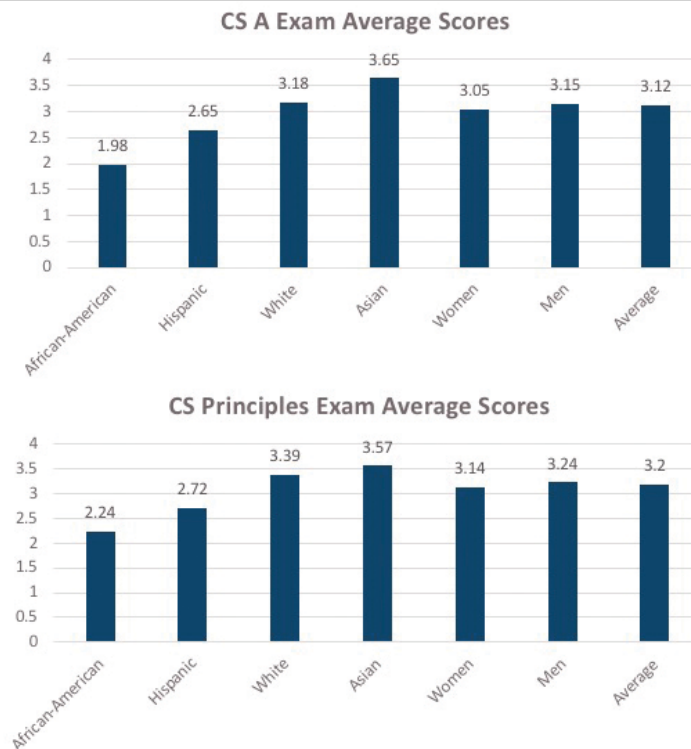
Despite significant proliferation and increased access of the past decade, there is still a significant number of households in Maryland that do not have broadband Internet, whose primary access point is a mobile device, or who do not have access to hands-on learning experiences such as robotics, unmanned aerial vehicles, 3D printers, or other similar tools. The digital divide creates significant disparities between those who have access to the full range of learning resources with

both broadband access and regular access to computer, and those who do not. Increasingly inexpensive components (such as microcontrollers) have improved accessibility but are themselves not sufficiently distributed to make substantial impact for traditionally underrepresented populations.

Another critical consideration that needs attention is making technology more accessible for individuals with physical or cognitive disabilities. There are numerous examples of individuals with varying abilities who are able to thrive in technical fields with appropriate accommodations. The principles of universal design for learning, together, with investments in the necessary infrastructure to support learners of all kinds, are important components of creating innovative and sustainable ways to address disparities in CS-related fields.



**Figure 6 – MARYLAND AP COMPUTER SCIENCE – SCORES IN 2017**



Source: Greater Washington Partnership Analysis of CollegeBoard Data.

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Technology for students in lower socioeconomic settings should consist of sufficiently up-to-date technology that can perform at the same level of technology to which other better-funded programs have access. Opportunities for in-kind or funded donations of technology exist through public-private partnerships which could be encouraged within promotion of a CS initiative.

### Measuring and Reporting

In order to appropriately capture the disparity gaps, we must capture the actual numbers or percentages of representation within those groups with specificity

and transparency. It is not sufficient to just capture the number of boys versus girls or the aggregate percentages of participation by racial and ethnic categorizations. Increasing the specificity of the data to allow for drill-down analysis that looks for subgroup trends will allow for improved understanding and engagement of underrepresented groups across lines of difference and through an intersectional lens. Figure 5 represents the current data available broken down by gender and race of students that took Maryland's AP computer science exams, while Figure 6 breaks down the AP exam scores by student race and gender.

## Additional Insights for Further Exploration

In addition to the recommendations contained in this report, the following community-generated insights are recommended in the interest of advancing CS education and workforce opportunities in Maryland.

### Author a Follow-up Action Report

- » Executive Order 01.01.2017.27 authorized the Task Force to issue additional reports as directed by the Governor. We recommend, and hereby request, to author an action report that would announce new measurable actions and commitments, including an intentional inclusion pledge to be made by organizations and agencies across the state committing to inclusive CS recruitment, hiring, and promotion policies and practices. These action statements will be announced collectively in a fact sheet within one year.

### Convene a Career Pathways Subcommittee of the Task Force

- » Support the creation of the Career Pathways Subcommittee (Subcommittee) of the Task Force. The Subcommittee will be comprised of members from business, education, and community organizations, who will work together to develop career pathways through apprenticeships and internships. The Subcommittee will utilize an innovative, design-based approach to work with employers who will pilot, promote, and champion apprenticeships and internships. The Subcommittee will work closely with employers to help identify and design programs that are beneficial and economically viable for all parties. The Subcommittee will coordinate with internship programs, apprenticeship programs, and educators to influence the design of their programs based on employer feedback. All data collected by the Subcommittee will be included in the continued reports from the Task Force.
- » The Subcommittee will be responsible for increasing the participation of employers on the Task Force. The increased and continued participation of current and future employers is critical to the success of the Task Force and in finding economically viable innovations for our future workforce.

### Encourage Innovative Recruitment Practices

- » Encourage technical practitioners and leaders from state agencies to publicly engage in recruiting and outreach efforts. While participating in job fairs, recruiting efforts, community outreach events, and others, many employers tend to send human resources departments or other non-technical personnel. In order to highlight the jobs and opportunities that exist, as well as highlight existing relationships to Maryland communities and establish real examples of success, technical employees and managers should be encouraged to attend these events directly, especially ones that are from the communities in which they occur.

### Provide Technology Access Tax Incentives

- » Create a mechanism, such as a tax incentives, to facilitate businesses, institutions, and agencies to support schools with fewer resources by donating resources and/or equipment to create up-to-date technology access.

### Address the Teacher Shortage in Computer Science-Related Fields

- » Address the teacher shortage in computing across Maryland by the following:
  1. Support MSDE proposed regulation COMAR 13A.12.01.08-1<sup>23</sup> which would allow for MSDE to issue an adjunct teaching certificate upon the request of a local school system superintendent or an education director of a nonpublic school in order to allow individuals in all CS-related fields to teach CS courses in grades K-12.

<sup>23</sup> See <http://www.marylandpublicschools.org/stateboard/Documents/01302018/TabR-COMAR13A.12.01.08AdjunctCertificate.pdf>.

2. Leverage existing talent and maximize the reach of each qualified educator. If there is a course that is not at capacity offered in different schools, a single instructor could facilitate the course in a blended or online format.

### **Provide Equitable Access to High Quality Afterschool & Summer Computer Science Learning Opportunities**

- » Support increased access to high quality CS-related out-of-school-time programs including such considerations as increased support for transportation, professional development for staff, program evaluation resources, and internship pathway support.

### **Recruit More People Into Computer Science Pathways**

- » Concerted efforts should be made to improve career guidance and counseling, advising, and coaching to increase awareness, interest, and pursuit of CS-related opportunities. These experiences could include exploratory experiences or courses early in student's academic program, varied out-of-school opportunities, and near-peer mentoring.

### **Create More Computer Science Spaces**

- » To increase access to both formal and informal CS learning opportunities, it is important to create more spaces dedicated to specific aspects of CS education. These spaces could include cyber ranges, tech centers, makerspaces, fab labs, libraries, science centers, and other places that allow for beginner, intermediate, and advanced training experiences.



# Appendix

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## Appendix A: Report Authorship & Contributors

To complete this report, Louis Dubin, Board Chair, and Michael DiGiacomo, Executive Director of the Governor's Workforce Development Board (GWDB) asked Andrew Coy, Executive Director of the Digital Harbor Foundation and former Senior Advisor on the Tech & Innovation Team in the White House Office of Science and Technology Policy, to serve as Lead Author. Along with the the GWDB's Task Force on Cybersecurity and Information Technology Co-Chairs, Chris Sachse (CEO of Thinkstack) and Ed Roberts (Cybersecurity Institute Coordinator at Community College of Baltimore County), the following individuals served as report contributors:

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