CSforCTE

The Intersection of Computer Science and Career and Technical Education

CSforALL

Luronne Vaval
Leigh Ann DeLyser
Stephanie Wortel-London

About CSforALL

CSforALL is the national hub of the computer science for all movement, with a mission to make high-quality computer science an integral part of K–12 education in the United States. Our work spans national and local levels to provide equitable and accessible K–12 computer science education to every student. We engage with diverse stakeholders leading computer science initiatives across the nation to support and facilitate implementation of rigorous, inclusive, sustainable computer science. For more information, see www.csforall.org or follow us on Twitter: @CSforALL.

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Contents

The purpose of this report is to share best practices for implementing computer science (CS) education within career and technical education (CTE) programs. Educators, policy and decision-makers, and workforce partners interested in CS CTE programs can use this report to identify best practices for equitable implementation of CS education in the United States. Each section introduces a thematic topic (classroom practice, course sequences, teacher preparation, certification, recruitment, industry engagement, and state and federal policy) and summarizes the discussion of experts with recommendations for the field. We hope this report inspires educators, school leaders, and policymakers to create and share examples of high-quality implementation and encourage schools to include CS as a part of course offerings with or without a CTE connection. In addition, we hope this report can serve as a starting point for CS CTE programs to self-assess and refine their programmatic components accordingly.

Key Findings and Recommendations

High-quality CS CTE classroom practices…
- emphasizes team-based routines.
- emphasizes real-world and student relevance.
- matches curriculum and pedagogy to foster both interest development and learning.

High-quality CS CTE course sequences…
- include broad on-ramps.
- requires flexible pathways.
- emphasizes secondary-postsecondary alignment and aligns with industry needs.

High-quality CS CTE teacher preparation, certification, and recruitment…
- is tailored to CS.
- should be mindful of unintended consequences.
- provides micro-credentialing opportunities.

High-quality CS CTE industry engagement…
- requires ecosystem creation.
- emphasizes the K-12 pipeline and career pathways.
- emphasizes long-term engagement and investment.

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Introduction

Computer science (CS) education has long been touted as a pathway to open high-paying jobs, reduce socioeconomic disparities, or even tell the story of a youth who has used technology to create something worthy of acknowledgment or praise. Despite national media campaigns, significant public and private investment in expanding CS education, and attention to participation gaps by race, ethnicity, and gender, the nation is still struggling to see participation rates equalize either at the high school or college level (Code.org, CSTA, & ECEP Alliance, 2021). Career and technical education (CTE) also promise employment opportunities for students while having challenges with student participation based upon gendered and socioeconomic perceptions of the individual fields. Historically, CTE programs focused on technical areas skew towards male participation, while more gendered programs (such as cosmetology and nursing) skew towards female participation (Leu & Arbeit, 2020). CTE programs are often perceived as less rigorous than more traditional academic pathways, despite the high percentage of CTE program graduates who choose to attend college instead of directly entering the workforce (Dietrich, Lichtenberger, & Kamalludeen, 2016; Plasman, Gottfried, & Sublett, 2017).

CTE and CS education share many strategies employed by advocates and implementers to benefit students, especially those at risk of not performing to their potential in academic settings. The use of real-world problems, engagement with community issues, connections to professionals for career exploration and mentoring, and more are often used and sometimes researched to promote CS or CTE. These practices are grounded in intentional, high-quality approaches that yield gains for students. CTE and CS education programs are closely tied at the high school level in many states. In some states, such as Texas, even stand-alone CS courses are labeled with CTE course designations. There is a rich ecosystem of recommended CTE pathways for CS topics such as programming, web design, game design, and cybersecurity in other states like Georgia.

Modern and forward-thinking CTE pathways combine the best of traditional academic pathways with the high-quality CTE approach. For example, the Georgia Department of Education lists pathways in the information technology cluster, including computer science which terminates with the Advanced Placement Computer Science course (Georgia Department of Education, 2021). By including AP or dual enrollment opportunities, students can earn the CTE diploma and college credits, expanding their options and often contributing to postsecondary success after the CTE program (Karp & Hughes, 2008). Education stakeholders are responsible for ensuring students are given clear and barrier-free pathways to a broader set of education outcomes, including graduation, early college, competitive transcripts for college applications, and helping students build self-confidence to persist in those pathways.

Computer science education and high-quality CTE programs can play essential roles in this goal.

This report seeks to identify the intersection of CS and CTE in the United States based on research literature and discussion from educators, advocates, researchers, state leaders, and nonprofit organizations. We encourage program designers and implementers to consider how the promising practices and expert opinions offered in this report can support the overall goals of equity in traditional education outcomes (graduation rates, performance on assessments, etc.) and broadening participation in postsecondary computing pathways. The appendices include the names and affiliations of participants, the structure of the meetings conducted during the summer of 2020, and the process by which the report sections were created.

MSDE Launches New CTE Program in Partnership with Apple

The Maryland State Department of Education launched a new CTE program of study where students will learn mobile application and software development with the Swift programming language. The new program offers students the opportunity to earn industry credentials upon graduating from high school, boosting their employment skills and supporting Maryland's growing tech economy.[1]

[1] Maryland State Department of Education (2021, January 22). *MSDE Partners with Apple in new app development program for Maryland schools* [Press release]. Retrieved from https://news.maryland.gov/msde/wp-content/uploads/sites/12/2021/01/News-Release-New-Apple-CTE-Program-Introduced-in-Maryland-Schools.pdf

1
Classroom Practice

Classroom practice encompasses teachers' complete set of pedagogical approaches and strategies, the curricular materials chosen, and the assessment techniques used to provide feedback to students and assess their learning of core concepts and skills. CTE and CS education share common ideas around best practices for classroom instruction. These include but are not limited to contextualizing learning to real-world situations, collaborating with peers, and having diverse role models for students. In this section of the report, we share promising practices and examples sourced from CTE and CS education experts from their discussion on high-quality CS CTE classroom practices.

High-quality CS CTE classroom practices emphasize team-based routines.
Few computer science professionals work in isolation; most belong to cross-disciplinary teams with different expertise and must break larger problems into smaller tasks and communicate well. While in a CTE classroom, teachers should reinforce the use of CS-related team-based practices and routines such as Agile[2] and SCRUM[3] methodologies and collaboration through code repository environments such as Github[4]. Additionally, students working in teams need to practice breaking complex problems into multiple components where each student works within a clearly defined scope and roles to finish a product.

High-quality CS CTE classroom practices emphasize real-world and student relevance. In CTE, high quality means more than just addressing specific concepts or skills in an abstract or isolated context. The context in the classroom matters, as CTE seeks to prepare students to transition to workplaces and the experiences that help shape professional ways of working and problem-solving that entry-level professionals employ every day. Simulated workspaces[5] are an innovative way to expose students to professional working conditions in a scaffolded environment within the CTE classroom. In addition to being the instructor, the teacher is also a manager and sometimes a mentor as students navigate relationships

Congressional App Challenge

Each year, thousands of students from across the United States engage in the Congressional App Challenge, an opportunity to design original mobile apps that will address a challenge put forth by congressional representatives. Programs like the app challenge can be leveraged as a part of CTE or CS classrooms to connect student projects to real-world problems and rewards. In addition to building the technical product, students need to understand what type of app would be valued by the community, a description of the app's purpose, and how it would connect with a target audience. Winners and finalists are often invited to present their app in person and connect directly with the congressman and/or their staff. More information is available at www.congressionalappchallenge.us

[2] Kastl, P., Kiesmüller, U. & Romeike, R. (2016). Starting out with projects: Experiences with agile software development in high schools. In *Proceedings of the 11th Workshop in Primary and Secondary Computing Education* (pp. 60-65). Association for Computing Machinery. http://dx.doi.org/10.1145/2978249.2978257; Kastl, P. & Romeike, R. (2018). Agile projects to foster cooperative learning in heterogeneous classes. In 2018 IEEE Global Engineering Education Conference (pp. 1182-1191). Institute of Electrical and Electronics Engineers. https://doi.org/10.1109/EDUCON.2018.8363364

[3] Wallace, C., Mohan, S., Troy, D., & Hoffman, M. E. (2012). Scrum across the CS/SE curricula: A retrospective. In *Proceedings of the 43rd ACM technical symposium on Computer Science Education* (pp. 5-6). Association for Computing Machinery. https://doi.org/10.1145/2157136.2157142

[4] Glassey, R. (2019). Adopting Git/Github within teaching: A survey of tool support. In *CompEd 19': Proceedings of the ACM Conference on Global Computing Education* (pp. 143–149). Association for Computing Machinery. https://doi.org/10.1145/3300115.3309518

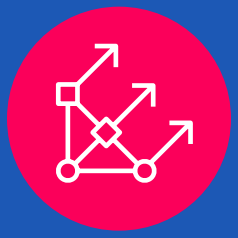
[5] Floyd, L., & McNally, K. (2021). Expanding access to high-quality work-based learning with simulated workplaces. *Techniques: Connecting Education and Careers, 96*(4), 16-20.

with peers and clients. The inclusion of real-world clients, from neighborhood businesses to industry partners, allows students to practice technical concepts and the skills necessary to navigate workplace communication. The CTE classroom often restructures itself to best align with a workspace, creating teams that report to the teacher, perhaps with team leads or other student leadership structures that are important to practice.

High-quality CS CTE classroom practices match curriculum and pedagogy to foster interest development and learning.

It would be challenging for a CTE teacher to adapt a curriculum designed without a CTE classroom in mind for the CTE classroom environment. Combining culturally responsive and sustaining education (Gay, 2018) and interest-based contexts are essential for equity and student engagement. Still, these must be presented in a way that authentically allows students to move beyond their personal views and incorporate the "client" as a stakeholder in designs. In a CTE classroom, the purpose of a project is directly connected to a larger context or deliverable for an actual or simulated client. The connection to a client fosters cross-disciplinary skill development through the meaningful integration of computer science technical skills and skills in other domains, including communication, writing (for documentation), and collaboration.

2
Course Sequences



Course sequences guide developing multi-year programs of study and influence how educators deliver standards and implement the K-12 CS framework. Students learn best and most efficiently when coursework is sequenced and builds upon knowledge from previous years. In CTE, course sequences are referred to as *Programs of Study*. They are required for approval by state education departments to take advantage of additional funding and receive special CTE designations. A *Program of Study* comprises a group of CTE courses often resulting in at least one certification, other industry-recognized credentials, or a reviewed portfolio of work. This section of the report shares promising practices and examples sourced from CS and CTE education experts as they reflected on high-quality CS CTE course sequences.

High-quality CS CTE course sequences include broad on-ramps.

Equity in course sequences should not be overlooked. Course sequences should support students in early course work by having entry points for students with different background exposure levels and include modifications for students with IEPs. Differentiated instruction and transparency around prior knowledge can help novice students not believe they are less able, just in need of preparation other students have already received. If possible, multiple entry points allow for students with prior experience to not relive the "first course" while at the same time not creating situations where previous academic privilege does not grant unfair advantage (or the perception of inherent skill). Multiple entry points could mean allowing some students to skip a basic introductory course or creating separate introductory courses where more advanced students go deeper into associated topics without leaping ahead.

High-quality CS CTE course sequences require flexible pathways.

Although high-quality CTE pathways have a clear goal in mind from the start (certification or other industry-recognized standards), there are multiple CS CTE focus areas available. More flexible pathways are needed as students may not initially make informed choices between web design, cybersecurity, software engineering, robotics, or information technology design and support. Allowing for general, shared introductory coursework that can satisfy multiple pathways will create opportunities for students to experience a variety of topics before needing to go deep into the certification-aligned coursework. Without allowing student experience to drive interest, those making recommendations for student enrollment may fall back on stereotypes of particular "types" of students who would do well or be interested in the field.

Georgia Department of Education Career, Technical, and Agricultural Education

Georgia has defined multiple programs for CS CTE (or Career, Technical, and Agricultural Education [CTAE]) programs of study[6] under the Information Technology cluster. The focus of the programs is diverse, including cybersecurity, game design, programming, web design, cloud computing, coding, app development, and others. Despite the different endpoints, there are several programs with common starting courses such as Introduction to Software Technology, which forms the basis for CS, Game Design, Internet of Things, Programming, Web and Digital Design, Web Development, and Cloud Computing.

High-quality CS CTE course sequences emphasize secondary-postsecondary alignment and align with industry needs.

Program designers should balance course sequencing to ensure students who exit are prepared for college and career opportunities. CS CTE programs should include course sequencing that provides students with coursework that results in employable

[6] GA information technology programs available at https://www.gadoe.org/Curriculum-Instruction-and-Assessment/CTAE/Pages/cluster-IT.aspx

entry-level skills such as full-stack development while also preparing students to be successful at the college level. Additionally, when designing course sequences, it is essential to consider the ability for students to have access to devices, connectivity, and educational materials that support intended outcomes and licensing opportunities. These two goals can sometimes be at odds, and carefully designed sequences will balance employable skills with postsecondary coursework such as dual enrollment or advanced placement courses. The choice of curriculum and projects within the postsecondary aligned coursework is key, as freshman-level college courses are meant to begin a multi-year journey into the workforce. At the same time, CTE programs are more directly connected to employability goals. High-quality course sequences require thoughtful consideration of what standards are covered throughout a student's journey and what introductory courses could satisfy the broad needs of the school while still being connected to high-quality CTE outcomes. A key component of CTE programs is to align with potential entry-level careers for graduates. High-quality course sequences include industry engagement to align program content with changing workforce needs. Computer science has always struggled to find the appropriate balance between "entry-level" positions defined for workers with a bachelor's degree and entry-level requirements for high school, associate's degrees, or candidates with proper industry certifications. Course sequences and credentialing should be vetted and refined through industry engagement activities such as an advisory council, and internships and portfolio review can help educate industry partners as to the capabilities of CTE students at various points in the program. There will be multiple pathways for students to pursue in completing CS CTE programs in a well-developed course sequence.

Chambersburg Area School District (PA)

Chambersburg Area Senior High School currently has four computer science courses: Introduction to App Development, App Development 2, 2D Game Design, and Augmented Reality (AR) with Apple's SWIFT Curriculum. In addition, the school is planning to add Advanced Placement CS Principles and potentially a course in cybersecurity. Although not yet a CTE pathway, the courses, student interest, and partnerships are helping to guide the discussion at the district around CTE and computer science offerings. The teacher, Mr. Barnabei, states, "I am a big proponent of accessibility and giving all students the opportunity to experience coding and feel that this is important even for those who have no interest in pursuing a CS-related career field. A few ways that I try to achieve this is through cross-curricular projects with other teachers to provide students with exposure and awareness of the opportunities at the school, offering flexibility and optimal times in the schedule when Intro to App Dev is offered, and by, generally speaking, striving to offer students a 'productive struggle' in any coding activity where they are challenged yet are still able to be successful."

3
Teacher Preparation, Certification, and Recruitment

In both CS and general CTE teacher preparation, teachers need specific content knowledge that is not always a part of core academic curricula in teacher preparation programs. Teacher preparation, however, is not a decision made by the universities or programs in isolation. All teachers employed by public schools must obtain certification from their state to teach. States may require teacher candidates to pass one or more exams, gain classroom experience, and take regulatory requirements. For CTE programs, these requirements often include a major or significant number of courses in the CTE domain and industry or other relevant work experience outside the classroom.[7] This section of the report shares promising practices and examples sourced from CS and CTE education experts as they reflected on teacher preparation, certification, and recruitment to support high-quality CS CTE programs.

[7] Zirkle, C. J., Martin, L., & McCaslin, N. L. (2007). *Study of state certification/licensure requirements for secondary career and technical education teachers*. National Research Center for Career and Technical Education. https://files.eric.ed.gov/fulltext/ED508968.pdf

High-quality CS CTE programs need teacher preparation, certification, and recruitment tailored to CS.

Teacher recruitment and preparation must emphasize the value of a teaching profession and help CS teacher candidates understand the intersection of the historical technical content (programming, hardware, etc.) and the increasing call for ethics, social impacts, and employability skills of teamwork and collaboration. Computer science teacher preparation has often been centered in professional development experiences for existing educators. CTE programs have often separated the technical content from pedagogical training to implement the content with additional skills and competencies. Teacher preparation programs should work with nearby CTE directors to develop relationships with industry partners for teacher candidates' internships and work-based learning experiences aligned to regional CTE program goals and partnerships.

High-quality CS CTE teacher preparation, certi ication, and recruitment initiatives should be mindful of unintended consequences.[8]

Complicating the landscape in CS education is the uneven distribution of computer science courses within subject areas throughout the 50 states. The teacher who can teach a course, and the certification required, are often driven by the subject area for which the course is coded. For example, a CS course can be a math course in New York, a science class in Georgia, a business class in New Jersey, or a CTE course in Texas. The subject area a CS course is coded for creates difficulty identifying stand-alone requirements for CS teachers and CS-related requirements for CTE teachers due to significant CS coursework and industry experience requirements. State policy moving CS in or out of the CTE umbrella must be accompanied by thoughtfulness around teacher preparation. Such as potentially upskilling non-CTE teachers to meet CTE standards and ensuring the availability of coursework or professional development focused on the best practices in this report and the wide variety of concepts and skills under the computer science umbrella.

Exploring Computer Science

Programs such as Exploring Computer Science have created opportunities to observe a combining of technical content with pedagogical approaches such as culturally responsive pedagogy. Teachers learn the computing concepts while preparing and teaching demo lessons to fellow attendees at the professional development sessions. Professional development facilitators question the participants about the pedagogies observed and how teachers lead classroom discussions and create project-based support for learners (Goode & Chapman, 2019).

[8] Bruno, P., Lewis, C.M. Computer science trends and trade-offs in California high schools. *Educational Administration Quarterly*. https://doi.org/10.1177/0013161X211054801

High-quality CS CTE programs teacher preparation, certification, and recruitment provide micro-credentialing opportunities.

Computer science education is best presented with real-world examples closely connected to local industry or community values. With significant value placed upon finding real-world problems and models relevant to students, both in CTE and non-CTE CS classes, teacher preparation and certification must balance the basics with context-driven tools and applications. For example, a rural community may want to emphasize topics related to farming tech and apply artificial intelligence and robotics to the core basics of CS. At the same time, an urban center may focus more on web applications. Teacher preparation and certification must provide a wide range of options for a teacher to experience. Certification opportunities must be flexible enough to encompass the broad range of topics that a teacher may ask within any given state. Micro-credential programs could serve as a possible way to add flexibility while still offering verifiable learning experiences.

4
Industry Engagement

Through industry engagement, CS CTE pathways can uniquely bridge the divide between the workforce and K-12 education systems. Computer science students need to experience workplaces, hear from industry professionals, and be given a chance to participate in real-world problem solving and technological creation. Industry partners can bring authenticity to the classroom through engagements as adjunct instructors, teaching assistants, or mentors. They can emphasize core fundamentals, help program designers focus on the necessary curriculum, and provide work-based learning experiences for students or eventual employment opportunities. The professional fields associated with CS are constantly changing. CTE programs need to maintain close connections with industry and community partners to meet changing needs. This section of the report shares promising practices and examples sourced from CS and CTE education experts as they reflected on high-quality CS CTE industry engagement.

High-quality CS CTE industry engagement requires ecosystem creation.
It starts with a community and a shared vision. An ecosystem of critical stakeholders is essential to eliminate work in silos, develop trust and partnerships, create and maintain collaboration hubs, develop expected timelines and goals, and streamline communication. The ecosystem must be one that educators, companies, and organizations can rely on for knowledge generation and information sharing. Professional CTE organizations, regional hubs, and industry associations can play an essential role in creating a healthy ecosystem and produce examples of high-quality industry engagement that can initiate or improve other CS or CTE programs.

Aviation High School – Queens, NY

Aviation Career and Technical High School in Queens, NY, is a flagship example of a long-term relationship between an industry partner, John F. Kennedy Airport, and the school. Because of the long-term partnership, students complete a program of study focused on becoming certified as aircraft maintenance technicians and do coursework on the airport grounds. The collaboration with the airport ensures that students get hands-on experience with an actual aircraft. The school was fortunate to receive the donation of a retired airplane to ensure students had the equipment necessary to pursue their studies.

High-quality CS CTE industry engagement emphasizes the K-12 pipeline and career pathways.
Industry engagement should occur throughout a student's K-12 experience and, hopefully, continue into their postsecondary years. Industry leaders and professionals should collaborate with educators on program development and curriculum design. At every point in the student's journey, the pathway ahead, with multiple options, should be made clear to them. Industry engagement can bring industry expertise into the classroom through teacher professional development for all grades and new course developments, keeping the K-12 pathway up to date and relevant to industry skills. Industry leaders can align workforce needs and student preparation by working together with the CTE programs.

High-quality CS CTE industry engagement emphasizes long-term engagement and investment.
School systems and industry move at very different rates, and while industry often prioritizes adopting or integrating new technologies, education programs cannot reinvent themselves every year. The most successful CTE programs focus on close relationships between schools and individual companies to reduce the broad swath of possibility and create meaningful opportunities for students that are consistent from year to year (Mulgrew, 2014). As these entry-level skills change with technology, close connections with industry are necessary to ensure the graduates of the CTE program are truly career ready. In terms of knowledge, given that the job market is continuously evolving, experts suggest that future-casting of desirable skills for entry-level jobs and careers that do not yet exist is crucial for two

key reasons. First, this will help us close skill gaps, identify what skills are already included in a CS CTE pathway, and ensure industry expertise aligns with that course of study. Second, industry-informed standards, curriculum development, and training can be in place for a CS CTE with this knowledge. Industry engagement is an essential support to the design, development, and execution of CTE programs. It can complement federal funding to create high-quality programs that are sustainable due to close industry relationships.

Together with industry, educators can continue to find new and innovative ways industry experts can have a meaningful role in K-12 CS CTE pathways. Despite the positives of high-quality partnerships, challenges emerge. There can be hesitation to invest in education settings if industry partners are not engaged in setting up programs. Early communication is key to establishing trust, plus research and evidence are necessary for full partnership.

TEALS Program

Microsoft Philanthropies supports the Technology Education and Literacy in Schools (TEALS) program. TEALS is a professional development program to help teachers learn CS by pairing them with industry volunteers with CS knowledge and experience. The TEALS program has worked with over 1,650 industry professionals from over 700 companies to serve thousands of students learning computer science. Although the TEALS program relies on the technical expertise of its volunteers, they also understand the special skills needed to teach that expertise. TEALS volunteers undergo professional development, are supported by a standardized curriculum, and are paired with a certified teacher who brings their experience and pedagogical expertise into the classroom. The TEALS program exemplifies how a thoughtful partnership between industry professionals and education settings can benefit students.

West Virginia Department of Education – Simulated Workplace

In West Virginia, the statewide program for simulated workplaces creates classrooms where students and teachers work together to solve real-world problems and challenges using project management skills, developing teamwork practices, and employing problem-solving practices (Cohen, 2018). Together with the Regional Educational Laboratory (REL) of Appalachia, the West Virginia Department of Education has produced a guide for educators on Strengthening Simulated Workplace Culture (REL Appalachia, 2019). Simulated workplaces treat classrooms as an opportunity for students to get work-based learning experiences within the school environment. Teachers work with industry partners to create authentic learning experiences that mirror what employees do, and students learn through hands-on projects in the environment. More information about Simulated Workplaces is available at wvde.us/simulated-workplace/.

5
Implications for State and Federal Policy

Education in the United States has multi-leveled decision-making and regulatory structure. While the federal government allocates specific funding, including funds for CTE through Perkins (sometimes referred to as Vocational and Technical Education Act [VTEA]) funds, the decision for how those funds are allocated and distributed lies at the state level. Additionally, although local school districts determine the individual courses and teachers who will instruct, most states set the graduation requirements, requirements for CTE programs or courses to be appropriate to qualify for CTE funding, and the requirements for teachers to instruct those courses. These policies can be either an accelerator of high-quality implementation or cause unintended consequences.

5 Implications for State and Federal Policy

The discipline of computer science has garnered significant representation in state-level policy across the United States in the past few years. Advocates and leaders within the computer science community are collaboratively working toward getting more state policies in place and effectively embedding computer science as a fundamental discipline and specialized subject within U.S. education. State policymakers and CS education advocates are working within each state's policy context to balance the fundamental learning for CS necessary for all students while defining high-quality pathways for students who wish to go deeper and prepare for college or a career.

State-level policy efforts have moved past expanding access to CS education. Recent efforts have gone further and have led to a fundamental policy shift that focuses on policies that grapple with defining what constitutes high quality, equitable, and inclusive computer science education for all students (Code.org, CSTA, & ECEP Alliance, 2021; Xavier et al., 2021). The experiences and insights of district and state leaders are also actively incorporated with emerging and established CS education policies. As the discussion around CTE, CS education messaging has used motivation focused on the ways computing has become a crucial aspect of daily life and has drawn bright lines around the critical need to democratize access to CS spaces for our nation's students.

States, districts, and school communities have collaboratively carried out efforts to increase capacity to offer computer science within CTE programs during students' K-12 education experience by training teachers, expanding teacher access to high-quality instructional and teaching resources, and encouraging the development of effective regional partnerships between schools and employers in the community. (See the "Industry Engagement" section to learn more about such partnerships.) Effective regional partnerships supplement CS CTE policy efforts, particularly in providing policymakers with a range of justifications for why their policy is crucial. Such policies ensure alignment between a state's current and future economic priorities and CS education policy efforts, provide alternative postsecondary education credential opportunities for all students, and create mutual value across industries and institutions. These initial collaborative policy efforts have allowed more states and districts to offer more rigorous, hands-on, and accessible CS CTE programs to all students. Having garnered endorsements for incorporating CS CTE programs into the traditional K-12 educational system, states and districts alike have shifted their efforts towards now addressing what constitutes high quality and equitable CS education for all students.

DC Can Code – CTE Coding Camp

DC Can Code is a high-quality example of an innovative CS CTE summer program. DC Can Code offers a free summer coding camp for rising ninth graders in public and public charter schools in the District of Columbia. For two weeks, students get to learn to code in Swift Playgrounds from Apple. Read more about DC Can Code at osse.dc.gov/page/cte-coding-camp.

5 Implications for State and Federal Policy

Education policy efforts have a long tradition of assuming that incorporating standards, requirements, or certification guidelines implies consistency in terms of outcomes for both the teachers delivering and the students receiving the educational content required by policy. However, at the state level, it has become evident that policy efforts around CS CTE programs need to address the reality that there is no “one-size-fits-all" when developing and implementing CS CTE programs within school communities. Standards are not necessarily uniformly translated into the K-12 education system resulting in a unified outcome for all students across different districts and schools. Additionally, as curriculum development efforts mature and there is increased pressure to address sub-domains of CS such as cybersecurity, artificial intelligence, and data science[9] within fundamental pathways and CTE pathways, standards and pathway definitions will need to be adjusted. The possibility of increased focus and sophistication will also reflect increased student preparation before high school, as many states now have mandated CS standards in grades K-8.

This variation presents a challenge and unique opportunity for policymakers attempting to expand and grow their local CS CTE education initiatives. Variation in implementation has allowed states to craft policy efforts that align with their local community definitions of high quality and equitable CS CTE. However, the lack of a unified guideline for standards, certification, and requirements at the national level has presented challenges in creating better alignment and a foundational definition of CS within the CTE context. Teachers themselves often lack experience with the expanding definition of CS for K-12 education and experiences with various topics in a CS CTE program. Therefore, teachers need more opportunities to learn about sub-domains and introductory CS. Simply establishing policies around computer science education teaching and learning practices cannot guarantee teacher and student success in developing a foundational K-12 understanding of the computer science field.

Bryan Cox
Computer Science Program Specialist, Georgia Department of Education

“Computer Science naturally becomes the discipline that spans the hallway because as it currently stands, CTE is on one side of the hallway and CS instruction and curriculum is on the other.”

Bryan Cox
Computer Science Program Specialist, Georgia Department of Education

[9] DeLyser, RL. & Born, C. (2021). *The future of problem solving with data and intelligence: Increasing artificial intelligence and data science education across the US*. CSforALL. https://firebasestorage.googleapis.com/v0/b/summit-website-production.appspot.com/o/AI%20and%20Data%20Science%20Ed%2FCSforAll_AI_DSE_100821.pdf?alt=media&token=758ba767-817a-450c-b9ba-fa87a93cbfc2

Key Policy Recommendations

The following recommendations are focused on policies and implementation strategies at the state and federal level to better align equity and broadening participation goals of CS education with the policies governing CTE.

1. Clear communication of desired outcomes, and possible course sequences are needed to address the ambiguity of how computer science and career technical education are treated within the policy governing the U.S. K-12 education systems. The outcomes and the communication should involve cross-stakeholder collaboration and thought partnership between industry, educational institutions, policymakers, and workforce nonprofits.

2. Policymakers need to ensure their policies have a foundational element of equity integrated into the first stage of policy implementation practices, requirements, and measurement. The measurement in policy implementation and the reflection on the data should be specific to equity and allow for the assessment of impact outcomes, the experiences of all involved parties, and the critical implementation decisions made locally to translate the policy into action.

3. The state framework for CTE program graduation requirements needs to shift from gaining credentials to a skills-based approach that allows students to develop experiences and portfolios that demonstrate career-ready skills. Complementary to the shift in end-point requirements, clarity around quality in the pathways that approach the end requirement, CTE opportunities, and upskilling for K-12 stakeholders for shared understanding and decision-making are valued.

4. Computer science should be infused into earlier grades (K-8). Career awareness in middle school should be aligned with available CTE pathways and use Perkins funding to support updating the current middle school career awareness curriculum.

5. Schools of education and postsecondary institutions that offer CS programs need to work together to ensure CTE teachers have fundamental introductory coursework and opportunities to explore sub-domains of CS.

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List of Meeting Attendees and Contributors

Jared Amalong
Director, Computer Science and Digital Learning, Sacramento County Office of Education

Kevin Bals
Deputy Director,
CSTA NJ

Tim Barrett
Trade & Industry Specialist, CTE,
Minnesota Department of Education*

Jamie Boettcher
Regional Specialist,
Division of Career and Technical Education,
South Dakota Department of Education*

Jason Bohrer
Chapter Relations Manager,
Computer Science Teachers Association

Peter Borchardt
Technology Instructor,
High Technology High School, NJ

Chris Breazeale
Education Programs Consultant,
California Department of Education*

Denise Brock
Computer Science CTE Specialist,
Oregon Department of Education*

Thea Charles
Head of Knowledge and Impact,
Siegel Family Endowment

Angela Cleveland
Program Director,
National Center for Women & Information Technology

Andrew Cook
Education Associate,
Office of Career and Technical Education,
South Carolina Department of Education*

Bryan Cox
Computer Science Program Specialist,
Georgia Department of Education*

Jackie Cullen
Executive Director,
Pennsylvania Association of Career & Technical Administrators

Chris Dovi
Executive Director,
CodeVA

Sarah Dunton
Director,
ECEP Alliance

Timothy Elliot
CTE Director,
West Virginia Department of Education*

Jacqui Garrison
Communication and Information Systems Career Field Specialist,
Nebraska Department of Education*

Joan Goldberg
Computer Science Teacher,
PCTVS - DCL STEM Academy

Delda Hagin
Business & Computer Science Program Specialist,
Georgia Department of Education*

Khurram Hassan
Facilitator,
Collective Impact Initiative, CS4GA

Jill Hubbard
NSF Grant PI/CS Faculty,
CS for Oregon, Oregon State University

Appendix A

Cale Hutchings
CTE Educational Consultant Information Solutions,
Iowa Department of Education*

Sean Jackson
K-12 Computer Science Lead,
CS/IT Academy Certifications Program Manager,
Kentucky Department of Education*

Stephen King
Education Program Consultant,
Kansas State Department of Education*

Michael LaMastra
Associate in Instructional Services,
New York State Education Department*

Larry Lieberman
Chief Executive Officer,
Mouse

Laura Maher
Relationship Manager,
Siegel Family Endowment

Debbie Marcus
Senior Director,
Break Through Tech

Dawn Morrison
State CS Administrator,
Alabama State Department of Education*

Scott Nichols
Coordinator of Career Programs,
STEM, and Computer Science,
Maryland State Department of Education*

James Novotny
Full-time Lecturer,
Kean University

Tom O'Connell
Chief Partnerships Officer,
Mouse

Davina Pruitt-Mentle
Lead for Academic Engagement,
National Initiative for Cybersecurity Education *

Wayde Sick
Director and Executive Officer,
North Dakota Department of Career and Technical Education

Terrel Smith
President-Elect,
Oregon Computer Science Teachers Association

Glennon Stratton
STEM Program Director,
CDE Foundation

Brett Tanaka
Computer Science Education Specialist,
Hawaii State Department of Education*

Kevin Wang
Founder,
Mentors in Tech

Ramik Williams
Executive Director,
Kings Against Violence Initiative

Pat Yongpradit
Chief Academic Officer,
Code.org

*This agency does not necessarily endorse the opinions or ideas expressed in the report.

Appendix B

CSforCTE Meeting Agenda

The CSforCTE meeting was split between multiple days to reduce zoom fatigue and promote active discussion across topical breakout sessions. The meeting was hosted virtually on the Zoom platform. Day 1 (August 17) was an open forum with registration available to the larger CS education community and advertised over social media. The remainder of the agenda was by invitation or request to participate only to keep breakout sessions manageable and foster discussion. The invitation list was collaboratively developed with CSforALL, industry partners, and CTE national leaders' input. Additionally, invited participants could nominate additional professionals for an invite, and several professionals applied to attend through an online form.

Date	Time	Duration	Session Number & Topic
August 17, 2020	2:00–4:00PM EST	2 hours	**General Public Plenary** • Career and Technical Education and CS Education: Who, What, How, and Why • CTE Panel - Policy, Practice, Industry, and Courses • CTE and Considerations for Equity
August 18, 2020	2:00–3:00PM EST	1 hour	**Closed Expert Meeting** • Introduction to CSforCTE project and goals for next two days • Lightning Talks • Breakout room assignments
August 19, 2020	2:30–5:00PM EST	2.5 hours	**Breakout Room Discussions** • Classroom Practice • Course Sequences • Industry Engagement • Policy
August 20, 2020	3:00–5:00PM EST	2 hours	**Breakout Groups Report outs/Shares/Next Steps/Wrap**

Appendix B

The breakouts used a scaffolded approach to identify critical gaps and recommendations for each topical area. The breakout protocols were adapted from the Multiple Perspectives Protocol from the School Reform Initiative.[10] The following process was encouraged for use by the facilitators in each breakout room:

Purpose:
To make the process of using multiple perspectives to enrich conversations transparent by seeing what various voices contribute to the whole.

Process:
1 Participants introduce themselves with their names and point of view. Director points out that this point of view can be broadly defined — "teacher," "administrator," "policymaker," "researcher" or more narrowly "CS Teacher" or "Hispanic CS Teacher" or "Rural Woman CTE Teacher". Participants are encouraged to select their identifying perspectives related to CS and CTE. *This may involve judgement, but no one's self-selected perspective should be argued with. It must be stressed that we all have multiple ways we could describe ourselves*. (5 minutes)

2 Director presents a question from the scaffolded notes document., E.g. "What are high-quality approaches to CS and CTE classroom practice?" (Please see your particular notes document for specific questions.

3 All participants write their first thoughts independently. (5 min)

4 Each participant, in turn, gives their preliminary thinking on the question, prefaced with their point of view: "From the point of view of a rural administrator, I think…" (10 min)

5 There is a second round, with each person giving their thinking based upon what they heard from the other participants: "Having heard other points of view, I now think…" (10 min)

6 A final round to reflect on any big ideas or themes from the responses: "I noticed that my/our responses..." (10 min)

7 Steps 2-6 will be repeated for the other two questions in the guided notes.

8 Any remaining time will be used to return to particular questions or topics. Be sure to nominate someone who will represent this team's view (with input/comments) when topical breakouts are collapsed to 1.

Each room was tasked with answering the following questions using the protocol:
1 What are the key aspects of high quality and equity in <breakout topic> in CS and CTE education?

2 What resources, exploration, knowledge, or action do we need to support high-quality CS and CTE Education?

3 If you were speaking to policymakers, educators, or school leaders, what would you recommend they consider for their classroom, school, or state?

4 Optional questions if time: What are the biggest challenges right now in CTE or CS education? What can CS learn from CTE or vice versa?

[10] https://www.schoolreforminitiative.org/download/multiple-perspectives-protocol/

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