COMPUTER SCIENCE EDUCATION IN PENNSYLVANIA

A Landscape Report

September 2024

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EXECUTIVE SUMMARY

This Landscape Report establishes a baseline assessment of computer science education in Pennsylvania, to inform and support goals, policies, and practices for broadening participation and success in computing and computing-intensive pathways. The report was developed by a working group formed (in 2023) of researchers, educators, school administrators, community members, and industry representatives.

The state of computer science education in Pennsylvania is encouraging, with 18.99 percent of K-12 students having access to some level of computer science educational experience. In addition, state legislation and policy changes that set goals for increasing access, equity, and quality, to include certification requirements for teachers are poised for growth and success as resources and support coalesce through communities of practice.

While the number of Pennsylvania students who take computer science Advanced Placement (AP) courses is relatively small, those students score better than their peers across the nation. Data suggests that more needs to be done to increase equity in AP courses because the demographics reported for those courses do not reflect the diversity of students enrolled across the state.

There is little data available regarding the state's dual enrollment offerings, which is reflective of the lack of a statewide framework for dual enrollment. Pennsylvania is one of only two US states that does not have such a framework in place (Jamieson et al., 2022).

Recent investments in the Pennsylvania Training and Technical Assistance Network (PaTTAN) centralized a repository of computer science-specific K-12 pathway resources and toolkits, including the CSinPA Data Dashboard. The dashboard gives valuable insights into the availability of computer science education at the K-12 level and holds potential to bridge gaps in understanding about equity in access to college prep programming, career pathways, and future postsecondary enrollment.

The dynamics influencing the following recommendations are outlined in the following report, with the recommendations fully detailed in the closing segment.

Recommendations

The Commonwealth of Pennsylvania has a goal to provide statewide access to high quality computer science education that contributes to general digital literacy and encourages teaching and learning along the computer science career pathways that lead to

high-demand occupations that drive economic growth. To do this, it is essential to nurture current successes, bolster effective strategies, and address gaps in continuity between education, workforce development, and the employment landscape.

The following recommendations are intended to strengthen the state's approach to providing computer science education.

1. Further develop the CSinPA data dashboard to increase capacity for data-driven decision-making.
2. Engage a broader range of partners to strengthen the computer science education continuum and career pathways.
3. Prioritize accessibility in computer science education to ensure all students, including students with disabilities, can fully participate.
4. Support policy changes that support creating equitable pathways to computer science learning.
5. Increase and diversify the certified computer science teacher workforce to enhance the rigor and quality of K-12 computer science instruction.

INTRODUCTION

In a 2022 ECEP publication, Ottenbreit-Leftwich et al. recommended that policymakers "evaluate the relationship between who is teaching computer science courses, schools offering computer science courses, and the demographics of students participating in computer science courses" (p. 4). This Landscape Report contributes to that work, by establishing a baseline assessment of computer science education in Pennsylvania, to inform and support goals, policies, and practices for broadening participation and success in computing and computing-intensive pathways. The report was developed by a working group formed in 2023 of researchers, educators, school administrators, community members, and industry representatives. Work was facilitated through asynchronous collaboration, synchronous virtual meetings, and two 1-day, in-person convenings at PaTTAN Harrisburg (December 2023 and February 2024).

Significance of Computer Science

Computer science (CS) is "the study of computers and algorithms, including their principles, their hardware and software designs, their implementation, and their impact on society" (Computer Science Teachers Association, 2017). "Science, technology, engineering, and math (STEM), including computer science" is identified by PDE as one of 17 subject areas that comprise a "well-rounded education" (PDE, 2019, p. 100).

Computer science is transforming society, and computer science education is becoming imperative for all K-12 students, regardless of their post-secondary plans (Ryoo et al., 2020). In its 2022-2026 strategic plan, the National Science Foundation (NSF) observed that technology has "…already affected many aspects of human life, transforming our work, learning, interactions within communities, and even our sense of self" (NSF, 2022, p. 25).

The computer science pipeline metaphor is often used to describe the progression of students from K-12 education through higher education and into the workforce. However, this model oversimplifies the complex realities of educational pathways. To effectively prepare students for computer science careers, it is essential to examine the various factors that impact their pathways. By understanding the challenges and opportunities within the K-12 computer science education, educators, industry leaders, policymakers, and other vested partners can work collaboratively to ensure students are prepared for diverse, fulfilling postsecondary pathways in all fields, not just the technology sector.

CS Workforce

There is a good deal of documented occupational demand (annual demand 1,533) and growth (13.9 percent through 2032) for computer and information systems (SOC 11-3021) within Pennsylvania's workforce (CWIA, 2022). CS occupations are expansive and exist across the industry spectrum. Indeed.com shows more than 900 full time jobs in August 2024 with a wide range of employers in education, banking, retail, and municipal settings. The Pennsylvania Department of Labor & Industry estimated that in 2022, 178,480 people worked in "computer & mathematical occupations," and 168,870 worked in "computer occupations" (Center for Workforce Information and Analysis (CWIA), 2022). The Ten-Year Strategic Plan for Economic Development projects 17,000 net new jobs created across robotics and technology sectors over the next decade, showing that Pennsylvania is primed to become a leader in these high-growth industries (Sterling, 2024, p. 24).

Beyond those computer-specific careers, occupational employment forecasts highlight expected high demand for workers in occupations that use computer science skills or knowledge over the next two years (CWIA, 2022). This includes everything from advanced manufacturing technicians in computer-driven production to agri-STEM engineers developing new high-tech hardware and software applications. Creating equitable education pathways for developing computer science skills and knowledge is essential for Pennsylvania to meet the growing demand for jobs that are transforming the state's economy.

Post-Secondary CS Education

Of the 330 institutions of higher education in the state of Pennsylvania that report data to the annual National Center for Education Statistics (NCES) IPEDS survey, 143 institutions offered at least one Computer Science degree (defined as any degree program within Classification of Instructional Programs [CIP] Code 11) and three of them offered a Computer Science Education degree (defined as degree programs with CIP code 13.1321). Of those, 133 Computer Science degree programs reported graduates in these degree programs in 2022; 48 of those schools awarded associate's degrees (1,206) and 102 awarded bachelor's degrees (5,548) in CIP-11 programs. Further examination of enrollment and completion data for computer science degree programs is not possible with publicly available datasets.

The NCES IPEDS survey provides aggregate enrollment data for all programs across an institution but does not provide access to enrollment data disaggregated by CIP code at the institutional level. Nor can the data be disaggregated by student gender, race, ethnicity, or

any other identity. The Pennsylvania State System of Higher Education reported 2,793 undergraduate and 193 graduate level computer science majors in 2022 enrolled in public institutions throughout the state and a 4-year graduation rate of 36 percent for the 2019 cohort; however, further disaggregation of statewide data does not appear to be available.

The lack of access to such data limits the ability to analyze potential investment needs to build capacity for postsecondary computing education to meet future workforce needs, to identify equity gaps in participation in postsecondary computing education, to identify potential needs for bridges and pathways from K-12 to postsecondary computer science programs, and to set goals for broadening participation in postsecondary computing education. Being able to compare enrollments to degree completions (with demographic data) and workforce demand would help institutions and state leaders understand where there may be mismatches in the demographics of who is entering programs and who is completing them, and how those completions contribute to or exacerbate demand in the workforce.

K-12 Computer Science Education

In addition to preparing learners for a wide range of careers, K-12 computer science education supports cross-discipline learning, and enables students to enact social change (Montoya, 2017; Nager & Atkinson, 2016; Vegas et al., 2021). Studies have found that K-12 computer science (CS) education positively impacts students' math abilities, problem-solving skills, and college enrollment rates (Brown & Brown, 2020; Fan, 2022; Montoya, 2017; Vegas et al., 2021).

Underrepresentation in computer science education in PA includes female students and Black/African American, Hispanic/Latinx, and Native American/Alaskan students as well as students from rural communities, socioeconomically disadvantaged students, English learners, and students with disabilities.

Despite this critical importance, K-12 computer science (CS) education is not mandated to the extent that STEM education is at the federal and state level (Decker & McGill, 2019; Fan, 2022; Israel et al., 2015). The patterns seen nationally in CS education and documented by the US Department of Education and the National Science Foundation reveal that those underrepresented in CS professions are the same who are underserved in CS education. This includes students who are Hispanic, Black, low socio-economic status/low income, those with disabilities, and also female students (Aiwohi, 2024; Fancsali & Israel, 2021; Johnson, 2020).

As of the 2021-22 school year, 71 percent of Pennsylvania public high schools offered foundational CS courses, but those courses engaged only 10 percent of high school students (Code.org et al., 2023a). Student data for K-12 computer science instruction does not allow examination of specific elements of career pathways aimed at facilitating transition between educational milestones like high school and post-secondary experiences. A lack continuity in data from K-12 to postsecondary limits the ability to assess the effectiveness of various efforts to improve access and equity in access to computer science instruction and career pathways. The demographics of participation in CS education is a complex question, and the troubling lack of data regarding who is and who is not being served in PA schools (and at what level of academic rigor) can only be answered through much more complete reporting and analysis. The findings presented in this report rely upon the data currently available, with recognition of significant gaps and inconsistencies in measures, all of which must be addressed in order to make better data-informed decisions for CS education.

Data on elementary CS access and participation is limited in PA and nationally because CS is commonly integrated into instruction, rather than taught as an explicit course that is reported to the state (PIMS). Due to this limitation, the majority of data in this report is focused on grades 7-12, unless otherwise noted. One key recommendation of this report is that capacity for data collection in K-6 be increased, in order to make data-driven CS education decisions for those grades.

Course and site enrollment data for K-12 public schools and districts published by PaTTAN, PDE, and the U.S. Department of Education was used for this landscape report. Limitations are identified throughout the report where necessary. Data quality is more challenging in computer science than in core subjects, for which course enrollment data is mandated and uniform (Dunton et al., 2022). Computer science is a relatively new and unmandated discipline, and data collection and reporting vary widely.

Prior to 2020-21, reporting K-12 computer science courses was voluntary in Pennsylvania. Data reporting for K-12 computer science enrollment data in Pennsylvania became mandatory in Pennsylvania in 2020-21 when the Pennsylvania Department of Education began requiring schools and districts to “submit all courses, instructor assignments, and student course enrollments, in all subjects” for Pre-Kindergarten to grade 12 through the Pennsylvania Information Management System, commonly known as PIMS (PDE, 2021).

Although reporting is mandatory, data quality remains vulnerable at local data entry, as is common in other states (Zarch et al., 2024). PDE requires schools and districts to assign a National Forum on Education Statistics' School Codes for the Exchange of Data (SCED) code to every course, based on the content covered in the course. (PDE, 2021). PDE provides PIMS instructional manuals and technical assistance but is not directly involved in the assignment of course codes to courses.

The majority of data in this report is focused on grades 7-12, unless otherwise noted. Data on elementary CS access and participation is limited in PA and nationally because CS is commonly integrated into instruction, rather than taught as an explicit course that is reported through PIMS. There is very limited elementary CS course data, and what data is available varies widely in accuracy. 27 schools reported that every student in one or more grade levels between kindergarten and eighth grade were enrolled in the high-school level course, Computer Science Principles, in 2021-22 (Frey, 2024). Two schools, (serving grades 1-8 and K-6) reported schoolwide participation in the course.

Expanding K-12 CS with CAPE

This report focuses on K-12 education in computer science and employs the CAPE framework to analyze and evaluate the landscape of opportunities and challenges within this field. Achieving computer science for all students requires identifying and addressing equity gaps for historically underrepresented students in computer science education (McGill et al., 2022). The Expanding Computing Education Pathways (ECEP) Alliance is a federally funded, nationally recognized program that has been leading the work to broaden participation in CS education for more than a decade. The Commonwealth of Pennsylvania joined ECEP in 2023, so that PA teachers and students can benefit from their research and resources.

One important ECEP resource is the CAPE Framework, which brings a critical lens to understanding who is in computer science courses, what factors create or block enrollment opportunities, and how students experience or engage in computer science courses. The CAPE framework was developed to support broadening participation efforts by drawing attention to factors of inequities in computer science education for historically underrepresented students across four components: Capacity for, Access to, Participation in, and Experiences of computer science education (Fletcher & Warner, 2021). It poses questions about enrollment disparities such as those based on gender, geography, socioeconomic status, ethnicity and other identities.

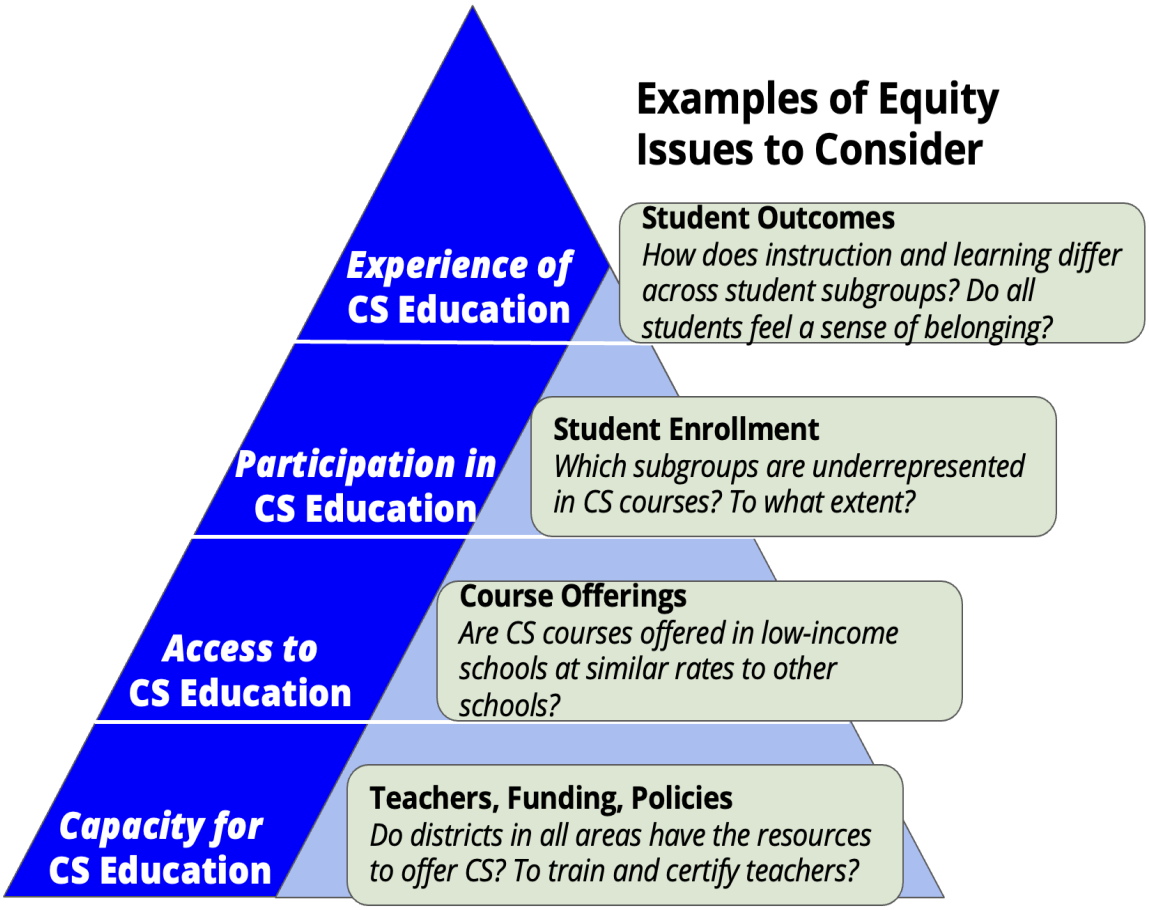

Figure 1 - Capacity, Access, Participation, and Experience (CAPE) *A Framework for Examining Equity in CS Education* (Fletcher & Warner, 2021)

This framework is a tool that allows educators and education leadership to look across the CS ecosystem and focus on finding root causes that can be addressed in order to broaden participation. The four components of the framework build progressively, each dependent upon the previous component. Each of the four components are discussed in detail in the subsequent sections.

The CAPE framework is at the heart of this Landscape Report, providing the context and measurement of inclusive and equitable computer science education.

CAPACITY

Broadening participation in computer science begins with Capacity– the availability of resources, including faculty, funding, and policies, to support CS (Fletcher & Warner, 2021).

Teachers

Answering "Who teaches computer science in Pennsylvania?" requires understanding local contexts, many of which are immeasurable within current state data systems. The quantities and demographics of computer science teachers in the CSinPA data dashboard are representative of individuals who are teachers of record of computer science courses. Teachers who integrate computer science into other subjects are not included in the data.

The majority of 7-12 CS educators in Pennsylvania identify as white (>95 percent), with few educators reflecting the demographics of the student body. The gender split over the 2,424 computer science educators is balanced at just over 51 percent female and approximately 48 percent male. The majority of these educators hold a master's degree (1,553) or a bachelor's degree (807), while 32 hold no degree, and 29 hold doctorates or specialist degrees.

Table 1 - Age of CS Educators Grades 7-12

Age	< 26	26 - 30	31 - 40	41 - 50	51 - 60	60+
# of CS Educators	59	166	649	808	634	108

Source: (CSinPA Data Dashboard, 2023)

Table 2 - Years of Service of CS Educators Grades 7-12

Years of Service	0 - 9	10 - 19	20 - 29	30+
# of Computer Science Educators	737	927	646	114

Source: (CSinPA Data Dashboard, 2023)

Teacher Certification

Per policy requirements (22 Pa. Code § 49.13(b)(10)) the Pennsylvania Department of Education (PDE) has formulated the Certification and Staffing Policies and Guidelines (CSPG) to offer direction on adhering to state laws governing certification and staffing practices within school entities across the Commonwealth.

There is currently no specific certification for teaching computer science in Pre-kindergarten through sixth grade, but PK-6 computer science is briefly addressed under CSPG 71, the staffing guideline for 7-12 CS. PK-6 educators may teach computer science consistent with the grade level limitations of their certificate (PDE, 2023). Recommendations are made however, for elementary teachers to participate in professional learning–most specifically to increase their own knowledge and skills in CS. There is no statewide system for collecting and reporting data on K-6 teachers' attendance at computer science professional learning, so it is difficult to measure the participation in and impacts of professional learning on teachers' practices.

CSPG 71 requires any educator who is employed to teach 7-12 grade CS courses for the first time in 2023 or later are now required to become certified in computer science (PDE, 2023). Prior to CSPG 71, teachers holding specific certifications, as listed below, were permitted to teach 7-12 grade computer science courses under Act 86. With CSPG 71, educators holding any of the certificates listed here who were employed to teach 7-12 CS prior to 2023 may continue teaching their current courses under a temporary license, as long as they remain in the same LEA:

- Science 7-12 Certificates
- Mathematics 7-12 Certificate
- Middle Level Math and Science Certificates 6-9

- Grades 4-8 certificates with Math and/or Science concentrations (applies to teachers of 7th and 8th grades)
- Business Computer Information Technology PK-12
- Technology Education PK-12 (PDE, 2023).

From school years 2018-19 to 2022-23, between 31 percent and 35 percent of CS teachers were non-compliant with PDE's certification requirements to teach a CS course (Schwarzhaupt et. al., 2024).

Teacher Preparation

Teacher preparation is often cited as the most significant factor in expanding computer science education (Garvin et al., 2019; Joshi & Jain, 2018; Judson & Glassmeyer, 2019; Vegas et al., 2021; Webb et al., 2017). Educator preparation is especially crucial in computer science because many teachers are recruited from other subjects and may lack training in relevant content and pedagogy (Saffar-Perez, 2024; Vrieler & Salminen-Karlsson, 2022).

The Pennsylvania Department of Education (PDE) works through and funds the Pennsylvania Training and Technical Assistance Network (PaTTAN) and the 29 Intermediate Units (regional clusters of educational service units) to provide training and technical assistance in CS. As tasked by the Pennsylvania Department of Education (PDE), the CSinPA initiative at the Pennsylvania Training and Technical Assistance Network (PaTTAN) leads statewide efforts to expand equitable K-12 computer science education. The CSinPA initiative at PaTTAN provides access to free professional development in multiple modalities, including the annual CSforAllPA summit that brings educators, educational leaders, and policy makers together to learn and collaborate around tools, pedagogies, and best practices in CS education. All professional learning programs designed and offered by PaTTAN are guided by research-driven frameworks and evidence-based practices, including the Universal Design for Learning (UDL) framework and PDE's Culturally relevant and Sustaining Education (CR-SE) Program Framework Guidelines (PDE, 2022).

Additionally, PaTTAN established the Training and Consultation to Implement Computer Science (TACTICS) team to empower TaC from the intermediate units in supporting educators in creating accessible and inclusive CS learning experiences. The TACTICS program supports TaC who want to participate in CSinPA projects at a deeper level and grow their capacity as leaders in CS education via a professional learning community model. TACTICS engage in CSinPA profession learning, collaborate to develop and revise CSinPA resources, and provide technical assistance to participants in CSinPA professional learning. The CSinPA initiative also maintains a digital collection of resources on the

PaTTAN website ("CSinPA toolkits") that includes a variety of resources to assist educators in planning inclusive computer science learning experiences. Among these are the CSinPA Equity Guide, the UDL in CS tool, which allows users to explore CS teaching strategies based on universal design principles, and the CS Instructional Planning Workbook, which guides educators in designing equitable learning experiences using the backward design approach from Understanding by Design (UbD).

K-6 educators

PaTTAN has offered a professional learning pathway specifically designed for K-8 educators since 2018. The program helps K-8 educators enhance their ability to engage students in computer science (CS) learning through stand-alone classes or by integrating CS concepts and practices into other subject areas. Participants engage with CS concepts, experience effective instructional practices, and explore strategies for stakeholder engagement. From 2019 to 2023, 241 LEAs and 1,286 participants were involved in the program.

Other professional learning programs available for K-6 educators in PA include offerings through Code.org's regional partner program with Montgomery County Intermediate Unit and Allegheny Intermediate Unit 3, workshops and technical assistance from intermediate units, and offerings from various vendors and non-profit organizations, such as BirdBrain Technologies, which is based in Pittsburgh. Founded at the CREATE Lab at Carnegie Mellon University in 2010, BirdBrain Technologies is a research-based company that creates hands-on tools, standards-aligned curriculum, and professional development for computer science and STEM learning. CS is Elementary is a national project aiming at engaging K-5 educators in and creating resources and materials to support elementary educators in integrating CS concepts in their instruction.

7-12 educators

The CSinPA 7-12 Certification Reimbursement and Stipend program, provided by PaTTAN and supported by PDE, is available to Pennsylvania educators in public LEAs who achieve the 7-12 CS certification. Through the program, qualifying educators may receive reimbursement for out-of-pocket costs associated with the Praxis exam registration ($130 per attempt) and PDE certification application ($200). Qualifying educators may also receive a one-time stipend of $400.

Regional 7-12 CS certification efforts

The Pathways for Equitable Computer Science Instruction (PECSI) builds capacity for replicable educational pathways for equitable computer science instruction that leads to certification for teachers in secondary schools in Montgomery County, Pennsylvania.

Through conversations with teachers, principals, and district leaders, researchers at Temple University found that recruiting in-service teachers to become computer science certified is challenging for many reasons, including the following factors.

- Lack of interest in the high-pressure, short duration intensive workshop formats typically offered for computer science teacher professional development.
- Lack of incentives that align with intrinsic motivation to participate in computer science professional development.
- Lack of professional recognition and professional capital through informal professional development that could be gained through certification.
- Fear of unintended consequences for poor performance on annual performance evaluations when attempting to teach a new course in a challenging subject with no formal education in computer science
- Lack of support for continued development and implementation of knowledge and skills.

With support from the US National Science Foundation (Award #2122510), PECSI addresses these challenges through a partnership with Temple University's Department of Computer and Information Sciences (CIS) and the Montgomery County Intermediate Unit (MCIU) to develop and implement the Graduate Certificate for Computer Science Instruction program.

PECSI targets in-service teachers to develop the necessary skill set to teach computer science at the secondary level, with a focus on equitable and inclusive instruction. Implemented as a 4-course sequence, the graduate certificate provides knowledge and skill development in computer science content and inclusive pedagogy while addressing teachers' needs for adequate preparation, professional credentialing, and recognition through academic credit. The PECSI project also includes teachers in a community of practice centered around equity-focused computer science instruction and provides instructional coaching. Participating teachers are eligible for the CSinPA 7-12 CS Certification Reimbursement and Stipend program facilitated by PaTTAN. As of December 2023, 20 of the 22 initial PECSI participants completed the first course, with 17 ultimately earning the Graduate Certificate. To date, four participants have passed the Praxis exam and are now certified to teach computer science in grades seven through 12.

The Jumpstart Philadelphia Researcher Practitioner Partnership aims to bring equitable, inclusive, and high-quality computer science instruction to all Philadelphia high school students. The project addresses the shortage of certified computer science educators by

forming a Networked Improvement Community (NIC) involving Drexel University, Temple University, the School District of Philadelphia (SDP), educators, community organizations, and public sector stakeholders.

The project focuses on:

- Offering multiple pathways to computer science teacher certification.
- Identifying and supporting a diverse pool of potential educators.
- Strengthening communities of practice for current and aspiring computer science teachers.
- Developing policies to encourage diversity among computer science educators and learners.

Jumpstart Philadelphia NIC members represent leadership in CS4Philly, an affiliate of the national CS4ALL consortium, and the Philadelphia STEM Ecosystem Computer Science Workgroup. Jumpstart Philadelphia builds on the SDP's plan to provide equitable access to computer science instruction across all 220 K-12 schools, including 54 high schools. Funded by the US National Science Foundation (Award #2219442), the project has engaged 93 teachers in CS Praxis pathway professional development. As of July 2024, 39 SDP teachers have become CS certified.

A key component of the Jumpstart approach is the use of informal coursework, with stipends made possible through a PAsmart advancing grant to support teacher participation. Participating teachers are eligible for the CSinPA 7-12 CS Certification Reimbursement and Stipend program. The project integrates research and education to promote equity and diversity in computer science instruction, by identifying characteristics and needs of students and teachers, and implementing plans that address them. It provides a model for increasing access to teacher professional development with multiple pathways to computer science certification and increased computer science instruction throughout Philadelphia's K-12 school environment.

Computer Science Teachers Association

The National Computer Science Teachers' Association (CSTA) is a professional organization focused on building a strong environment to support K-12 CS educators. Overall, CSTA promotes being a voice for teachers, is committed to equity, provides professional development, and offers community building for all members (CSTA, 2024). CSTA provides both a national membership and regional chapter memberships. In Pennsylvania, there are

four established regional chapters, Pittsburgh, Susquehanna Valley, Longwood, and Philadelphia. Regional chapters provide virtual and physical meetups throughout each school year focusing on topics of equity, community support, teaching practices, and recruitment. As of November 2022, there were 846 registered national CSTA members within the state of Pennsylvania and 346 of those members are affiliated with a regional chapter.

The CSTA Equity Fellows Program represents an important CSTA initiative addressing several key challenges in Pennsylvania's computer science education landscape. This selective, year-long program develops leadership in equitable practices for teaching and advocacy, directly supporting efforts to broaden participation and improve access to quality CS education across the state. Pennsylvania's Equity Fellows, including Sandra Hartman (2020-21), Jigar Patel (2022-23), and Sofia De Jesus (2023-24), serve as role models and change agents, working to diversify the predominantly white, male CS teacher workforce highlighted in the state's demographic data. Their efforts align closely with Pennsylvania's goals to increase equity in CS education and provide valuable professional development resources for educators. Their work addresses several barriers identified in the landscape report, including lack of teacher preparation, access and equity issues, and the need to change perceptions about computer science. By integrating the Equity Fellows' initiatives into existing state efforts, Pennsylvania can leverage this program to support its recommendations for scaling up targeted investments in teacher professional development and strengthening connections between various stakeholders in the CS education ecosystem. The Fellows' focus on equity and inclusion complements the state's data-driven approach, potentially informing future enhancements to the CSinPA Data Dashboard and other equity-focused initiatives.

Funding

In 2016, Pennsylvania Governor Tom Wolf established the PAsmart initiative to prioritize computer science education in the administration's policy agenda, programming, and annual budget (Commonwealth of Pennsylvania, 2024). Anecdotal evidence and scattered data points indicate that between 2016 and 2023, CS education in Pennsylvania was shaped by investments in the PAsmart targeted grants program (Commonwealth of Pennsylvania, 2024). However, the programs were each designed to be short-lived, so meaningful change has been hard to measure. The grants were awarded at two levels and evaluation of the grant program suggested that the higher-level grants, which provided for more funds to plan for and implement new courses, including steps to ensure qualified

instructors are available, had greater impacts on enrollment and teacher quality measures (Schwarzhaupt et al. 2024).

Two rounds of PAsmart targeted grants were distributed to support schools with limited to no computer science offerings (PDE, 2023a). Three hundred and fifty-seven school districts received targeted grants, as well as career and technical centers, charter and cyber charter schools, and intermediate units. Each grantee was awarded $35,000 for computer science professional learning, technical assistance, and resources. In the second round of PAsmart targeted grants, LEAs were required to participate in strategic planning that addressed computer science as part of a comprehensive education plan. Professional development using the Strategic CSforALL Resource and Implementation Planning Tool (SCRIPT) was provided at no cost by PaTTAN.

Three rounds of PAsmart advancing grants supported building partnerships and ecosystems that support the expansion of STEM and CS experiences at a larger scale. In total, there were 758 proposals from 502 schools and $100,251,666 in funded grant awards. These grants were made to individual schools, intermediate units, higher education institutions, and libraries. The largest percentages of funding went to districts (47.36 percent), intermediate units (30.02 percent), and post-secondary institutions (18.93 percent; PAsmart, 2024). Awarded grants focused on integrating STEM with an emphasis on computer science in existing science courses and also as stand-alone computer science experiences for students. The grants had an additional aim to include historically underrepresented groups, including women, minorities, and economically disadvantaged students, in STEM and CS. The proposals also focused on issues in rural areas of the state and the unique challenges faced by more isolated communities. Common approaches included building partnerships with local post-secondary institutions, businesses, and community organizations as well as building capacity through teacher professional development, the creation of out-of-school time activities and improving infrastructure and equipment to support teaching STEM and CS.

Policy

While the calls for increasing CS education via policy changes have a decades-long history, calls to action specifically targeting state education agencies began in 2017 when the Code.org Advocacy Coalition published policy recommendations to make computer science a foundational component of K-12 education (Code.org et al., 2023b).

These 10 recommendations were based on extensive research that shows their impact on moving the needle in computer science education (Garvin et al., 2024; Levitt & Ray, 2024; Mak & Torrejon Capurro, 2024; Parker & Hendrickson, 2022; Zarch et al., 2020). Research has shown that in states that adopt at least seven of these policies, the number of high schools offering CS is 23 percent higher on average (Code.org et al., 2023b).

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1. ***Create a statewide plan for K-12 computer science.***
2. **Define computer science and establish K-12 computer science standards.**
3. **Allocate funding for computer science teacher professional learning.**
4. **Implement certification pathways for computer science teachers.**
5. **Create programs to encourage all preservice teachers to gain exposure to computer science.**
6. **Establish dedicated computer science positions in state education agency.**
7. ***Require that all schools offer computer science.***
8. ***Allow computer science to count toward a core graduation requirement.***
9. **Allow computer science to satisfy a higher education admission requirement.**
10. ***Require all students take computer science to earn a high school diploma.***

Table 3 - Code.org Advocacy Coalition Policy Recommendations for State Education Agencies (Code.org et al., 2023b)

Since 2017, the percentage of Pennsylvania high schools offering foundational computer science courses has increased by 4 percent annually (Code.org et al., 2023a). Currently, Pennsylvania meets the requirements for six policies, but not the most impactful policies (Code.org et al., 2023a). The 2023 State of CS Education report recommended that Pennsylvania create a state plan for computer science education (#1) and require that all high schools offer at least one computer science course (#7).

Standards

The K-12 Computer Science Framework (*K-12 Computer Science Framework*, 2016) was developed through a national partnership of educational institutions, and provided the basis of the CSTA K–12 Computer Science Standards for Students. The framework is "designed for all students, regardless of their age, race, gender, disability, or socioeconomic status." The structure and content of the framework were designed to reflect the need for

student diversity in computing and attention to issues of equity, including accessibility. The standards provide a scope and sequence for LEAs to design a comprehensive K-12 computer science education experience, illustrate similarities and links between computer science and other areas of STEM education, and tie directly to widely used math and science standards documents (Mohr-Schroeder, 2019).

In 2017, the Pennsylvania State Board of Education endorsed the CSTA K-12 Computer Science Standards for Students (PDE, 2017). However, at this time there is no mechanism in place to track if, and to what degree, schools implement the standards.

New opportunities and challenges for implementing the computer science standards arose with the introduction of Pennsylvania's new Science, Technology and Engineering, and Environmental Literacy and Sustainability (STEELS) standards in 2022. Curriculum leaders and educators working to implement the STEELS standards must balance current accountability-driven efforts for science with unmandated efforts for computer science. Although there are commonalities, the STEELS standards do not fully address all foundational concepts and skills identified in the CSTA standards. Crosswalks created by the PaTTAN CSinPA initiative are available to support curriculum development.

The CSTA standards are referenced in Act 86 of 2016, which permitted a computer science course to count as a math or science credit toward high school graduation requirements (PDE, 2017). Thirty-six other states have similar policies allowing computer science to count as math or science (Mak & Torrejon Capurro, 2024). Advocates use Act 86 as evidence that computer science should be a part of primary course pathways, and not be viewed as only an elective or extracurricular activity. Data about local implementation of Act 86 is unavailable, making it difficult to measure what impact the policy has on expanding access and participation in computer science education.

School Culture and Ideology

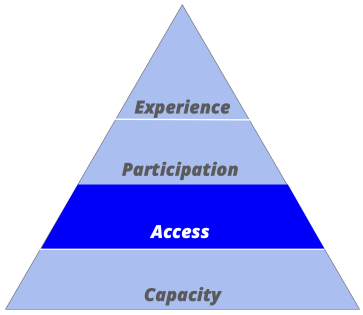
Buy-in and support from administrators and counselors is crucial for expanding equitable computer science education (Fancasli et al., 2020; Garvin et al., 2019; Joshi & Jain, 2018; Koshy et al., 2022; Levitt & Ray, 2024; Parker & Hendrickson, 2022). In a 2022 national survey, 28 percent of computer science teachers identified administrator support as a major challenge, and 25 percent identified counselor support as a challenge (Koshy et al., 2022).

PDE and PaTTAN collaborate with the national non-profit organization, CSforALL to provide opportunities for school and district leaders to engage alongside their faculty in strategic

planning for computer science education, using the Strategic CSforALL Resource and Implementation Planning Tool (SCRIPT). SCRIPT is a unique computer science professional learning experience for administrators, counselors, and educators. Through SCRIPT, teams use rubrics to self-assess their district on computer science materials and curriculum, leadership, teacher capacity and professional development, partnerships, community engagement, and technology infrastructure. Based on the results, teams craft short and long-term goals as part of a strategic plan for a comprehensive K-12 computer science education program (CSforALL, 2023). SCRIPT workshops and supplemental technical assistance are available to Pennsylvania districts at no cost and are facilitated by PaTTAN and intermediate unit consultants. To date, nearly half of Pennsylvania's 500 public school districts have participated in SCRIPT.

Case Study: Counselors for Computing

The National Center for Women in Information Technology (NCWIT) Counselors for Computing (C4C) program provides information and resources that help counselors join the front line of the CS education pathway conversation through professional development opportunities. Counselors 4 Computing Program attendees leave with full knowledge of computer science, computational thinking, and action steps to increase access and equity in computer science skills and learning opportunities. Attendees receive resources and hands-on learning activities to help them engage with students, administrators, and teachers. They explore and discuss diversity and equity in CS education and professions. Supported by PaTTAN and PDE, more than 400 educators in Pennsylvania have participated in programming offered by NCWIT, including a program facilitated by Millersville University as part of a PAsmart advancing grant project. In addition, 10 Pennsylvania school counselors have participated in further NCWIT C4C training, including leadership development so they can present to other counselors on behalf of NCWIT.



ACCESS

The second step in the CAPE Framework is examining Access. Are courses available to all students? The total number of computer science courses and the availability of advanced classes contribute to a school's access.

Measuring access solely on the grounds of whether or not courses are offered is difficult to do on a large scale. Listing a course in the annual course catalog is different than enrolling and teaching students in the course. As a result, access is commonly determined by whether a school reports enrollment in a CS course. In this report, access is measured with PIMS enrollment data for foundational computer science courses, as listed in the chart on the next page.

K-8

As discussed earlier, data on elementary CS access and participation is limited in PA and what data is available varies widely in accuracy because CS is commonly integrated into instruction, rather than taught as an explicit course that is reported through PIMS.

Based on self-reported data from the national "CS is Elementary" project, there are 93 school districts in PA where the elementary schools are teaching computer science.

The following schools in PA achieved CS 100 Awards in 2023:

- Chartiers Valley Primary School - Bridgeville, PA
- Gettysburg Montessori Charter School - Gettysburg, PA
- Northern Bedford County Elementary - Loysburg, PA
- Old Forge Elementary - Old Forge, PA
- Chartiers Valley Intermediate School - Pittsburgh, PA
- Pittsburgh Woolslair K-5 - Pittsburgh, PA

Foundational High School Computer Science Courses

SCED code	Title
10011	Computer Science Principles
10012	Exploring Computer Science
10013	Project Lead the Way (PLTW) Computer Science Essentials
10014	PLTW Computer Science A
10015	PLTW Computer Science Principles
10019	Advanced Placement (AP) Computer Science Principles
10021	Computer Science Discoveries
10054	Data Systems / Processing
10151	Business Programming
10152	Computer Programming
10153	Visual Basic Programming
10154	C++ Programming
10155	Java Programming
10156	Computer Programming – Other Language
10157	AP Computer Science A
10158	AP Computer Science AB
10159	International Baccalaureate Computer Science
10160	Particular Topics in Computer Programming
10197	Computer Programming – Independent Study
10198	Computer Programming – Workplace Experience
10199	Computer Programming – Other
10205	Computer Gaming and Design
10206	Mobile Applications
21009	Robotics
02156	Computer Mathematics with Algebra

Note. Foundational computer science course – a course aligned with the definition of computer science and includes a "minimum amount of time applying learned concepts through programming" (Code.org, CSTA, & ECEP Alliance, 2023a, p. 32). A K-8 foundational

computer science course contains at least 10 hours of programming, whereas a foundational 9-12 grade course contains at least 20 hours.

Similar to national trends, Pennsylvania schools in city and rural locales are less likely to offer computer science courses (Code.org, CSTA, & ECEP Alliance, 2023). Access also varies sharply between small (52 percent) and large (94 percent) schools.

7-12

In 2022, 75% percent of high schools across the commonwealth reported enrollment in at least one computer science course, compared to the national average of 60% (Code.org, CSTA, & ECEP Alliance, 2024).

These offerings encompass a diverse range of options but do not include additional offerings through career and technical education (CTE) programs, extracurricular activities and out of school time programs.

The courses covered a wide spectrum of topics, with the majority of schools offering between one and five distinct courses. Among the listed courses, the most commonly offered include:

- Computer Programming (250 schools)
- Web Page Design (205 schools)
- Computer Science A (194 schools)
- AP Computer Science Principles (163 schools)
- Exploring Computer Science (75 schools)
- Java Programming (68 schools)
- C++ (29 schools)
- Business Programming (10 schools)
- Cisco Panduit Network Infrastructure Essentials (8 schools)

A review of the state-of-the-state and student data indicate an ongoing need to ensure that all students have access to high-quality, rigorous CS courses that adequately prepare them for the demands of today's technology-driven world.

Geography is one factor in differences in access in the commonwealth and across the U.S. Figure 1 compares access by geography in Pennsylvania to national averages, and Figure 2 compares access by school size. On average, PA provides more access to CS courses than the national average; however, there are notable gaps between PA schools. Table 2 illustrates the lack of consistency across small, medium, and large districts.

Case Study: Chartiers Valley District

Chartiers Valley is a suburban school district located a few miles south of Pittsburgh with approximately 3,500 students. The student body is diverse with over 45 different countries represented and more than 30 different languages spoken by students. Approximately 14 percent of students qualify for special education and approximately 35 percent are economically disadvantaged.

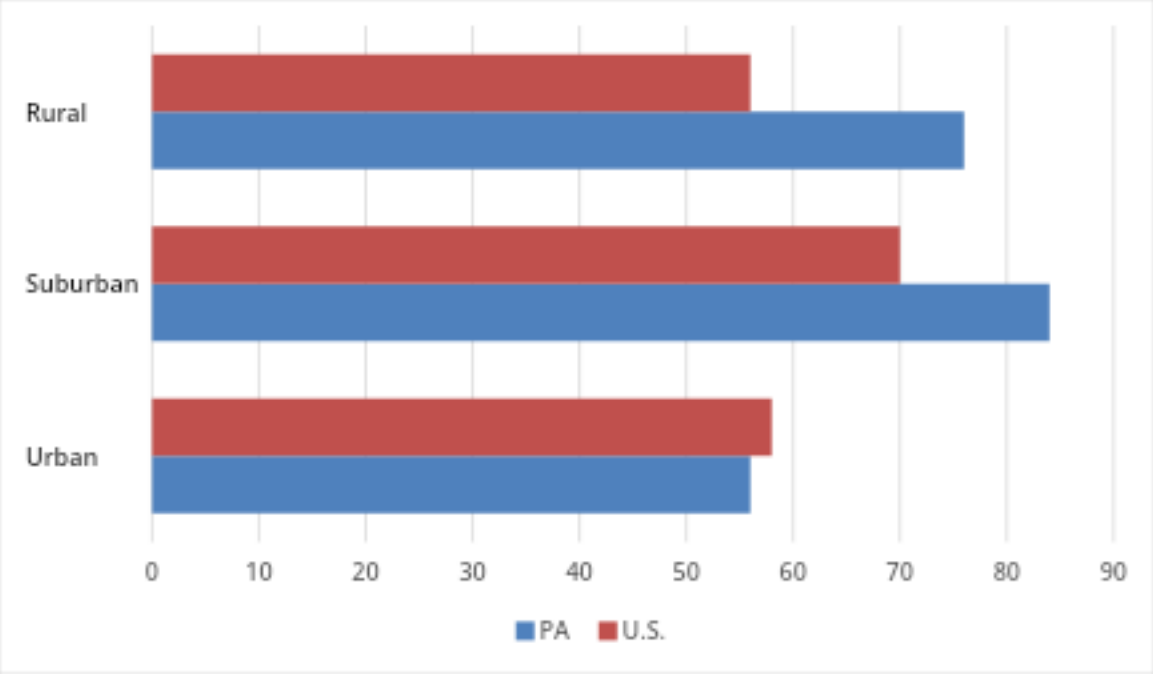
Over the past two years, Chartiers Valley School District has led a pilot project for the CSinPA team at PaTTAN through the Zero Barriers initiative from the Smithsonian Institute. With an introductory focus on the Intermediate School (grades 3-5), the district is working hard to increase accessibility and equity in computer science learning. While all Chartiers Valley Intermediate School students engage in foundational computer science learning during a library class, the district aimed to increase computer science learning opportunities. Initial efforts focused on aligning curricular activities across all disciplines to the CSTA standards and developing accommodations to help all students succeed, with support from PaTTAN CS consultants and Alleghany Intermediate Unit Training and Consultation (TaC). Another early project success was an after-school coding club co-facilitated by the librarian and emotional support teacher. The club ran twice in 2023-24 with highly positive results.

Building on the success of the intermediate school's computer science activities, the district has extended its efforts to the primary school. Here, students engage in computer science during Technology class, which is held once per special area rotation. The course is designed to provide whole group, small group, and individual project-based learning, allowing for different pathways based on individual student skills and needs. This individualized approach underscores the district's commitment to catering to the diverse needs of its students.

Additional plans to expand equitable computer science in CVSD focus on the secondary grades. Middle school students engage in computer science during Technology Education and Business courses offered at various points throughout the three years. The high school

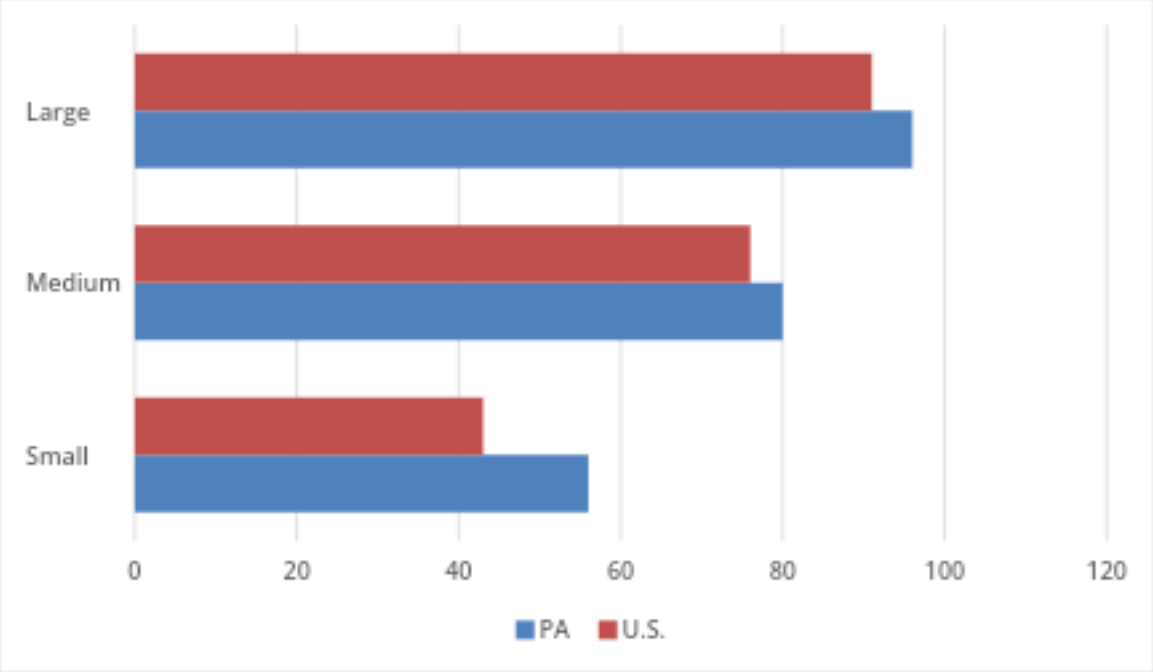
offers several computer science courses, including AP Computer Science A and AP Computer Science Principles. The district plans to create a new high school course that allows students to become directly involved in the computer science and technology field. Students will partner with the computer science teacher and technology department to help drive the curriculum and hands-on opportunities.

Figure 1 – Percentage of High Schools with CS Courses by Geography



Source: (Code.org, CSTA, & ECEP Alliance, 2024).

Figure 2 – Percentage of High Schools with CS Courses by School Size



Source: (Code.org, CSTA, & ECEP Alliance, 2024).

Table - School District Size and CS Course Offering

School Size	# of CS Courses (K-6)	# of CS Courses (7-12)
Large Town	**1**	**9**
Medium Town	**2**	**3**
Small Town	**0**	**3**
Small Urban A	**1**	**5**
Small Urban B	**1**	**8**

Table - School District Size and Student CS Standalone Course Enrollment Grades 7-12

School Districts	Number of 7-12 Students Enrolled in District	Number of 7-12 Students in CS Courses	Percent of Students in a CS Course (%)
Large Town (Pop. 30k-50K))	3497	1120	32.02%
Medium Town (Pop. 10K-30K)	2360	1614	68.39%
Small Town (Pop, <10k)	380	131	34.47%
Small Urban A (Pop. >50K)	6540	3563	54.48%
Small Urban B (Pop. >50K)	7066	1098	15.54%

Source: (Future Ready, 2023, CSinPA Data Dashboard, 2023)

Increasing understanding of what leads to better or lesser access to foundational CS courses will be an important focus of future research.

Advanced Placement (AP) Courses

Advanced Placement (AP) courses offered by the College Board are a unique opportunity for high school students to earn college credit while engaging in computer science learning. AP courses are taught by high school teachers, but are developed and reviewed by higher education faculty to ensure appropriate rigor for college-level CS credit. Students who pass the end of course exam with a score of three or better are eligible for college credit from most higher education institutions.

There are two AP computer science courses: AP Computer Science A and AP Computer Science Principles. AP Computer Science A and AP Computer Science Principles are both introductory courses, but some people assume AP Computer Science Principles is a precursor to AP Computer Science A (Sax et al., 2022). Both courses meet the definition of a

foundational computer science course and are widely viewed to be an appropriate introductory level course for high school students. Computer Science A focuses on the programming language, Java. Computer Science Principles does not have a designated programming language (College Board, 2023). In Computer Science Principles, students learn broad computer science concepts, explore the societal impacts of computer science, and design algorithms to solve problems. The AP Computer Science Principles exam contains a shorter end-of-course written exam than AP Computer Science A, plus a performance task that students complete throughout the course as part of class activities.

Access to AP computer science courses varies by school in Pennsylvania. In 2021-22, AP computer science courses were offered in 274 Pennsylvania schools with 9-12 grade students (CSinPA Data Dashboard, 2023).

Some schools may not offer AP courses because the College Board requires commitments from the school, teachers, and students. For the school and teachers, there are course audits, mandatory professional development, and fees. For students, each exam costs approximately $100, although socioeconomically disadvantaged students may qualify for reduced fees. Schools may offer courses aligned to AP-endorsed curriculum without engaging in the College Board's AP program. For Computer Science Principles, this is seen with differences in course enrollment reporting in PIMS. AP Computer Science Principles (SCED code 10019) is unique from Computer Science Principles (10011) and Project Lead the Way Computer Science Principles (10015). In 2021-22, 16 Pennsylvania schools offered both AP Computer Science Principles and Computer Science Principles.

Career and Technical Centers

In addition to traditional high schools, Pennsylvania provides Career and Technical Center (CTC) programs for high school students. There are 80 CTCs located throughout the state, offering courses as a part of the public education system (credit-bearing, free of charge). Five programs within those CTC options include computing-related programs: Computer Programming General, Web Page and Digital/ Multimedia, Computer Network/Telecommunications, Electromechanical/ Electronic, and Computer/Computer Systems. Not all CTCs offer the same programs, and it is not known at this time which CTEs offer which of these programs, nor which or how many high schools have access to the CTEs with CS courses.

Dual Enrollment

Another option for secondary students is dual enrollment (DE) courses offered through community colleges (CCs) and other higher education institutions. DE is an evidence-based practice to address credential gaps across race and class, declining enrollment in public colleges, and a lack of skilled workers (Forman & Ngongi-Lukula, 2021).

Pennsylvania does not have a statewide DE program; therefore, implementation varies dramatically across the state depending on the agreements between the institutions of higher education and the school district. It also means that it is hard to judge the equity of access to CS education through these opportunities.

The processes that school districts use to provide instruction also vary, ranging from students being taught by college-approved secondary teachers, to the college partner providing access to their courses with their professors, to professors who visit the school district to teach the course–each of which provides different levels of access. In all cases, high school students receive college-level credit for completing the courses that apply to undergraduate degree programs at the partnering institution of higher education. The cost of attending DE programs varies by district.

Case Study: Harrisburg University

Harrisburg University offers dual enrollment (DE) computer science courses through two models. In the *traditional* DE model, students attend classes on HU campuses in Harrisburg or Philadelphia and receive instruction by full-time or full-time corporate faculty. The *College in the High School (CiHS)* model involves an educational agreement between HU and a school district. Students attend courses at their high school and receive instruction from high school teachers who undergo a vetting process with HU prior to becoming corporate faculty.

Both DE programs introduce students to the college environment, where they can explore majors and get a head start on a Bachelor of Science degree. High school sophomores, juniors, and seniors are eligible for DE. Students may take up to 11 credits per semester or 23 credits in a year. As an accredited university, HU DE course credits are accepted by other institutions. Depending on the college and course of study, HU courses may transfer as general education, major requirement, or elective credits.

Currently, HU offers five DE computer science courses:

CISC 103 – Introduction to Computer & Information Sciences
CISC 120 – Programming I
CISC 140 – Programming II (Prerequisite CISC 120)
CISC 160 – Data Structures
CISC 225 – Information System Analysis & Design
ISIT 300 – Web Technologies (formerly CISC 300)

Participation in HU computer science DE courses has increased over the past three years, growing from 93 students in 2021-22 to 209 students in 2023-24.

Out of School Learning

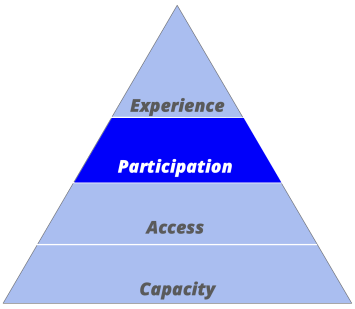
Computer science (CS) learning opportunities extend beyond the traditional classroom. Many students participate in CS activities through after-school programs, community centers, online platforms, and summer camps. These informal settings complement formal education by offering a flexible and creative environment where students can explore CS at their own pace. However, there is currently no widespread data collection on the reach and impact of these out-of-school programs, making it difficult to fully understand their effectiveness in increasing access and participation. The working group responsible for this landscape report began the complex task of inventorying these opportunities, but the effort remains incomplete. This initial step was limited to identifying available programs, without collecting or analyzing data on participation or outcomes. Despite these challenges, key organizations such as the Pennsylvania STEM Ecosystem and the Pennsylvania Statewide Afterschool Youth Development Network (PSAYDN) afterschool network, can provide valuable insights into out-of-school CS learning opportunities.

Case Study: STEM Coding Lab

STEM Coding Lab (SCL), a Pittsburgh-based nonprofit, provides computer science education to K-8 youth who would not otherwise have access to it. With 10 teachers on staff, SCL has quadrupled in size in 3 years, now providing 140 computer science classes every week across 38 locations and 11 school districts. SCL provides weekly CS instruction during the school day, the after-school period and summer months, offering coursework to the most under-resourced K-8 youth of the SWPA region. SCL plans to serve more than 4,000 under-resourced students in 2024. Schools and afterschool programs are required to have 70%+ Title I-qualifying student populations.

SCL's independently curated curriculum leverages resources from open-source platforms like Code.org, CS First, Khan Academy and Scratch, but is designed to support kids with low literacy skills, equipping them with the skills to be creators rather than just users of technology. Since SCL's founding, the organization maintains a 100% retention rate - meaning no partner (school or afterschool program) has ever canceled SCL's programming for any reason. SCL's curriculum includes a variety of curriculum focuses, including CS Fundamentals, 4 different robotics courses (Ozobots, Beebots, Finch 2.0 and Hummingbirds), Website Design & Development (HTML), App Design & Development (Java), Storycode (for ELA teachers), Career Literacy & Exploration (w/ Pittsburgh Technology Council, 22 different companies participate), and Game Design.

SCL also does not rely on traditional learning environments to provide CS education. The organization currently operates with 2 buses, entitled the Wifi on Wheels CyberBus, which serves as a mobile learning lab, in conjunction with the Bus Stops Here Foundation and the Housing Authority of the City of Pittsburgh.



PARTICIPATION

Participation is operationalized when students enroll in computer science courses (Fletcher & Warner, 2021). This component examines demographic representation, including barriers and challenges that may need to be addressed.

K-8

As previously mentioned, measuring participation in K-8 computer science is challenging. Measuring student participation in K-8 computer science (CS) presents several challenges. Unlike high school, where specific CS courses may be more clearly defined, K-8 CS instruction is often integrated into other subjects or offered through sporadic activities. This lack of consistency across schools makes it difficult to track which students are engaging in CS and to what extent. Additionally, variations in program delivery, informal learning opportunities, and the absence of standardized data collection further complicate efforts to measure participation in K-8 CS education.

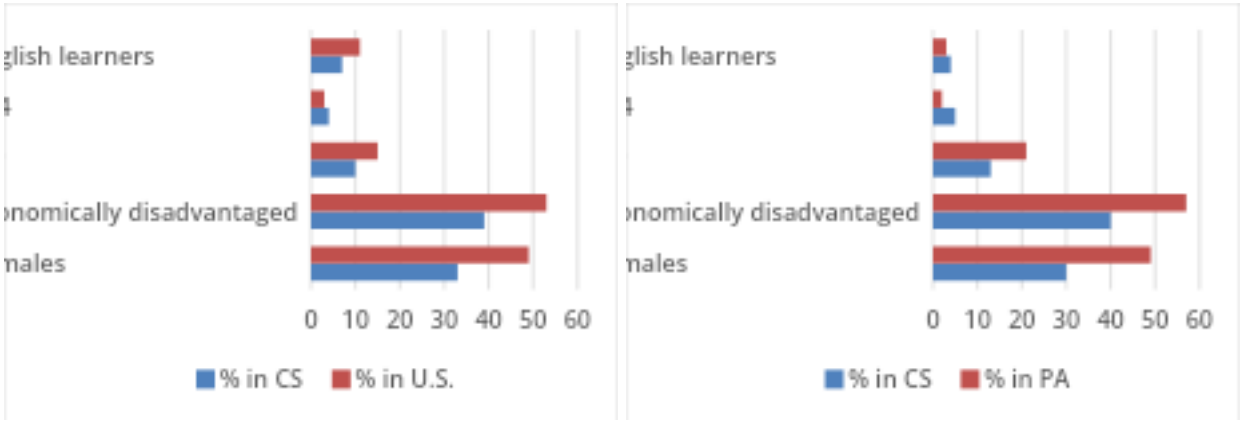
7-12

There is a growing body of evidence that increasing access to computer science education does not automatically result in increased participation (Lindsay, 2020; Torbey et al., 2020; Yonezawa et al., 2021). 60 percent of U.S. high schools offer computer science courses, but only six percent of high school students take them. In Pennsylvania, 75 percent of high schools offer computer science courses, and six percent of students took computer science courses in 2021-22 (Code.org, CSTA, & ECEP Alliance, 2024).

As shown in Figure 3 and Figure 4, year over year trends show enrollment demographics drawing closer to parity, with increases in participation among women, students with disabilities, economically disadvantaged students, and those minoritized by race and/or ethnicity, which show that efforts to increase access and participation are having an impact.

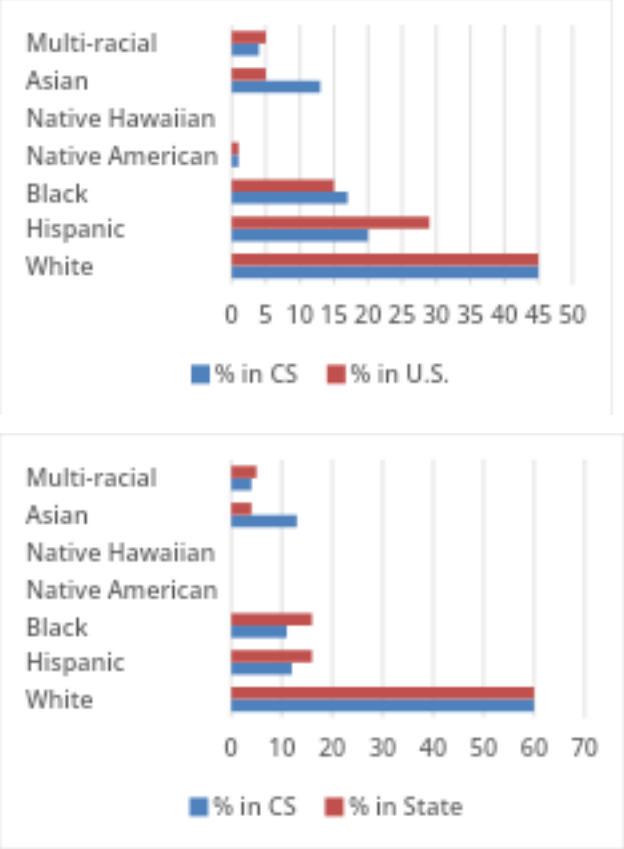
While these numbers appear encouraging, with the ratio of participation not exceedingly disparate from the representation of each group in the overall student body, more details regarding the curriculum, pedagogy, and learning environment are needed to determine if all students are receiving a high-quality computer science education.

Figure 3 – Participation in CS by Demographics in Grades 9-12



Source: (Code.org, CSTA, & ECEP Alliance, 2024).

Figure 4 – Participation in CS by Race in Grades 9-12



Source: (Code.org, CSTA, & ECEP Alliance, 2024).

Case Study - School District of Philadelphia

The School District of Philadelphia (SDP) offered Computer Science courses to more than 37,000 students in the 2023-2024 school year.

The district's approach focuses on exposure and fundamentals in K-8 to prepare students to be responsible and effective digital citizens and learners and to inspire and prepare students for experiences in high school. SDP offers a course in grades K-8 called "Digital

Literacy and Technology," focusing on three main areas: Computing and Society, Computer Science Fundamentals and Coding, and Media and Information Literacy. The course, typically taught as a year-long experience that meets weekly, engages more than 34,000 students in 112 K-8 schools. Introduced a decade ago, the course is regularly revised. Most recently, SDP rewrote it to shift from high-level grade-band objectives and resources to center on grade-specific lessons aligned with CSTA standards. Teachers receive professional development on the curriculum and materials, including computers and codable robots, to support teaching it.

More than 2,500 students in 27 high schools enrolled in computer science courses in 2023-24. High school offerings include introductory computer science courses, AP Computer Science Principles, and AP Computer Science A. In 2024, four SDP high schools received the College Board AP Computer Science Female Diversity Award for their work improving gender representation in AP Computer Science Principles (AP CSP) for the 2022-23 school year. Additional opportunities for high school students will be available in 2024-25 with the launch of a new Career and Technical Education (CTE) program at two high schools.

Advanced Placement (AP) Course Participation

It is important to note that AP data is typically skewed towards college-bound students and may not represent all students as a whole. In 2022, there were a total of 10,397 students who enrolled in AP-CSA and 8,574 in AP-CSP, across 273 high schools in the commonwealth.

While the state dashboard shows relative gender parity in overall CS participation in public high schools, there is a large gap between male and female participation in the AP program, with the majority of students enrolling in the course identifying as male (College Board, 2022c).

Table 8 - Enrolled AP CS Students by Gender in 2021-2022

AP CS Students	Male	Female
Percent of total Students Enrolled in grades 9-12 (eligible for AP courses)	51.2%	48.8%
Enrolled in AP-CSP	59.13	40.87

AP CS Students	Male	Female
Enrolled AP-CSA	58.86	40.14

Source: (College Board, 2022c)

With respect to race and ethnicity, the state dashboard also shows relative parity in AP-CSP, but the numbers drop precipitously in the more rigorous AP-CSA course.

Table 9 - Enrolled AP CS Students by Ethnicity in 2021-2022

AP CS Students	White	Hispanic	Black/ African American	Native American / Alaskan	Native Hawaiian / Pacific Islander	Asian	Multi-racial
% total student body	64.45	13.01	14.25	.17	.09	4.16	3.87
AP-CSP	64.70	9.11	8.23	.13	0.16	12.60	5.07
AP-CSA	70.23	8.96	5.12	0	0	11.84	3.64

Source: (College Board, 2022c)

Table 10 - Additional Demographics for Enrolled AP CS Students in 2021-2022

AP Computer Science Students	Economically Disadvantaged	English Language Learners	Individuals with Disabilities	Students with 504
AP-CSP	33.93	4.75	13.53	3.70
AP-CSA	31.55	4.41	14.54	2.84

Source: (CSinPA Data Dashboard, 2023)

Career and Technical Centers

Enrollment in CS/IT programs in the 2021-2022 school year included 3,654 students, compared to the 546,391students enrolled in the 9-12 grade statewide. The CTC programs continue to provide another route for students to engage in computing-related topics

outside of typical high school offerings; however, as the data show, there is work to be done in identifying and addressing gaps in these programs. With the vast majority of participants identifying as white and male, there is a clear opportunity to increase participation for those from underrepresented groups.

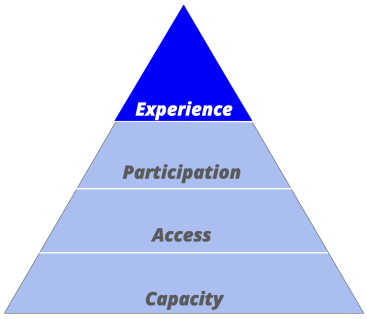
Table 11 - CTC Participation by CS Program

CTC Participation	Male	Female	White	Hispanic	Black	Multi-Racial	Has IEP	Economically Disadvantaged
Computer Programming General	87.2	12.8	78.6	*	*	*	20.9	39.8
Web Page Digital/Multimedia	67.1	32.9	63.6	15.6	13.5	*	30.3	52.7
Computer Network/ Telecommunications	91.8	8.2	72.6	8.4	12.3	3.0	28.3	40.7
Electromechanical/ Electro	89.2	10.8	74.4	13.3	5.2	4.0	20.6	32.1
Computer/Computer Systems	92.2	7.8	77.6	8.9	8.0	3.2	25.9	50.1
Totals	**88.4**	**11.6**	**73.3**	**9.6**	**9.7**	**2.7**	**26.5**	**43.1**

Source: (Pittman, 2024)

Dual Enrollment

In testimony provided to the Pennsylvania House Education Committee in 2023, Michael Giazzoni, PhD, the Director of *College In High School* at the University of Pittsburgh, provided data showing that more than 28,000 students took part in dual enrollment programs in Pennsylvania in 2021, ranging in subjects from Mathematics to Science, to include computer science. Further disaggregated data is not available.



EXPERIENCE

Experience in computer science education refers to outcomes of participating in computer science education, including, but not limited to, student achievement. Other factors include the extent to which curricula explicitly address equity issues, are culturally responsive, and whether the learning environment is inclusive and supports students' sense of belonging (Fletcher & Warner, 2021).

The Pennsylvania Training and Technical Assistance Network CSinPA data dashboard provides a useful tool for gaining insights to capacity, access, and participation trends. It does not currently contain any experience data, a gap which again hinders equity work.

As previously discussed in the Capacity section, the professional learning programs offered through PaTTAN equip teachers with knowledge and skills to address equity issues by applying the Universal Design for Learning (UDL) framework and culturally responsive teaching strategies, fostering inclusive and accessible learning environments. However, measuring the impact of these strategies on students' experiences and achievement during the implementation process remains challenging, highlighting the need for more systematic data collection and analysis.

Access versus Accessible

As described in the Access section, the CAPE framework explores factors that impact the number and type of computer science education opportunities available to students. This definition of access as opportunity differs from true accessibility. Even if computer science courses are available, and even if students enroll in them, computer science education remains inequitable if students are unable to fully engage in the learning.

According to the Joint Letter from the U.S. Department of Justice and the U.S. Department of Education (2010), accessibility means individuals with disabilities can acquire

information, engage in interactions, and enjoy services equally and effectively, with comparable ease of use. Unfortunately, most computer science curricula do not meet these standards, despite legal requirements for equal access (Fan, 2022; Huff et al., 2020; Israel, 2023; Stefik et al., 2019).

Individuals with disabilities are the largest minority group globally but have historically been excluded from efforts to broaden participation in computer science (Blaser & Ladner, 2023; Edwards, 2022; Fan, 2022; Huff et al., 2020). Nationally, while 15 percent of K-12 students have disabilities, only 10 percent of those enrolled in computer science courses share this characteristic (Code.org et al., 2023). This underrepresentation continues in post-secondary education, where only 4 percent of computer science majors are students with disabilities, despite 12-19 percent of the overall undergraduate population being disabled (Blaser & Ladner, 2023). Recent revisions to accessibility rules at both federal and state levels, including adherence to the WCAG 2.1 AA standard, emphasize the need for compliance among computer science education resources. Alarmingly, the majority of current curricula, including AP Computer Science courses endorsed by the College Board, do not meet these standards.

Barriers such as a lack of academic support, inaccessible tools, and curricula hinder students with disabilities in computer science (Fan, 2022). Advocacy efforts must focus on technology accessibility, teacher professional development, and inclusive curricular resources to ensure that computer science education is welcoming and supportive for all students (Israel, 2023). The mantra “Nothing about us without us” underscores the importance of including the voices of students and families in discussions about accessibility. 10 percent of the general workforce is disabled, but only 3 percent of the STEM workforce is disabled, making it critical to ensure that STEM college pathways, including in CS, are accessible to students with disabilities to facilitate their pursuit and success in careers of their choice (Oleson et al., 2024).

Case Study - Warwick School District

The Warwick School District, located in Lititz, PA has four elementary schools, and each school has access to an Innovation Lab that can be used for computing-related topics as teachers identify opportunities within their curricula. The district's tech coaches support the integration of computing topics in the classroom. The tech coaches' main goal is to empower educators to do activities and lessons on their own through a coaching model. Grades K-6 have used materials from Code.org since 2016 and prior to the pandemic, incorporated high school mentors to aid younger students in learning computing topics. The K-2 level teachers focus more on unplugged activities while instructors in grades three through six integrate various computational thinking tools into their pedagogy. The elementary school also uses a Digital Discoveries curriculum that integrates computer science-related topics into core instructional lessons in science, mathematics, and other subjects.

The district's middle school follows a more integrated model for computer science. The technology education department uses Vex robotics and integrates coding to interact with the robots. The district's tech coaches also integrate Sphero Robots and other coding tools into core subject areas to introduce computer science concepts to students during specific project-based learning opportunities. The tech coach's goal is to provide a content-specific computer science integrated lesson that each of the grade-level teachers can deploy within their curriculum.

The high school curriculum and computer science model has changed drastically over the past ten years. In 2013, the district offered two-semester courses, one focusing on website design, and the other on Java programming. For the 2023-2024 school year, the district offered two web design courses, two Java Programming Graphic courses, a mobile applications development course, and the AP Computer Science A course. Students can access a course by having a specific math prerequisite. Any level two course requires students to have taken the first course, and the mobile applications development course requires a Java Graphic Programming course first.

Students participating in computer science courses can receive up to one college-level credit in science or mathematics, in accordance with Act 86. Currently, all courses in the district are taught by one certified computer science teacher and one partially certified math teacher who has taught the web design course before and is, therefore, able to

continue to teach the course under CSPG 71 without complying with current certification requirements.

In the 2023-2024 school year, the high school began to offer the Computer Science Honor Society which inducts students based on completion of a computer science course and shows interests and aspirations in growing in community service and leadership. Students in this society put on building and school-wide events and have had a presence in their regional CSTA Chapter to share what they are doing with other computer science teachers in the region.

The district is now revamping and remodeling the courses to reduce the barriers to taking computing-related courses and offering a secondary prerequisite pathway for students. After completing the first half of Algebra I, students will be able to take a foundational Python programming course. From that course, students can take Website Design, Graphic Java Programming, Cybersecurity, and AP Computer Science P. In addition, students can skip the foundation Python programming course by completing additional math courses such as finishing all of Algebra I, or Geometry or Algebra II. Students completing Graphic Java Programming or AP Computer Science P can then take AP Computer Science A or Algebra II as this course meets the prerequisite skill and knowledge requirements for either course.

Warwick SD is also served by the Lancaster Lebanon Intermediate Unit 13 (IU13), an education service agency supporting school districts in Lancaster and Lebanon counties, along with other areas of Pennsylvania. Lancaster Lebanon IU13 is a leader in developing strategies for engaging students with disabilities in CS learning. One example, the Build|Fly|Code program, has been particularly effective for Deaf and Hard of Hearing students. The program uses visual and hands-on learning tools, such as drones, for teaching abstract concepts like coding and caters to the students' communication methods. It also provides opportunities for working in pairs and groups, which strengthens teamwork skills and demonstrates the power of collaboration for enhancing learning outcomes. The Lancaster Lebanon IU13 Special Education staff emphasizes that not every CS education tool or resource will work for every classroom. They encourage their fellow educators, even if they lack experience or feel uncertain about CS education, to try out ideas for incorporating CS skills in their classrooms.

Achievement

The Pennsylvania Training and Technical Assistance Network CSinPA data dashboard provides a useful tool for gaining insights to capacity, access, and participation trends. It does not currently contain any per student/per class/or per school performance data, a gap which again hinders equity work. However, as an unmandated subject in Pennsylvania, there are no benchmark assessments for monitoring student learning in computer science. Nationally, there is very little data on assessment in CS education, outside of the College Board's AP exam data, which only shows achievement. Fully examining equity at the assessment level requires using assessments that measure students' growth and strengths, not just their deficits.

Globally, in 2022, 134,651 students took the AP Computer Science Principles exam (College Board, 2022). According to the 2021 AP Report, student achievement in Pennsylvania shows a degree of strength in performance on the AP exam overall.

Table 12 - AP CSP Outcomes 2021-2022

AP CSP Outcomes	Pennsylvania	Global
Number of Students Enrolled	10397	130602
Number of Students Taking the Exam	2511	21,586
Average AP Exam Score (out of 5)	3.21	3.05
AP Score of 5 (%) (highest possible)	26.4	22.9
AP Score of 4 (%)	20.6	19.9
AP Score of 3 (%) (minimum required for most colleges to grant credit)	20.5	20.7
Percent of students that passed the exam with a score of 3 or higher	71.01	63.5

Source: (College Board, 2022a, 2022b, 2022c)

Table 13 - AP CSA Outcomes 2021-2022

AP CSA Outcomes	Pennsylvania	Global
Number of Students Enrolled	8574	711011
Number of Students Taking the Exam	3719	48,888
Average AP Exam Score (out of 5)	3.33	2.99
% with AP Score of 5 (highest possible)	17.0%	12.1%
% with AP Score of 4	27.1%	20.8%
% AP Score of 3 (minimum required for most colleges to grant credit)	32.8%	33.2%
% of students that pass the exam with a score of 3 or higher	71.36%	67.05%

Source: (College Board, 2022a, 2022b, 2022c)

Looking across the two AP exams, there were two to three times as many male test takers as female.

Table 14: AP State vs. Global Experience; Exams by Gender

State vs. Global	Male PA	Male Global	Female PA	Female Global
AP-CSP	2,522	86,195	1,185	43,420
AP-CSA	1,958	52,659	540	17,996

Source: (College Board, 2022a, 2022b, 2022c)

Table 15: AP Outcomes by Race/Ethnicity

AP Outcomes	Black/ African American	Hispanic	Native American/ Alaskan	Native Hawaiian/ Pacific Islander	Asian	White	Multi-racial
AP-CSP Enrolled	7.47%	18.92%	0.69%	0.17%	23.90%	44.06%	4.78%
AP-CSP Enrollees who Took Exam	5.49%	6.83%	0.75%	0.08%	21.03%	57.43%	4.25%
AP-CSP Exam-takers who Scored 3 or better	34.8%	56.3%	60.71%	0.00%	75.58%	75.23%	68.99%
AP-CSA enrolled	3.82%	5.00%	0.71%	0.09%	27.05%	58.48%	4.85%
AP-CSA Took Exam	3.31%	5.54%	0.40%	0.04%	30.19%	52.21%	4.50%
AP-CSA Exam-takers who Scored 3 or better	32.53%	51.08%	70.00%	0.00%	73.22%	73.68%	72.57%

Source: (College Board, 2022a, 2022b)

CTC Student Experience

Relevant data on experience and achievement in Career and Technical Education (CTE) computer science courses was unavailable for inclusion in this report. As a result, this aspect of the landscape report does not provide insights into the experiences and outcomes of students within these specific programs.

Dual Enrollment Experience

A scan of readily available data sources from the state and public colleges did not result in any usable information regarding the availability, use, or performance of students in computer science related dual enrollment programs. Pennsylvania is one of two US states that lack a statewide framework for dual enrollment, meaning the availability, design, subject matter, and accessibility of dual enrollment courses is highly variable and the availability of data related to these courses reflects this state policy dynamic.

CONCLUSIONS

The educational landscape for computer science in Pennsylvania is defined by early exposure to computational thinking and foundational skills through low-tech, unplugged pedagogies, which lay the groundwork for students to engage in various instructional approaches as they progress through their educational milestones.

The statewide PaTTAN repository for computer science education support materials, including the CSinPA Data Dashboard, various constituency toolkits, links to career pathways, and educator professional development creates a strong continuum of resources for foundational computer science education. While small in number, the availability of computer science AP courses supports transitions through academic milestones with higher pass rates yielding college credit compared to the national average. Many of the state's postsecondary educational institutions are also engaged in dual credit programs to provide or oversee instruction of college level curricula to high school students, for-credit, at a heavily discounted rate to support equity in access to higher education. Approximately half of the state's 330 colleges and universities offer computer science programming. But there are no publicly available data sets to determine which programs and schools are specifically engaged in computer science dual enrollment. In both cases, the statewide K-12 data in the CSinPA Dashboard cannot be disaggregated to assess the impacts of these approaches in terms of academic outcomes or college access.

Foundational instruction in computational thinking and increasing exposure to computer science instruction as K-12 students progress through educational grade levels has resulted in nearly 19 percent of all public-school students receiving computer science education. The CSinPA Data Dashboard (2021, 2022) shows year over year growth in the number and percent of students, and it shows that participation is near parity for female students and racial and ethnic minorities, with only slight overrepresentation of white, male students compared to all public-school enrollments. However, when examining data for the AP courses, which is a college prep program, there are stark disparities and equity gaps in access and the faculty teaching these courses overwhelmingly identify as white and male.

Several states have produced state-wide data repositories that contribute to effective policy and strategic investments in computer science career pathway education. The Illinois Board of Higher Education data dashboard is a strong example of how a centralized repository can support effective and strategic investments. The CSinPA Data Dashboard is already a centralized repository of data and should be strategically expanded to support the state's

efforts to improve access to computer science instruction as part of a twenty-first century curriculum.

Recommendations For CS Education in Pennsylvania

Pennsylvania has a goal to provide statewide access to high quality computer science education that contributes to general digital literacy and encourages teaching and learning along the computer science career pathways that lead to high-demand occupations that drive economic growth. To do this, it is essential to nurture current successes, bolster effective strategies, and address gaps in continuity between education, workforce development, and the employment landscape. The following recommendations are intended to strengthen the state's approach to providing computer science education.

1. Further develop the CSinPA Data Dashboard

Although the CSinPA data dashboard currently focuses on CS education in 7-12 grades, the dashboard holds potential to create greater continuity across educational milestones, up to and including employment outcomes for students. To enhance the effectiveness of the CSinPA Data Dashboard, it is essential to expand the scope of data collection and improve overall data quality. The following steps should be prioritized:

A. **Improve overall data quality.** Enhancing the quality of the data collected is critical to ensuring accurate insights into CS education. This includes refining data collection methods to provide more detailed and reliable information on student access, participation, and outcomes at all educational levels.
B. **Incorporate K-6 access and participation data.** Currently, there is very little data on elementary CS education. Therefore, it's necessary to identify processes to collect and analyze K-6 CS data as part of existing systems, including PIMS.
C. **Integrate postsecondary and workforce data.** Connections between K-12, postsecondary, and workforce data can inform the long-term impact of CS education on student outcomes. Integrating data from postsecondary institutions and the workforce enables tracking students' transitions from K-12 education into various postsecondary CS pathways. Linking workforce data also provides insights into how K-12 CS education influences career outcomes, including employment rates and job sectors.

2. Engage a broader range of partners.

To strengthen the computer science (CS) education continuum and career pathways, collaboration among education institutions, government agencies, workforce and industry partners, employers, and community-based organizations must be expanded and formalized. Partnerships should include data governance agreements to ensure shared accountability and data-driven decision-making, and efforts to align and streamline resources related to CS education, career pathways, and workforce opportunities. The ECEP-PA group can lead efforts to broaden and diversify the range of vested partners in CS education. Initial priorities may include:

A. **Strengthen K-12 and postsecondary partnerships.** Formal agreements between K-12 schools, career and technical centers, community colleges, and universities can help create clearer pathways from secondary education to higher education and careers. Agreements should focus on aligning curricula, strengthening dual enrollment options, and ensuring credit transferability for CS courses, reducing barriers to college access and success.
B. **Engage nonprofits, community-based, and out-of-school learning organizations**. By integrating these organizations' programs into the broader CS education framework, students can benefit from continuous learning opportunities that complement formal education. Collaboration with these organizations also allows for innovative program delivery and extends the reach of CS education to communities that may otherwise lack access.
C. **Leverage workforce and industry partners**. Collaboration with workforce development agencies, employers, and industry associations will increase opportunities for work-based CS learning, such as internships, apprenticeships, and mentorships. Programs should focus on creating clear pathways to employment, career advancement, and wage growth in CS-related fields. Workforce and industry partners can also offer insights into the skills in demand, helping to align curricula with workforce needs.

3. Prioritize accessibility in computer science education.

To ensure that all students, including those with disabilities, can fully participate in computer science (CS) education, accessibility must be prioritized in both K-12 and higher education settings. This involves two critical components: (a) using accessible CS resources

that meet federal accessibility standards, and (b) integrating the teaching of accessibility concepts into CS curricula.

A. **Teach CS with accessible resources.** To ensure that students with disabilities are able to fully engage in CS learning, all learning resources must be accessible. Regularly audit CS resources and curricula to ensure that they meet federal and state accessibility standards, including WCAG 2.1 AA standards. Select resources that are universally designed and born-accessible. Provide teachers with professional development and support on identifying and addressing accessibility needs.
B. **Teach about accessibility in CS education.** In addition to using accessible resources, CS education should include instruction on the principles of accessibility. Teaching about accessibility not only raises awareness but also equips students with the skills to design and develop technology that is inclusive of all users, including those with disabilities. At all levels of CS education, students should learn about accessibility and how to integrate accessibility into multiple stages of the design process, including early stages of development and user testing.

4. Support policy changes.

A. Create a statewide plan for K-12 CS education

A comprehensive statewide computer science (CS) education plan is essential for creating equitable pathways to CS learning, particularly in a state where CS is not mandated. The plan should serve as a strategic guide for developing, implementing, and sustaining high-quality CS education across all grade levels, ensuring that all students have access to rigorous CS opportunities. Development and implementation of the plan should involve educators, administrators, policymakers, parents, students, higher education institutions, and industry partners. Guidance and examples from the Expanding Computing Education Pathways (ECEP) Alliance can support the development and implementation of the plan.

Key components of the plan should include:

A. **Set explicit equity-based goals.** Identify underserved and underrepresented student groups and set specific targets for increasing their participation and success in CS courses. Use the CAPE framework to outline strategies for reducing barriers to CS education.

B. **Identify CS pathways from K-12 to postsecondary and workforce.** Identify and develop pathways that connect K-12 CS education to postsecondary institutions and the workforce. This includes strengthening career and technical education (CTE) programs, internships, and work-based learning opportunities in partnership with industry and higher education.
C. **Improve data collection and accountability.** Establish a framework for collecting and analyzing data on CS enrollment, participation, and outcomes. This framework should include disaggregated student and school-level data to ensure equitable outcomes. Additionally, incorporate mechanisms for tracking progress and supporting data-driven decision making.
D. **Address resource allocation.** Ensure that the highest-need schools receive adequate support, and explore ways to leverage state, federal, and other funding sources to sustain CS programs.
E. **Examine CS policies.** Review implementation and compliance with existing policies, such as Act 86 and CSPG 71, and explore potential policy changes that can support the expansion of CS.

B. Establish a statewide framework for dual enrollment programs

Dual enrollment is an evidence based practice that improves access to in-demand career pathways, including those in computer science. A statewide framework for dual enrollment would standardize data collection and performance metrics, ensuring that dual enrollment contributes to equitable access and success. This framework would also support the successful transition of students to college with earned credit.

5. Increase and diversify the certified CS teacher workforce

Teacher certification is critical for enhancing the rigor and quality of K-12 computer science (CS) instruction. Certification requirements can encourage teachers to pursue focused professional development and elevate CS as a priority for school administrators (Parker & Hendrickson, 2022). However, as of the 2022–23 school year, 31 percent of grades 7–12 CS teachers in Pennsylvania did not meet the state's certification requirements, a number that is expected to rise as certification mandates expand.

An additional concern is the lack of diversity in Pennsylvania's CS teacher workforce. From 2018–2023, white and male CS teachers were disproportionately overrepresented compared to the student population (Schwarzhaupt et. al., 2024).

To improve certification rates, teacher workforce diversity, and school capacity to offer CS courses, the following actions should be considered:

A. **Support schools in certification planning**: Assist schools in identifying certification needs as part of their comprehensive professional development planning. This will help schools strategically address certification gaps and support ongoing professional growth in CS education.
B. **Incentivize 7-12 CS certification**: Provide additional financial and professional development incentives for obtaining the grades 7–12 CS certification. Consider personal incentives such as additional stipends and student loan forgiveness, especially for pre-service and in-service teachers of color, who are more likely to hold student loan debt.
C. **Expand 7-12 CS certification pathways**: Develop alternative certification routes such as pre-service educator programs with embedded coursework preparing candidates for certification, and alternative CS teacher preparation programs. Partnerships with organizations such as Teach For America and Historically Black Colleges and Universities (HBCUs) may increase access for candidates from underrepresented racial and ethnic groups.
D. **Provide K-6 CS training guidance**: While there is no specific certification for elementary CS, additional guidance is needed regarding recommended training, as outlined in CSPG 71. Publishing guidelines and creating a repository of training opportunities would contribute to the quality of K-6 CS education.
E. **Improve data collection regarding K-6 trainings**: Develop mechanisms to collect and analyze data on educators' participation in CS professional development at the elementary level. This will better support decision-making for expanding elementary CS education.

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