Overcoming the Digital Divide among Youth

Computer science (CS) is the foundation of the information society. Although CS skills are valuable and CS careers are essential and often well paid, access to them is inequitable. In effect, a digital divide excludes many Americans. The divide is due in part to device costs and to regional constraints in broadband access. Sociodemographic factors exacerbate the divide (Jackson, et al., 2008). In response, diverse social groups, including advocacies, nonprofits, public agencies, and some companies, are striving to improve access to computer science education (CSEd).

The digital divide contributes to disparities in healthcare access, education, and work opportunities (Robinson, et al., 2015). In the aggregate, students who use information technology earlier generally perform better academically (Jackson, et al., 2008). This element of the digital divide is known as the "homework gap." Students in lower-income households are less likely than other to have Internet access or a computer for homework (Vogels, 2021). Students with reliable Internet access have an academic advantage that can lead to better career opportunities. In medicine, eHealth assigns patients some responsibility to monitor their own health (Robinson, et al., 2015). Yet barriers of technology and skill can limit access to eHealth.

CollegeBoard is a not-for-profit that claims it seeks to "expand access to higher education" (2023a). Their AP Computer Science Principles course introduces computer science before college. The required materials for this course are accessible on their webpage. CSforALL is another national advocacy that provides CS educational resources and connections. It calls itself "a central resource for individuals and organizations interested in K-12 computer science (CS) education" (CSforALL, 2022a). Similarly, Code.org is a national nonprofit that develops accessible CS resources for underserved schools. It helped develop the K-12 Computer Science

Framework, “a high-level guide for states, districts, and organizations implementing computer science education” (Code.org, 2022). CodeVA is an affiliate partner with Code.org that drafts state-level policy initiatives. It contributed to a 2016 Virginia law “requiring K-8 computer science literacy for all students through standards integrated across all other subject areas” (CodeVA, 2022a).

Next, the Expanding Computing Education Pathways Alliance (ECEP) advocates for state educational “policies, pathways, and practices that advance equity at scale” (ECEP 2022a). The organization developed a framework “to build the capacity of states to access and use available data internally” to track CSEd progress (Dunton, et al., 2022).

Lastly, the Association of Computing Machinery (ACM) facilitates academic discussion in CS. Their platform encourages computing teachers and professionals to share resources and discuss challenges within their respective fields (ACM, 2022). The combined efforts of these advocacy groups promote CS education accessibility by challenging the facets of the digital divide.

Review of Research

The literature on CSEd accessibility displays a narrow focus on state policies and initiatives. One example is the 2022 State of Computer Science Education annual report written by the Code.org Advocacy Coalition. It provides updates on the national and state-level progress towards enforcing computer science education policy. However, efforts of local organizations are omitted. This contradicts the goal of the report to help develop or revise state advocacy plans (Code Advocacy Coalition, 2022). To promote efficient methods of advocacy, quantified results must be presented with the actions that caused them.

In 2021, Vegas et al. outlined challenges facing computer science education in primary and secondary schools. Advocacy work and its impact are recounted throughout the essay, along with quantifiable evidence of successful implementation. However, the focus lies on illustrating the progress of computer science education. Their evidence consists of various advocacy projects that support their claims about CSEd. There is limited information shared about the organizations, such as their mission statements or achievements.

Literature regarding computer science education accessibility reveals a lack of emphasis on advocacy groups and their work. The following sections combat this state of research by expanding upon the referenced reports. The participant groups and their projects are presented before offering evidence on their impact on CSEd. This contribution provides a basis for evaluating the advocacy groups as a tool in determining the progress of the movement.

CollegeBoard

CollegeBoard is a not-for-profit that claims to "connect students to college success and opportunity" (2023). Their AP CS Principles (CSP) course opposes the digital divide by offering accessible resources online. For students, CollegeBoard (2023b) provides AP daily videos, topic questions, and a searchable database of real AP questions to review. This offers a way for students to engage with the material without paying for materials. On the teaching side, webinars and online workshops allow a wider range of teachers to develop their ability to teach computational skills and embrace the course in their own schools.

These elements of the AP CSP course advance CS accessibility, thereby diversifying the field while helping students pursue higher CS education. CollegeBoard verifies this in a study that shows AP CSP students are more than three times as likely to major in CS in college

(CollegeBoard, 2023c). The course is also shown to be the first AP STEM experience for Black, Hispanic, and first-generation students who take it. They close this study with their intention to track how this study applies across the nation as more schools "embrace their goal of diversifying the pipeline of students interested in computer science in the years to come" (Wyatt, Feng, & Ewing, 2020).

CollegeBoard fights social conventions surrounding digital inaccessibility through recognition and funding. In 2021, the organization recognized 1,119 schools for their work in closing the gender gap in computer science (CollegeBoard, 2021). This recognition empowers other schools to pursue the award by promoting women's participation in CS. In addition, CollegeBoard announced its new funding from Ken Griffin, Citadel, and Citadel Securities to promote the AP CSP course in 500 schools with large Black student populations (CollegeBoard, 2022). By focusing on these schools, Black students are enabled to overcome harmful stereotypes surrounding computer science. Collegeboard states that they've seen the effects of their "collaborative efforts across the country to introduce more students from all backgrounds" to CSEd (2022).

Code.org

Code.org is an education innovation nonprofit that enables students to learn computer science as part of their core K-12 education (2022). Their annual Hour of Code campaign challenges the digital gap by supporting a diverse range students to try computer science at a young age. Children of any age in K-12 are able to access the one-hour coding tutorials, showing that anyone can learn CS. By 2019, Code.org reported that 720 million students joined the Hour of Code, over thirty times more than that in 2013 (Code.org, 2023b).

The K-12 Computer Science Framework (fig. 1) was developed with Code.org to bridge

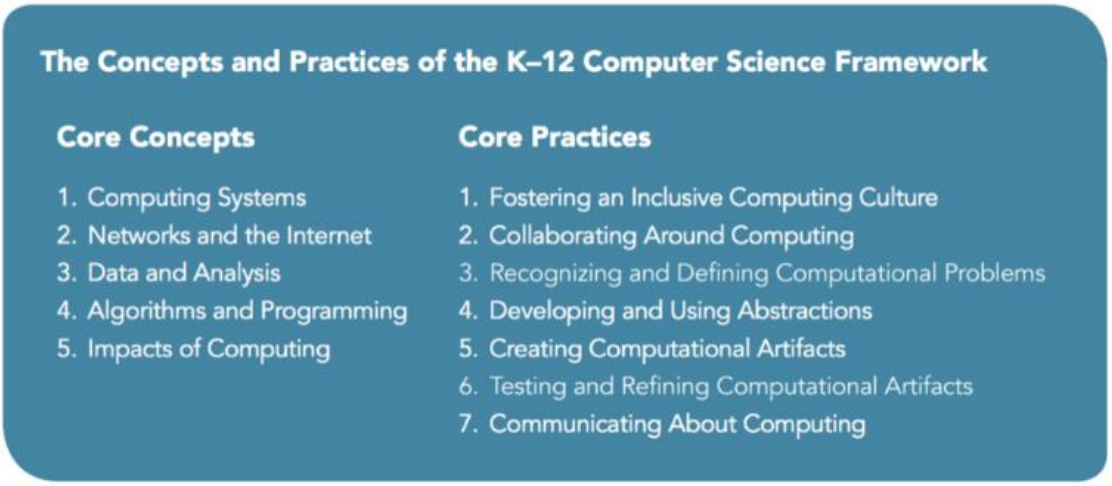

Figure 1.K-12 CS Framework (Code.org, 2016)

the digital divide through its pursuit of standardized CS education. The framework is designed to guide CS towards becoming a subject in all K-12 schools (Code.org, 2016). Code.org states the framework "promotes a vision in which all students critically engage in computer science" in a Tumblr post announcing its release. It has received a plethora of recognition for its guiding principles, thereby propelling it as a standard within CS curricula. It is recognized by institions such as the New York City Department of Education and universities like Stanford and Harvard. Research papers utilize the framework as a benchmark, with Oda, Noborimoto, and Horita (2021) using it to identify international trends in K-12 CS curricula. Through this, Code.org provides a pathway towards creating quality CS courses for students on a national scale.

Expanding Computing Education Pathways Alliance

The Expanding Computing Education Pathways (ECEP) Alliance is a collective impact alliance that advocates for accessibility in computing education (ECEP Alliance, 2022a). ECEP creates a variety of standardized materials to evaluate CSEd accessibility across the nation, including the Capacity, Access, Participation, and Experience (CAPE) framework. The group is

supported by the National Science Foundation (NSF) to promote the Broadening Participation in Computing Alliance (BPC-A) program.

The BPC model lists steps for states to better quantify the effects of the digital divide in order to advance schools in pursuing accessible CS education. In 2022, an article co-authored by Sarah Dunton from the ECEP Alliance determined two main challenges to the BPC model on a state-level:

1. States must improve their data systems to collect data on student experience and class capacity.
2. States must determine how different subjects implement computer science topics and whether these courses are consistent with computer science education standards.

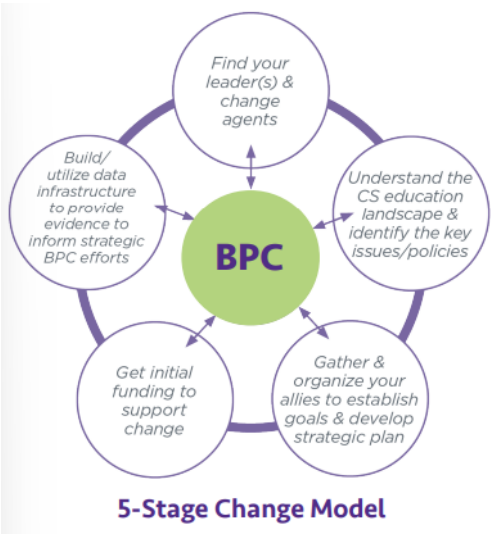

Figure 2. Five-stage Model towards Broadening Participating in Computing (ECEP, 2022b).

This diagnosis is the first step towards all states in the ECEP Alliance effectively applying the BPC model. In 2022, the ECEP quantified their progress towards this mission, finding that 68% of the ECEP states have identified one or more priority K-12 populations to serve and 83% have developed a landscape report (ECEP Alliance, 2022b).

CSforALL

CSforALL is an initiative organization with the mission of creating high-quality computer science education in K-12 schools (2022a). The group began as the New York City Foundation for Computer Science (CSNYC) in 2013 before evolving onto a national scale. The organization presents cost-efficient and informational teaching resources in order to overcome

the economic side of the digital divide. AlignCS is a curriculum directory that allows teachers to search for curricula that match their school's needs (CSforALL, 2023a). It collaborates with the K-12 Computer Science Framework by approving curricula that aligns with the standards set forth. In 2023, CSforALL found that over 150 courses are available for teachers to use (2023b). Among this collection, there are various price ranges and difficulty levels for teachers to choose from, therefore promoting accessibility.

To empower teachers to overcome the digital divide's challenges, CSforALL created the SCRIPT framework. SCRIPT addresses five areas for developing CS education:

1. Leadership
2. Teacher capacity and development
3. Curriculum and materials selection and refinement
4. Partners
5. Community

Through this frame, educators can self-assess and set goals for their school districts to support systematic change. According to CSforALL, more than 90% of participants say that SCRIPT helped to identify actionable goals towards achieving quality CS education (2023c). One example is Corricelli from the Computer Science Teachers Association (CSTA). In her article, she explains her focus on bringing SCRIPT to Connecticut by reaching out to CSforALL. She now works with CSforALL to secure funding for SCRIPT training and spread its use in Connecticut (Corricelli, 2020). The Milwaukee (MKE) Tech Hub Coalition has also adopted the SCRIPT program in their mission to help seven local school district teams. Using the SCRIPT framework, they were able to articulate goals and find CS education resources for their schools (MKE Tech Hub Coalition, 2022).

Association for Computing Machinery

The Association for Computing Machinery (ACM) is an international computing society that shares resources and fosters academic discussion. The organization works to establish worldwide chapters, offer volunteer opportunities, and form special interest groups (ACM, 2022). ACM utilizes its global scale to create child organizations to overcome different facets of the digital divide, such as social stereotypes and the lack of CSEd standards. First, the creation of the Association for Computing Machinery Women (ACM-W) confronts gendered stereotypes regarding CS. This group facilitates an inclusive society of women in STEM to discuss their challenges and support other women. The Computer Science Teachers Association is another organization created by ACM. Their largest accomplishment is the CSTA K-12 Computer Science Standards framework. The standards are divided based on grade level, thereby supporting a pathway for students to follow (CSTA, 2020a). This facilitates the creation of new curricula that may be compared and aligned with the framework to ensure quality education.

By fostering academic discussion, ACM promotes new teaching methods that makes CS more accessible for different students. The ACM Digital Library is a database of literature spanning across multiple subtopics of computer science (ACM, 2022). Experts, educators, and advocacy groups publish academic papers onto the database to engage in discussions. The exchange of ideas advances the search for new pedagogical methods that can be used with CS education. These new methods defy the effects of the digital divide by exploring how computational thinking can be taught without costly materials.

CodeVA

CodeVA is a local organization that works with students, teachers, school districts, and policymakers to make CSEd a priority in Virginia. In 2013, it became the first affiliate partner of Code.org (CodeVA, 2022a). CodeVA works to overcome Virginia's digital divide by drafting statewide legislation for CS education. Leading up to 2016, CodeVA led a team of educators to write new CSEd standards for Virginia. Their first policy requires the Board of Education to include CS course credits as either science, math, or career credits towards a high school diploma. The second policy mandates the inclusion of computer science into K-12 schools. Lastly, the final policy requires professional development for CS teachers (CodeVA, 2016a). These three bills were implemented and propelled Virginia as a figure of advocacy for computer science education.

CodeVA negates the digital divide by promoting diversity within CSEd among young students. The Eureka Workshops include summer camp and after-school activities to teach computer science through arts and crafts activities (CodeVA, 2016b). It is important to consider that CodeVA is based in Richmond, VA, a city with a majority Black demographic. To promote the inclusion of this community, CodeVA's publications and webpages show a diverse range of students and teachers. The target audience is K-5 students, therefore CodeVA offers a plethora of innovative teaching methods that foster creative thinking. The workshops are free for students and offered in English and Spanish, providing accessibility for low-income or immigrant families. By 2022, more than 900 students participated in these activities, with 155 students attending per week (CodeVA, 2022b).

Conclusion

The digital divide obstructs CSEd in social perspectives, economic feasability, and political progression. The advocacy groups discussed are challenging these obstacles through

their individual efforts. In order to strengthen the movement, an assessment of these advocacy methods must be considered.

Through this research problem, the presentation of the participant groups and their efforts were compiled to form a foundation for evaluation. Each group is introduced with their origin and mission before their works are assessed for their efficacy. First, there are two similar frameworks that work to achieve the same thing: create a set a standards to ensure quality computer science education. These include the K-12 Computer Science Framework and the K-12 Computer Science Standards. For future research, it may be beneficial to consider the pitfalls of either framework to acquire the best one moving forward. Second, there are conflicting assessment tools to determine what strategies are most helpful to a region or district. For example, SCRIPT from CSforALL and the BCP model from ECEP both work as self-assessments to develop a plan towards CSEd accessibility. An impact study may be required to decide which is more helpful on a larger, national scale.

References

ACM-W. (n.d.). Association of Computing Machinery Women. Supporting, Celebrating, and Advocating for Women in Computing. ACM-W: women.acm.org

ACM (2020). Association for Computing Machinery. Computing Curricula 2020: Paradigms for Global Computing Education. New York City, NY: Association for Computing Machinery.

ACM (2022). Association for Computing Machinery. About the ACM Organization. ACM: www.acm.org/about-acm/about-the-acm-organization

ACM (n.d.). Association of Computing Machinery. Curricula Recommendations. ACM: www.acm.org/education/curricula-recommendations

Code Advocacy Coalition. (2022). State of Computer Science Education: Understanding our National Imperative. Seattle, Washington: Code Advocacy Coalition. advocacy.code.org/2022_state_of_cs.pdf

Code.org. (2016, October 17). Introducing the K–12 Computer Science Framework, a milestone for CS education. (blogpost) Tumblr: blog.code.org/post/151935557103/introducing-the-k12-computer-science-framework-a

Code.org. (2016). K–12 Computer Science Framework. K–12 Computer Science Framework: k12cs.org

Code.org. (2022). About Us. Code.org: code.org/about

Code.org. (2023a). Code.org Professional Learning. Code.org: code.org/educate/professional-learning/middle-high

Code.org. (2023b). Code.org Statistics. Code.org: code.org/statistics

Code.org. (2023c). Hour of Code. Hour of Code: hourofcode.com/us

CodeVA. (2016a). Our Impact. CodeVA: www.codevirginia.org/about/our-impact/

CodeVA. (2016b). Student Programs. CodeVA: www.codevirginia.org/students-programs

CodeVA. (2022a). About Us. CodeVA: www.codevirginia.org/about

CodeVA. (2022b). CodeVA Connecting Together Annual Report. Richmond: CodeVA.

CodeVA. (n.d.). Professional Learning. CodeVA: www.codevirginia.org/educators/professional-development

CollegeBoard. (2020a). AP Computer Science Principles. New York, NY: CollegeBoard.

CollegeBoard. (2020b, December 9). New Data: AP Computer Science Principles Course Bringing More Diverse Set of Students Into Computer Science Pipeline. *Newsroom*.

CollegeBoard. (2021, January 25). Significant Increase in Schools Receiving Annual AP Computer Science Female Diversity Award. *Newsroom*.

CollegeBoard. (2022, February 28). 500 Schools with Significant Black Student Populations Will Offer AP Computer Science Principles with New Funding from Ken Griffin, Citadel, and Citadel Securities. *Newsroom*.

CollegeBoard. (2023a). About Us. CollegeBoard: about.collegeboard.org

CollegeBoard. (2023b). AP Computer Science Principles. CollegeBoard: apcentral.collegeboard.org/courses/ap-computer-science-principles/course

CollegeBoard. (2023c). AP Computer Science Principles: Research Findings. CollegeBoard: apcentral.collegeboard.org/courses/ap-computer-science-principles/ap-csp-research-findings

CollegeBoard. (2023d). Our National Offices. About Us: about.collegeboard.org/national-offices

CollegeBoard. (n.d.). AP Computer Science Principles: Research Findings. Collegeboard: apcentral.collegeboard.org/courses/ap-computer-science-principles/ap-csp-research-findings

CSTA (2020a). Computer Science Teachers Association. How to Use the Standards. CS Standards: www.csteachers.org/Page/standards

CSTA (2020). Computer Science Teachers Association. Standards Alignment Review. CSTA: www.csteachers.org/page/standards-alignment-review

Corricelli, J. (2020, Apr 17). SCRIPTing Change in Connecticut. *CSEquity*.

CSforALL. (2017). K-12 School and District Pledge. CSforALL: www.csforall.org/projects_and_programs/k-12-school-district-pledge

CSforALL. (2022a). About CSforALL. CSforALL: www.csforall.org/about

CSforALL. (2022b, October 20). The National Computer Science for All Movement Announces Sixth Year of Commitments, with 181 Commitments from 135 Organizations. *Medium*.

CSforALL. (2023a). AlignCS FAQ. CSforALL: www.csforall.org/projects_and_programs/aligncs-faq

CSforALL. (2023b). Curriculum Directory. CSforALL: www.csforall.org/projects_and_programs/curriculum_directory

CSforALL. (2023c). SCRIPT Program. CSforALL: www.csforall.org/projects_and_programs/script

CSforALL. (2023d). What is the CSforALL Summit? CSforALL: www.csforall.org/projects_and_programs/csforall-summit

Dunton, Zarch, Xavier, Warner, & Peterfreund (2022). Determining metrics for broadening participation in computing: Connecting data to multi-state computer science education policy efforts. *Policy Futures in Education.*

ECEP (2022a). Expanding Computing Education Pathways Alliance. Home. ECEP: ecepalliance.org

ECEP (2022b). Expanding Computing Education Pathways Alliance. Key Features of ECEP. Austin: Expanding Computing Education Pathways Alliance.

Hazzan, O., Gal-Ezer, J., & Blum, L. (2008). A model for high school computer science education: the four key elements that make it! *SIGCSE '08: Proceedings of the 39th SIGCSE technical symposium on Computer science education*, 281-285.

Jackson, Zhao, Kolenic, Fitzgerald, Harold, & Eye. (2008). Race, Gender, and Information Technology Use: The New Digital Divide. *CyberPsychology & Behavior*, 437-442.

Kyungbin, Minji, Meize, Ge, Jiyoung, Ottenbreit-Leftwich, & Brush, (2021, December 16). Computational thinking practices: Lessons learned from a problem-based curriculum in primary education. *Journal of Research on Technology in Education*. doi:10.1080/15391523.2021.2014372

Machanick, P. (2007). A Social Construction Approach to Computer Science Education. *Computer Science Education*, 1-20.

MKE Tech Hub Coalition. (2022). The Importance of Computer Science Education in M7 Region. Milwaukee: MKE Tech Hub Coalition.

NSF (2014, December 8). National Science Foundation. College Board launches new AP Computer Science Principles course. National Science Foundation: www.nsf.gov/news/news_summ.jsp?cntn_id=133571

Oda, M., Noborimoto, Y., & Horita, T. (2021). International Trends in K–12 Computer Science Curricula through Comparative Analysis: Implications for the Primary Curricula. *International Journal of Computer Science Education in Schools, 4*(4). doi:10.21585/ijcses.v4i4.102

Robinson, Cotton, Ono, Quan-Haase, Mesch, Chen, Stern. (2015). Digital Inequalities and Why They Matter. *Information, Communication, & Society*, 569-582.

Vegas, E., Hansen, M., & Fowler, B. (2021). Building Skills for Life: How to Expand and Improve Computer Science Education Around the World. Washington, DC: The Brookings Institution. www.brookings.edu/essay/building-skills-for-life-how-to-expand-and-improve-computer-science-education-around-the-world

Vogels, E. A. (2021, June 22). Digital divide persists even as Americans with lower incomes make gains in tech adoption. Washington, D.C, U.S.A.

Wang, J., & Moghadam, S. H. (2017). Diversity Barriers in K-12 Computer Science Education: Structural and Social. *SIGCSE '17: The 48th ACM Technical Symposium on Computer Science Education*, (pp. 615-620). Seattle, Washington USA.

Wyatt, J., Feng, J., & Ewing, M. (2020). AP Computer Science Principles and the STEM and Computer Science Pipelines. CollegeBoard.