Key Levers for Advancing K-12 Computer Science Education in Chicago, in Illinois, and in the United States

CME GROUP FOUNDATION

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PART 1

Executive Summary

CONTENTS

Suggested Citation:

McGill, M.M., Giglio, E., Thigpen, L., Lu, A. (2024). Key Levers for Advancing K-12 Computer Science Education in Chicago, in Illinois, and in the United States. CME Group Foundation. **DOI: 10.13140/RG.2.2.19442.07360**

EXECUTIVE SUMMARY

Since 2013, the landscape of K-12 computer science (CS) education in the United States has undergone rapid changes, and 42 states have now implemented policies to ensure CS education reaches their students (Code.org, CSTA, & ECEP Alliance, 2022). This remarkable growth has created a greater demand for support in both in-school and out-of-school CS learning opportunities. The CME Group Foundation (the Foundation) strives to empower future generations through education, equipping today's students to tackle the challenges of today and tomorrow. The Foundation believes in the power of collaboration, innovation, and transformative change.

During this transformative period, Chicago Public Schools (CPS) has emerged as a pioneering national leader, spearheading the CS for All movement. CPS, in collaboration with various partners such as non-profit organizations, industry, and research institutions, has diligently worked to eliminate barriers and provide equitable CS education to its students (Hegeman-Davis, 2021, p. 9). Recognizing the critical importance of CS education, the Foundation has placed a significant focus on building the K-12 CS education ecosystem in the Chicago area by providing multiple grants to support building the capacity of CS education efforts in Chicago and Illinois.

Measuring the impact of the Foundation's initiatives can provide insight into how their efforts have shaped the Chicago K-12 CS education landscape. It can also shed light on the gaps that remain and where future funding should be directed. In particular, the Foundation funded this study to understand:

- How the landscape of K-12 CS education in Chicago has changed across 2013-2022, with a focus on public schools, out-of-school-time (OST) programs, and research for evidence of progress.
- The current strengths and opportunities of the K-12 CS education landscape in Chicago, in Illinois, and nationally.
- How the support from the Foundation since it first started funding K-12 CS education in Chicago in 2015 has influenced the CS education landscape.

Computer science has become an essential skill for students. As the demand for computing jobs grows, there is a pressing need to advance K-12 CS education in Chicago, in

Illinois, and across the nation. To achieve this, there are several key levers that can advance change, including policy changes, teacher training and development, increased access to technology and resources, and partnerships between educational institutions, non-profits, and industry leaders. By leveraging these, we can equip students with the skills they need to thrive in an increasingly digital world and drive innovation and progress.

Through a combination of in-depth interviews and quantitative data analysis, this report presents a comprehensive set of recommendations for the Foundation's initiatives in supporting K-12 CS education in Chicago and Illinois. By engaging with 57 individuals closely involved in these domains, this impact study offers the Foundation valuable insights into various aspects of interest.

In the executive summary, we provide a set of these key levers within Chicago, across Illinois, and nationally to advance K-12 CS education. These levers are derived from a synthesis of *all* of the data in our study, including a synthesis of sentiments from one or more participants and quantitative data that may show opportunities for growth. These recommendations primarily target the corporate community, philanthropic organizations, school systems, and out-of-school-time (OST) providers, ensuring a well-rounded approach to fostering CS education and are not listed in priority order.

1. CHICAGO

To advance K-12 CS education in the Chicago Public Schools (CPS), funding organizations can further support the following levers. This includes support for teachers, curriculum, resources, and research.

1.1 Chicago Public Schools

>> Support consistency and fidelity across CS programs in CPS

There has been a tremendous effort to increase equitable learning outcomes in CS. These activities can be enhanced by supporting efforts to ensure fidelity of curriculum implementation across schools. Activities could include the creation of a new designation for high achieving schools that meet fidelity standards.

>> Support research within CPS to inform decision making to improve equitable outcomes for all students

Many interviewees emphasized the need to have evidence to enable a continuous improvement model that supports the decisions needed to promote equitable student outcomes. Previous research supports the need for further studies with a focus on curriculum scaffolding, pedagogical approaches, family needs, student experiences, and ethnographic studies. Further, longitudinal studies provide unique insight into changes over time associated with CS educational experiences/curricula and can uncover how pertinent psychological processes (e.g., self-efficacy, identity, and career interest) related to academic achievement develop over time for various students.

>> Continue to address the CPS teacher shortage

The teacher shortage has grown since the start of the pandemic. Addressing the need for teachers trained in CS will likely improve student outcomes. Strategies could include providing incentives for teachers from

historically marginalized groups to learn CS and to seek teaching opportunities in Chicago Public Schools.

>> Support teacher professional development in CS

Teacher licensure is a significant, ongoing barrier to CPS's ability to staff their schools equitably and uniformly with qualified, properly credentialed CS teachers. Continuing to support teacher professional development (PD) for in-service teachers will help ensure meaningful CS learning opportunities for them as well as for their students. Teacher professional development is uniquely critical in computer science education given the persistence in evolution of the field itself.

>> Support workforce pathways for high school students

Supporting workforce pathways for high school students, including internships and pathways into college to study CS, are important steps in ensuring that workforce development needs are met.

>> Support expanded K-8 CS

While high schools have been the primary focus of CS in CPS, learning is quickly trickling down into the K-8 classrooms. CS instruction in K-8 is important for reaching all students early to increase inclusion and belonging and to make it a part of their regular studies. These efforts will require additional training and development within CPS as well as in OST programs.

>> Support an increase in CS integration into other subject areas

There is a unique opportunity to integrate CS into other subject areas across K-12, such as in literacy, history, or mathematics. This includes exploring the integration of CS, data science, cybersecurity, and machine learning into subjects like social studies and history. This will reinforce CS learning for all students.

>> Support the design of scaffolded, standards-based curriculum

With CS instruction expanding across CPS, supporting the design of scaffolded curriculum that considers new learning happening across various grade levels will help ensure that students' CS learning continues to grow.

1.2 Out-of-School-Time Programs

>> Support searchable OST CS learning opportunities

Interviewees noted the continued need for students and teachers to easily locate OST learning opportunities. Supporting a searchable, up-to-date website will benefit the community.

>> Support Out-of-School-Time (OST) provider partnerships with CPS

Interviewees would like to see closer ties between CPS and OST program providers so that their efforts will be complementary, providing students with more aligned learning experiences. This could include providing ways that in-school and out-of-school can have common ways of tracking learning.

1.3 Other

>> Create networking opportunities for CS stakeholders in Chicago

Several interviewees expressed their wish to further connect with other providers and CPS educators in Chicago. Networking would help them better understand the Chicago CS landscape and where their program fits. It also would enable them to better meet the needs of students in different areas of the city.

>> Support an increase in hardware resources and internet access for individual students

Several interviewees noted that many students are still without resources to learn CS away from school. Providing hardware and internet access to these students would enable their learning.

2. ILLINOIS

While Illinois has made notable changes to support the growth of CS education, there is more that can be done to offer CS to all students. We recommend support be directed at the state level to teachers and community building efforts, and to research.

2.1 State Legislation and Department of Education

>> Support advocacy to build upon House Bill 2170[1], House Bill 3909[2], and Senate Bill 2374[3]

Illinois has passed House Bills 2170 and 3909, both of which support efforts to build the capacity of CS education in the state. In accordance with policies recommended by Code.org, Computer Science Teachers Association (CSTA) and the Expanding Computing Education Pathways (ECEP) Alliance (2022), and with the support and guidance of state-based organizations devoted to achieving CS for all students (i.e., CS4IL), Illinois can continue to adopt additional legislation (like Senate Bill 2374, currently pending as this summary was published) that requires CS to be taught in all grades to all students and teachers to be trained accordingly. The newly formed CS4IL Coalition and Illinois' new status as a

1 **HB2170** requires the Illinois State Board of Education to develop learning standards for CS and requires all school districts to ensure students receive opportunities to gain computer literacy skills starting in elementary school. Beginning in the 2022-2023 school year, high school students are required to take one year of a course that "includes intensive instruction in computer literacy".

2 **HB3909** establishes a microcredential for teachers to receive training in introductory and intermediate CS that will cover the best practices for teaching CS to students, focusing on content mastery and teaching strategies; provides that the State Board of education shall also establish a microcredential for teachers to receive training for Advanced Placement classes in CS after completing the introductory microcredential; and provides that the State Board of Education shall make the microcredential a primary endorsement area.

3 **SB2374** provides that, subject to appropriation, the State Board of Education establish a competitive grant program to support development or enhancement of CS programs in K-12 schools; provides that approved entities shall be responsible for ensuring appropriate facilities are available and educators are appropriately trained on the use of any technologies or devices acquired for grant purposes; and sets forth requirements to use the grant, renewal provisions, and rulemaking.

state in the ECEP Alliance may be a way to leverage multiple organizations to advocate for change.

>> Simplify course codes

Due to the complexity of the current course code system, it is nearly impossible to know which students have access to and participate in CS education and which do not. A simpler system would enable consistent data collection, which will make it possible to gauge CS implementation across the state. Further, data about students' CS experiences is essential. This might include their satisfaction with the course, sense of their ability to do well in CS, and desire to continue to study CS.

2.2 Teachers

>> Provide funding for downstate and rural teachers to attend CS professional development

This funding ensures that opportunities extend to all Illinois teachers. Funding could include attendance and travel stipends.

>> Provide support to community and four-year colleges to train pre-service teachers

Provide support to community and four-year colleges to train pre-service teachers, including funding for developing, selecting, and implementing curriculum for pre-service teachers.

2.3 Community Building

>> Support state-wide collaboration efforts by bringing together stakeholders

Supporting state-wide networking and collaboration efforts will help decision-makers understand how to bring CS into their classrooms. Efforts could include bringing together in-school teachers, OST program providers, administrators, and parents, to engage in one to two days of deep discussion about improving equitable access to CS education.

>> Support community efforts to develop K-12 CS learning opportunities

Providing support to OST programs for students outside of Chicago can be an important way to expand CS opportunities. In many areas, this may be the only way currently for students to access CS learning opportunities. Supporting localized efforts enables those who know their communities best to offer relevant learning opportunities for local students.

2.4 Research

>> Support research into student experiences and outcomes across Illinois

While access and participation can be measured by the number of course offerings and students enrolled, what this data cannot capture is whether there are equitable and positive outcomes. Research will enable a better understanding of what is working and what could be improved.

3. NATIONAL

3.1 National Strategies and Funding

>> Support the development of a national strategy for CS education

Without a delineated national strategy for CS education, programs and efforts may be launched inconsistently. Developing a national strategy can enable growth in CS education across the U.S. while ensuring uniformly appropriate offerings.

3.2 Teachers

>> Provide support to reduce the national teacher shortage, including for OST providers, and particularly for teachers of color

Addressing the national teacher shortage and the lack of teachers of color are critical steps for ensuring equitable CS opportunities in classrooms and in OST activities.

>> Provide support for training teachers to build their diversity, equity, inclusion, and belonging (DEIB) pedagogical practices

Providing support for training teachers to build their DEIB practices extends beyond content knowledge to include best practices for instructing all students.

3.3 Curriculum and Resources

>> Provide support for increasing awareness of the societal impacts of CS

While many teachers think teaching about societal impacts of CS is important, it is not a subject that is consistently taught. Given the rise of artificial intelligence, machine learning, and cybersecurity, additional efforts in this area are needed.

>> Provide support for K-8 CS for students

Expanding CS to earlier grades requires preservice teacher training and professional development at the K-8 grade level.

>> Provide support for resources for teachers serving lower-income elementary schools and more racially diverse schools

Supporting teachers in elementary schools designated as Title I and more racially diverse schools can help address inequitable student learning outcomes.

3.4 Research

>> Support the collection of research into best practices and equitable outcomes across the country

There is little national-level data and research on best practices and equitable outcomes in CS education. The experiences of students are understudied. It could be that required participation is driving students away from future participation in CS education – but we simply lack the evidence to know if this is indeed the case. Having evidence to drive change is critical, including how best to provide support to identify and reduce barriers for student participation in CS education.

PART 2

The Landscape of CS Education in Chicago, in Illinois, and Across the United States

CONTENTS

1. INTRODUCTION

The landscape of K-12 computer science (CS) education across the United States has changed rapidly since 2013, with 42 states adding policies to bring CS education to students (Code.org, CSTA, & ECEP Alliance, 2022). During this period, Chicago Public Schools (CPS) has been an innovative national leader and has been credited with being the frontrunner in launching the CS for All movement. Under the leadership of Brenda Darden Wilkerson, who played a pivotal role in getting the graduation requirement approved for CPS students and implementing the program until her departure in 2017, and with many partners (i.e., non-profit organizations, industry, research), CPS has removed barriers through a tremendous effort to bring equitable CS to their students (Hegeman-Davis, 2021, p. 9).

This phenomenal growth has brought an increased need for support for both in-school and out-of-school learning opportunities. The CME Group Foundation (the Foundation) strives to empower future generations through education, equipping today's students to meet challenges of today and tomorrow, empowering innovative partners, creating change through collaboration, and transforming systems. The Foundation has recognized this critical need for supporting CS education, and a major focus of the Foundation has been to build the K-12 CS education ecosystem over the last few years by providing multiple grants in and around Chicago.

Measuring the impact of the Foundation's initiatives can provide insight into how their efforts have shaped the Chicago K-12 CS education landscape. It can also shed light on the gaps that remain and where future funding should be directed. In particular, the Foundation funded this study to understand:

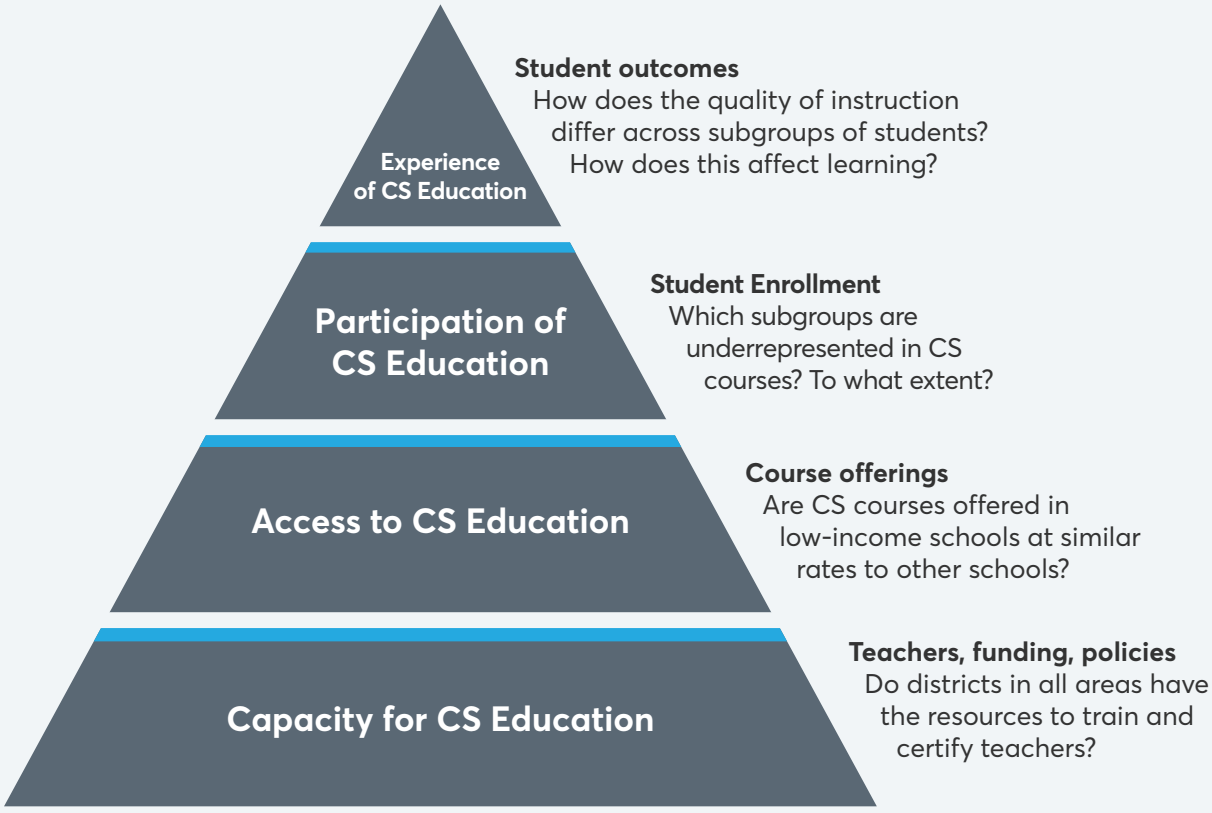
- How the landscape of K-12 CS education in Chicago has changed across 2013-2022, with a focus on public schools, out-of-school-time (OST) programs, and research for evidence of progress.
- The current strengths and opportunities of the K-12 CS education landscape in Chicago, in Illinois, and nationally.
- How the support from the Foundation since it first started funding K-12 CS education in Chicago in 2015 has influenced the CS education landscape.

This impact study provides the Foundation with a solid understanding of these topics from the perspectives of 57 individuals whose organizations work closely in these areas. This section uses the evidence from interviews we conducted with these individuals blended with quantitative data to create a set of recommendations for the Foundation to support K-12 CS education in Chicago and in Illinois with a focus on the corporate community, philanthropic community, school systems, and OST providers.

2. METHODOLOGY

We adopted a theoretical framework created by Fletcher and Warner (2020) to help us ascertain the *Capacity* for, *Access* to, *Participation* in, and *Experience* of equitable CS education as identified by student outcomes (**FIGURE 1**) across Chicago, Illinois, and the United States. Referred to as the CAPE Framework, it was designed to analyze how education ecosystems can contribute to effective CS education with a focus on equitable outcomes (Fletcher and Warner, 2019). CAPE has been adopted as a meaningful framework for disaggregating programs', schools', districts', and states' initiatives designed for equitable CS, including in the Expanding Computing Education Pathways (ECEP) Alliance (2020), which Illinois joined in 2023. The framework is deemed critical due to its careful consideration of the many factors that must be analyzed to ensure that all students are receiving impactful experiences in CS and that outcomes are comparable between various population subgroups such as Black, Indigenous, and Hispanic students, students identifying as girls or with non-conforming gender identities, students with disabilities, neurodiverse students, bi-lingual students who are learning English and students from low-income families.

Figure 1. Fletcher, C.L. and Warner, J. R., (2019). Summary of the CAPE Framework for Assessing Equity in Computer Science Education. *Retrieved from https://www.tacc.utexas.edu/epic/research.*



To investigate the four levels of the CAPE framework, we organized a qualitative study, conducting a set of 49 interviews with 57 people. The interviewees represented one or more of the following groups:

- One of the more than 15 organizations that have received grants from the CME Group Foundation
- Funders and others who are invested in supporting and providing K-12 CS education across Illinois or nationally
- Individuals from key organizations and in roles who could provide unique perspectives on the K-12 CS education landscape in Chicago, in Illinois, and nationally, including teachers, state leaders, researchers, non-profit leaders, and others

We asked questions related to the interviewee's role. We then used this wide lens of impact to stitch together a narrative from unique and interesting perspectives from the groups and individuals entrusted with building various pieces of the K-12 CS education ecosystem. These groups have adopted a "CS for all students" mentality and engage in program activities that reach a broad and diverse set of students.

We used a standard qualitative research

deductive coding procedure to carefully analyze each of the over 2,500 minutes of transcribed text against a codebook based on our interview questions and the CAPE framework. This process enabled us to synthesize groups of similar sentiments to derive themes and categories. We then complemented these themes and categories with supporting quantitative data to build a narrative about the landscape of CS education, with a particular focus on Chicago.

While the names have all been changed to protect the interviewees' identities, the table below shows which category each interviewee represents.

FUNDERS (4)
Sam and Jamie (joint interview)
Sean
Trina

CME GROUP FOUNDATION GRANTEES (21)	
Aaliyah and Linda (joint interview)	Kelly*
Aisha, Melinda and Darren (joint interview)	Leslie and Denise (joint interview)
Bernard	Lindsay and Jerod (joint interview)
Clinton	Martiza
Daniel	Olivia
Edwin	Wayne
Eliza	
Henry	
Kathleen and Lloyd (joint interview)	

*Individual represented two views

CHICAGO LEADERS (3)
Hubert
Kelly
Nicole and Amelia (joint interview)

ILLINOIS LEADERS (7)	
Christine	Sarahi
Jerome	Sloan
Mirabel	Tyson
	William

NATIONAL LEADERS (8)	
Beth	Lamar
Edward	Pamela
Henrietta	Rose
Janice	Roland

GENERAL INTERVIEWEES (14). THIS INCLUDES PROFESSIONAL DEVELOPMENT PROVIDERS, CURRICULUM DEVELOPERS, AND RESEARCHERS.	
Amanda	Latres
Angela	Lucy
Ben	Nathan
Blair	Teresa
Brooke	Valerie
George	Zachary and Tara (joint interview)
Kimora	

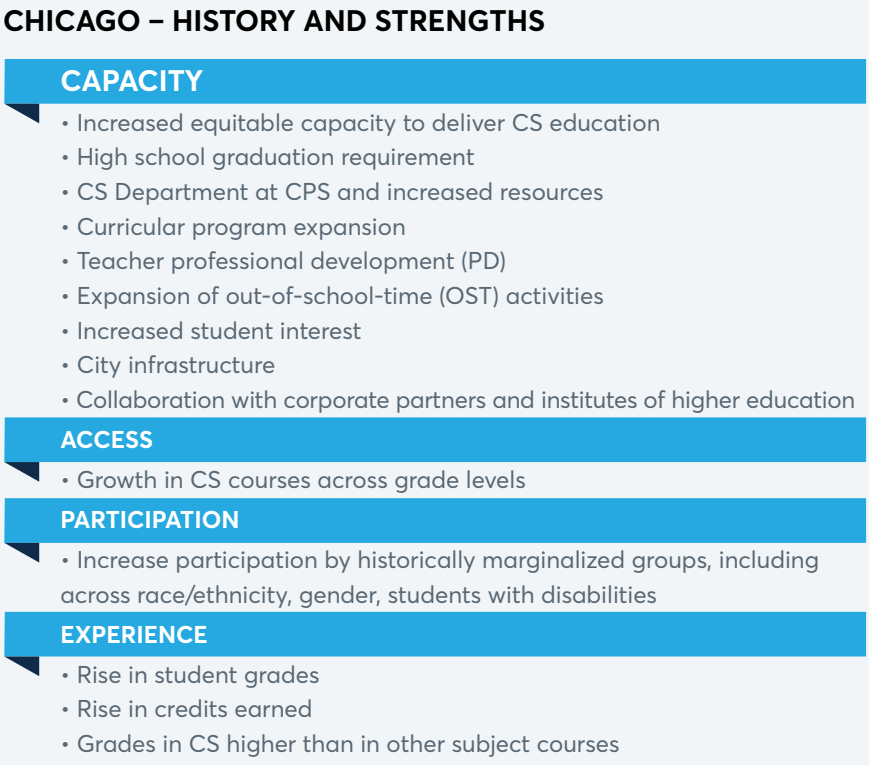
3. CHICAGO

The landscape of CS education in Chicago has changed significantly across the years 2013-2022, with Chicago serving as a national leader after launching the original Computer Science for All (CS4All) initiative in December 2013. As one of the largest cities in America—and the largest in Illinois—Chicago has some unique advantages. From philanthropy to public school educators to political figures, the consensus is that these roles have great potential to move CS education forward. Many interviewees offered unique perspectives and insight into recent changes by providing on-the-ground observations. This section includes interview results and corresponding quantitative data from other research efforts to describe these changes from a historical perspective.

3.1 CS Education in Chicago (2013-2022)

As an early adopter of K-12 CS education, particularly with its notable adoption of a high school CS graduation requirement, Chicago has paved the way for how to adopt curriculum, train teachers, and engage students in learning CS. As of 2020, CPS graduates approximately 14,000 students per year who take CS coursework. Interviewees provided meaningful insights, indicating distinct and overlapping patterns regarding the capacity for equitable CS education.

Figure 2. History and strengths of K-12 CS education in Chicago.



3.1.1 Capacity

Interviewees indicated that the most prominent areas of change in Chicago's K-12 CS education landscape include the adoption of a high school CS graduation requirement, CPS's creation of a CS department, and an office for CS learning and significant OST program expansion across the city.

Increased equitable capacity to deliver CS education. Across Chicago, interviewees witnessed a change over the last decade concerning diversity, equity, inclusion, and belonging related to CS education. One of CPS's goals for the CS graduation requirement was to increase equitable access (Dettori, Greenberg, McGee, Reed, Wilkerson, & Yanek, 2018). The 2012 choice to adopt Exploring Computer Science (ECS), a curriculum specifically created to introduce high school students to CS using culturally relevant pedagogy, was a key step in ensuring CS learning was directed to all CPS high school students (Barrow, Freire and de la Torre, 2020). As General Interviewee Brooke noted, "I've seen a shift in understanding the value of having diverse voices in CS and seeing that as a competitive advantage as opposed to something [needed to make] corporate pictures look [diverse]." Grantees Kathleen and Lloyd echoed this idea, noting that "It's clear that over the last decade there has been much more intentionality in getting to underrepresented students, whether it's race, ethnicity, and certainly gender."

This mindset shift may also be driving the increased awareness of and advocacy for delivering equitable CS education as a key part of Chicago K-12 education. This shift was noted by interviewees from many organizations, including CPS, employers, nonprofits, and universities. Chicago Leader and Grantee Kelly noted that initial research into how to develop an equitable CS program and how to provide an environment where all students felt that they belonged is starting to address the questions "How do we develop CS teachers' awareness of equity, and not just their CS content? How do we change the face of CS? How do we make it inviting for young women and students of color?" Interviewees noted that OST programs in Chicago have also become more comprehensive, offering a greater variety of learning opportunities that provide more in-depth experiences for a diverse group of learners: "There's been a definite increase in program providers and opportunities over the years…[including for] specific identity groups, such as Girls in STEM, Girls Who Code, and Black Girls Code," said Grantee Edwin.

High school graduation requirement. In 2016, CPS became the first large public school system to create a mandate requiring each high school student to complete a CS course (Barrow, 2020, p. 3). Over a third of all interviewees specifically cited CPS's high school CS course graduation requirement as a major catalyst for change, with General Interviewees Zachary and Tara stating, "With the high school graduation requirement [and] with other initiatives from corporate partners…[CS education in Chicago has] exploded." General Interviewee George also spoke of the CS4All Chicago initiative saying, "That early pilot work laid…a vision for what eventually became reality, which is: let's have it be a graduation requirement. That was a landmark decision."

CS Department at CPS and increased resources. Interviewees credit CPS's centralized CS department as a key part of

its support of the graduation requirement and its overall commitment to K-12 CS education. The adoption of a central office with its own director provides critical support of equity-enabling policies and aligns with one of the Code.org, CSTA & ECEP Alliance policies to establish CS supervisor positions in educational agencies. The general reaction to this new department was praise, since it shows a commitment to CS education that few districts have made—even those with a CS requirement. General Interviewee Brooke noted "that messaging has filtered to the school system, which I think also was one of the voices to help principals and administrators embrace CS as something that is critical and important." The centralized department also has created partnerships within the school district between teachers and administrators, afforded schools better resources and curriculum, and served as a "facilitator of resources" that could connect the right partnership to the right people.

After CPS passed the computer science high school graduation requirement, data from CPS indicated that funding for CS education rose from $100K in the Central Office (primarily a director's salary and operations budget) in 2012 to $3MM in 2022. School funding also grew from $2MM (based on estimated teacher salaries) in 2012 to $17MM, indicating a 29-fold increase and a 7.5-fold increase, respectively. Many interviewees noted that these increased resources across Chicago helped K-12 CS education grow over the past decade. As Brooke stated, "both in afterschool and in-school [programs]... there has been a tremendous increase in the number of teachers that are prepared to offer these experiences to students. I think that's a key ingredient for the success, scalability, and longevity of these initiatives." Interviewees also saw increased device and internet access having a positive effect on K-12 CS. Many interviewees mentioned that classes covered more and varied subjects related to CS.

Curricular program expansion. The high school graduation requirement and the new CS department at CPS have had a cascading effect into K-8. According to CPS, 225 of their elementary schools are now teaching CS (Chicago Public Schools, 2021). Grantee Wayne stated that "CS has become a primary focus of Chicago public schools and they're now trying to provide more CS opportunities at the middle schools for students." Chicago Leaders Nicole and Amelia also mentioned this trickle-down effect: "[F]rom the K-8 side, there's been a lot more engagement from schools and actually doing CS between the bells, not just out-of-school. There isn't a requirement in elementary, but there have been more schools seeing value in it, and incorporating it during the school day, whether that's integration [or] a siloed CS applied technology course all students go through."

> "CPS is trying to push the CS curriculum downstream, including integrating it into other subject areas and focusing on computational thinking in the K-8 space.
>
> —CHICAGO LEADER AND GRANTEE KELLY

Teacher Professional Development (PD). In the 2012-13 school year, as ECS was implemented in CPS, it was understood that adopting the curriculum also meant providing PD to teachers. By fall 2013, 75 teachers had received ECS PD (Barrow, Freire, and de la Torre, 2020). Before the CS graduation requirement, CPS was adding approximately 15 new CS teachers each year (McGee, 2022). However, after the requirement went into effect, the net increase in CS teachers was 38 teachers each year for the next four years, for a total of 152 during that time period (p. 6). This training includes efforts by Wachen, McGee, Yanek and Curry (2021), who embarked on an initiative to train over 100 CPS high school teachers in the ECS curriculum. This intensive training engaged teachers in PD and coaching interactions throughout the year. In a December 7, 2021, press release, CPS detailed that the district had trained more than 1,000 teachers how to teach CS as part of their mission to offer CS in every high school (Chicago Public Schools, 2021). General interviewee Ben remarked how the cycle of teacher training helps sustain K-12 CS education growth: "There've been many teachers that have gone through a lot of professional development in Chicago and [who] have become professional development facilitators."

There are significant costs for teachers to be trained and certified in a new subject. Illinois Leader William detailed who CPS is working with to meet the financial need for funding the training for the CS teaching endorsement: "CPS [funds] 80% of the cost of their teachers pursuing an endorsement… [H]aving dedicated funding sources for teacher PD and teacher endorsement really shows leadership [in] how [CS education] can be prioritized." Since teacher PD does not transfer into progression toward being properly credentialed to teach CS in Illinois, additional funds may be needed to achieve a significant number of credentialed teachers.

Expansion of Out-of-School-Time (OST) Activities. In the OST or afterschool space, Chicago saw a proliferation of new programs over the past decade (data presented in the Access section, Section 3.1.2). Some interviewees believe that the growth of Chicago OST programs shows that they are a complementary niche to in-school CS education, with Chicago Leader Hubert commenting, "We've gotten better at articulating the need for out-of-school-time opportunities for students around the city." OST programs expanded their diverse program offerings, accessibility to underrepresented students, and awareness of learning outcomes. Further, Chicago Leader and Grantee Kelly noted that they initially "… used OST to help a school train a teacher in a safe, non-evaluative learning environment" and the teachers then brought CS to their classrooms.

Over the past decade, OST programs have been able to offer more types of programs, including robotics, web development, and video game design. Grantees Kathleen and Lloyd see the breadth of OST programs as a complement to in-school learning: "Allowing youth to have more project-based opportunities, but then also allowing them to now have more of a focus, like, *Maybe I'm interested in CS, but I'm also interested in robotics, or maybe I'm interested in game design or web development.* Our programming gives our young people an opportunity to have that space to really apply what it is that they are interested in during the school day." General Interviewee Brooke's statements support Kathleen and Lloyd's view, "In the K-8 space it's much more difficult to introduce

a course, so there is more opportunity for out-of-school activities that [introduce] students to…CS."

Programs have not only grown more intentional when it comes to the kinds of courses offered but also are more focused on equitable learning outcomes. This may be due to the fact that grant requests for proposals increasingly have placed emphasis on the evaluation of student learning outcomes. Brooke pointed out: "The other thing that has changed, I think, in the afterschool activities, especially as people have sought grants, and things like that is that we are paying better attention to what kids are learning…Are the students really learning? Are the outcomes the same for each and every student?"

Increased Student Interest. Interviewees mentioned the growth in interest in CS among students over the recent years. "Kids are more interested in learning about CS than ever," said Grantees Lindsay and Jerod, adding: "COVID hit, kids that have not used a Chromebook or computers or have any inclination towards technology, were forced to start using computers…that has brought an inclination towards using technology devices." Grantee Martiza spoke to the versatility of Chicago's students: "They're open to new stuff…and they're aware that things are constantly changing."

City Infrastructure. Interviewees spoke of the structured local leadership in Chicago that makes it unique. General Interviewees Zachary and Tara described this ecosystem as starting with the mayor: "The mayor's office has control over the school system, both the college system, community college system because they appoint the chancellor, and the K-12 system because they appoint the CEO. When Chicago Mayor Emanuel told local businesses, 'Hey, we need to provide opportunities in CS for these students,' they lined up to do so." At the district level, principals and educators are showing their interest in CS education beyond the CS mandate, becoming excited about the opportunities that CS skills may give their students. "There has been a shift on the part of the principals in schools where they see this not just as a burden or Oh, I got to check the box," said Brooke, "There is an understanding of how important this is for their students, as well as how exciting it is to introduce that in the school."

> "Chicago, just the amount of resources that are here, I think really sets it apart."
>
> —CHICAGO LEADER NICOLE

Interviewees described a vibrant city with robust resources when they spoke about Chicago's strengths.

One of the key strengths for K-12 CS education in Chicago is the city's robust community infrastructure, which includes OST programs, philanthropic groups, employers, political leaders, and more. "Chicago is a hub for the state. We're ahead of everyone else in the state I would say,"

shared Grantees Leslie and Denise. "We're a major metropolitan city that has way more opportunities than probably even downstate…we also have a very robust out-of-school-time ecosystem compared to other cities." The political infrastructure is unique in Chicago. Grantee Eliza remarked that "Chicago's a very structured, in some sense, ecosystem-based; the parks, the schools, the libraries report back to the mayor. If the mayor says, 'I want you to document all your out-school opportunities,' then your biggest organizations do that."

Physical infrastructure also plays a key part. Places to teach CS in the city are abundant, and some interviewees credited Chicago's ample public spaces as a great venue for accessible CS learning. "I think that the secret sauce here also is the parks and libraries, which Chicago has…in every community." said Eliza. Grantee Daniel agreed: "I think as far as in our communities, one thing that's going really well is having partnerships with local libraries, and then local libraries being very receptive to those partnerships to create community events and community activities that are STEM and CS related. They're key partners because one, it's a public space. Two, it provides additional exposure for other community residents that do frequent the library or introduces them to a resource like the library."

Transportation infrastructure also improves accessibility. Some interviewees mentioned that the public transportation system allows students an economical, reliable way to get to CS programs both within and outside of their neighborhood.

Collaboration with corporate partners and institutes of higher education. Partnerships with universities or employers who work with either CPS or OST programs to improve CS learning are a key strength. Without these critical partnerships, many of the grantees' programs would not be sustainable. "[W]e partnered with [a university] to offer STEM programming, specifically robotics and other CS-based programming as well. Without our partnerships, we're not able to do this work," noted Grantees Kathleen and Lloyd.

> "The fact that [CS education is] a shared mission among different institutions and organizations coming together, I think is powerful."
>
> —GENERAL INTERVIEWEE BEN

General Interviewee Amanda described Chicago as being "definitely much more tech-focused [than some other cities]. I think that external pressure and also support from external employers and collaborators in that space also helps." Ben mentioned the enthusiasm of corporate partners: "There's some connections to industry. Certainly, the support by the CME Group Foundation, support by Google, by Microsoft, that companies have come alongside and say, 'We want to help. We'll offer you meeting space. We'll offer you people to come visit your classrooms.' That's been another strength."

Chicago Leader and Grantee Kelly detailed a collaboration between CPS and corporate partners, saying "We get various in-kind grants from different corporations," like Microsoft TEALS, Amazon Future Engineer, Google, and the LEGO Foundation. General Interviewees Zachary and Tara said that Chicago tech corporations "recognize that this is a great place to come see if their things work. That can be both a positive and a negative, but I think Chicago is able to definitely use it as a strength in terms of bringing large corporations here and having meaningful partnerships and strategic initiatives in order to bring opportunities to their students."

Interviewees also valued partnerships with higher education institutions. Grantees Aaliyah and Linda were appreciative, sharing this about their university partners: "They have brought a lot to the table in terms of how we can redesign…coding curriculum, integrating music, like initiatives to reach our students. How we can take what we want to have them take away but meet them and where they're at, and like in terms of language so they're helping us bridge those gaps, which has been really instrumental."

> "What I'm seeing now as a strength is that CS education is being offered to more historically marginalized communities. Many of our schools on Chicago's southwest side did not have these programs even five years ago. Now you have some schools that are now offering CS and they have…Girls Who Code clubs and things like that."
>
> —GRANTEES AISHA, MELINDA, AND DARREN

3.1.2 Access

Growth in CS Courses. Following the announcement of the CS4All initiative in Chicago, access to CS has steadily increased. According to CPS data, there was limited CS education data available that reflected the amount of CS offered in elementary schools in 2012. When tracked based on teacher PD completion, the number of CS learning opportunities in elementary schools increased to 250. Across high schools there were 3 courses at 27 schools (mostly ECS and AP CS A) in 2012, with this number rising to 32 courses at 111 schools in 2021. Barrow et al. (2020) noted that in 2012, 33% of CPS high schools offered at least one CS course. By 2018, this percentage had more than doubled to 80%.

Further, expansion of access was geographically wide-spread, and by 2018, more than 60% of CSP high schools in each geographic region of the city were offering at least one CS course. This data indicates that significant resources and infrastructure have been deployed to improve access.

These changes did not go unrecognized by our interviewees. Class offerings and breadth of curriculum have expanded as a result of the high school requirement; General Interviewee Brooke stated that "[the] number of people that have access to intermediate and advanced courses has quadrupled" over the past decade in CPS. Chicago Leader and Grantee Kelly confirmed this sentiment, saying "We went from having a few classes in CS at the high school level and at the elementary school level to having our first class in 2020 graduate as part of a cohort that was the first year that every student who graduated in 2020 had to have had CS." This has come with additional "career and technical education pathways that include CS learning opportunities in high school," stated Chicago Leaders Nicole and Amelia.

The most common strength mentioned by interviewees about Chicago's K-12 CS education landscape was CPS's mandate that put CS courses into every high school. In fact, by the 2020 school year, all selective

> According to CPS, "Since the Advanced Placement Computer Science Principles exam became available in 2017, 7,658 CPS students have taken the exam, with 51.1 percent of 2022 test-takers identifying as female or non-binary, well above the national average of 33.3 percent.
>
> —CPS OFFICE OF COMMUNICATIONS, 2023

enrollment schools, STEM schools, and neighborhood schools except one offered at least one CS course (McGee, 2022). Chicago Leader and Grantee Kelly noted that "I have to say that the district, we really focused at the high school level on the graduation requirement because that was one way we could really measure and be accountable for every single student in the district having had an exposure to CS." The astronomical growth in CS education in the schools was mentioned by General Interviewee Nathan, who said that now 15,000 to 20,000 students each year participate in CS programming.

The high school CS requirement has prompted the creation of capacity to offer CS learning opportunities across all of Chicago. OST program grantees believed this was a strength because it put CS at the forefront, making their programs more accessible and valuable to the community.

3.1.3 Participation

Although little CS participation data exists for Chicago elementary and middle school students, annual enrollment in CS, especially in introductory-level courses, increased steadily in high schools following the introduction of Exploring Computer Science (ECS) in the 2012-13 school year. In 2012, only 3% of high school students enrolled in any CS course. As of December 2021, over 40% (over 65,000) of all CPS high school students have received CS education through the district (Chicago Public Schools, 2021). Further, enrollment in CS courses increased for all race/ethnicity groups in CPS. However, Asian students were still more likely to enroll in any CS course than other students, indicating an increased participation in advanced CS courses. Given that CPS serves over 100,000 students each year, the new requirement will result in tens of thousands of students participating in CS during their schooling.

Increased Participation by Historically Marginalized Racial and Ethnic Groups. In a study conducted one year after the graduation requirement went into effect, Barrow et al. (2020) found that within CPS, Black students were the least likely overall to enroll in a high school CS course, in part because they were the least likely to attend a school that offered CS. Once differences in CS access are accounted for, Black students were the most likely to enroll in a high school CS course (Barrow et al., 2020). In a more recent study, McGee et al. (2022) found that the race and ethnicity of students taking CS courses in CPS mirrored the overall demographics of CPS students within two percentage points.

Increased Participation by Historically Marginalized Genders. CPS's goal to have the demographics of students taking CS courses reflect the overall student population has had success regarding gender. Enrollment rates increased for both boys and girls, but boys remained more likely to enroll in an advanced CS course than girls (Barrow et al., 2020). However, the graduation requirement increased the percentage of girls participating in CS courses, narrowing the gender gap to less than 2% (McGee, 2022). According to CPS, "since the Advanced Placement Computer Science Principles exam became available in 2017, 7,658 CPS students have taken the exam, with 51.1 percent of 2022 test-takers identifying as girls or non-binary, well above the national average of 33.3 percent." In fact, several CPS schools earned the 2022 College Board AP CS Female Diversity Award (CPS Office of Communications, 2023). This award is given to schools that have high participation rates for girls taking the AP CS exams.

Increased Participation by Historically Marginalized Ability Statuses. Students with a disability in one of six categories—Autism, Deaf/Hearing Impaired, Emotional Disability, Intellectual Disability, Learning Disability, or Other Health Impairment—will have an individualized education program (IEP). Before the CPS graduation requirement, about one-third (32%) of students with an IEP participated in a CS course. After the graduation requirement, participation rates doubled for the first two student cohorts (71% and 76%) (McGee, 2022). These numbers still reflect an opportunity for increasing participation in CS learning among students with disabilities.

3.1.4 Experience

Empirical data that captures students' CS experiences and outcomes is lacking, but there are some indirect indicators. Grantees Kathleen and Lloyd noted that "We have some wonderful classes where kids are taking on social justice issues, taking on issues in their community. We've seen some teens who probably wouldn't define themselves as STEM-based kids, creating apps to code empty lots in their neighborhood to share with businesses." Similarly, some of the quantitative data specifically linked to the impacts of the Foundation are presented in the Foundations Impacts section, and the data from 2022 indicates that the majority of participants increased their CS or STEM interest (80.1%), 21st century proficiency skills (84.7%), self-confidence (77.8%), and identity (75.1%). About 3 out of 5 students (63.4%) of student participants indicated their intention to pursue a STEM or CS career.

Dettori et al. (2015) conducted a study with 349 high school students in CPS involved

> Overall and across student subgroups, students earned higher average grades in CS courses than in core courses, and few students failed CS courses.
>
> —BARROW ET AL., 2020

in one of the first implementations of ECS. Findings indicated that overall students:

- Rated the perceived value of the class as high, with no gender or racial/ethnicity differences in their responses.
- Felt that the teacher made the class enjoyable.
- Expressed interest in pursuing further studies in CS (74%) as well as in majoring in CS in college.

Barrow et al. (2020) note the following key findings regarding the high school experience and performance of students taking CS in CPS:

- Student grades in CS courses rose over time. In 2009, 61%of grades were As and Bs, while in 2018, this grew to 68%. Likewise, there was a decrease in the number of Ds and failing grades, with a 3% percentage decrease in each.
- Grades in CS courses were higher than grades in core subject courses, both overall and for all student groups.

A more recent study found that, after the graduation requirement, girls have achieved higher grades in CPS's ECS courses than boys (McGee et al., 2022).

Figure 3. Opportunities for K-12 CS education in Chicago derived from the data and the interviews.

3.2 Opportunities

FIGURE 3 summarizes the opportunities for K-12 CS education in Chicago that emerged from the data and the interviews.

3.2.1 Teachers

Continue to address the CS teacher shortage. CPS has a teacher shortage, particularly CS teachers. Grantee Eliza shared that since the implementation of the CS graduation requirement, "I think it went from a specialty to now a base literacy. It's good because now everyone has to attend to it, but the reality was there weren't enough educators prepared to do it. What you've seen happen is CS… there aren't enough [advanced CS] classes because every kid has to get it, which means you have a whole lot of introductory classes and not a lot of hands." Interviewees felt that the main reason for the lack of CS teachers was that industry salaries are higher than the school district. "You can make so much more money in [an] industry with computer science skills that you would be using to teach students than you ever could in education," said Chicago Leaders Nicole and Amelia.

To address this gap, CPS has been training teachers from other subjects to teach basic CS courses. This concerns interviewees who are concerned about the quality of these classes and the need for quality teacher training. "If you go into a CS classroom in Illinois, nine times out of ten, it's a teacher who's likely never taken a college-level computing course…It's a gap when you want to talk about a high-quality CS education and the person in the room is a

language arts teacher [who received] some support to teach CS, but not in the way if you would've done it in another subject," William explained. State Leader Tyson further noted that teachers may "...not be properly licensed to teach computer science, given that the historic and current requirements for endorsement include a minimum of 18 semester hours in the field and successfully passing an endorsement examination."

It is also challenging for CPS to incentivize all teachers from other subjects to obtain CS endorsements. "How do we expect teachers to be able to do that, and they don't get compensated afterward. You put in this amount of time and effort, but it doesn't change your salary," Chicago Leader and Grantee Kelly remarked.

Increase diversity among CS teachers. A major concern is the lack of CS teachers who look like their students. The stereotype that only White and Asian males are computer scientists has been harmful to CPS's diverse student population. "How do we change the face of CS? How do we make it inviting for young women and students of color?" Kelly asked, observing that "one group of students that has been really left out or neglected are our diverse learners. A lot of teachers, a lot of people still have that view that CS is for [only for] 'smart' kids."

Kelly's observations are in line with the research on CPS student participation. After the graduation requirement was implemented, White and Asian students still had higher participation in CS courses than students who identified as Black or Hispanic (McGee, 2022). CPS students who take the AP CS A course are three to four times more likely to identify as male than as female and are mostly White or Asian (Boda, 2021).

3.2.2 Curriculum

Increase focus on consistency and fidelity across CS programs in CPS. While the CS graduation requirement was generally seen as a strength, many interviewees thought its implementation has room for improvement. Interviewees expressed concerns about the lack of consistency across schools. Illinois leader Jerome noted, "There's a limit to school resources and accountability at the school level. We just don't have control when you're dealing with the school district, the size of CPS…it's very difficult to, obviously, have control over programming, and fidelity of programming just is difficult."

Increase CS learning opportunities through integration into other subject areas. Chicago Leader and Grantee Kelly noted that time constraints are a factor: "How do you start adding new content areas to a school day that's already packed with things that we know are important for students? Math and science and English language arts and the social sciences and art and music, and how—where do we find the minutes?"

Increase scaffolded curriculum. Interviewees were concerned about the lack of alignment between CPS programming and opportunities for Chicago CS students. "There needs to be more connectivity between grade bands, between K-8 and high school, high school and community college, high school and four-year college," stated General Interviewees Zachary and Tara. The graduation requirement means that there are many introductory courses, but not all high schools have intermediate or advanced CS classes. "[We] did a great job getting the graduation requirement there, but then how equitable is it if we…now have kids in high schools that have taken a CS class and like

> I think a big answer to [how to find time in the schedule for CS] is going to be integration, that computer science is going to need to be like it is in the real world, a part of all industries, so to speak. It's going to need to be a part of all content areas.
>
> —CHICAGO LEADER AND GRANTEE KELLY

it, but there's no other classes at high school," shared Chicago Leader and Grantee Kelly.

This problem isn't limited to CPS. Interviewees shared that it also exists in the OST programs. "There is just not a great pipeline from the basics to more advanced concepts," said Grantee Clinton. Grantees Leslie and Denise agreed: "There needs to be more than just introductory level. There needs to be additional opportunities to really get you to that next level. I don't think that we've done a great job of that." Ultimately, a lack of advanced opportunities hampers student learning.

Increase K-8 CS programming. Interviewees were generally worried about how late CS skills are introduced to students. "We don't start early enough to prepare students' learning for computational thinking and CS foundations even in middle school so that when they get to high school, they can pursue advanced computer science," said Chicago Leader Hubert. Chicago Leaders Nicole and Amelia agreed that K-8 CS education is still sparse in the city: "If students are really building a lot of their academic competencies and identities in elementary school, then starting in high school's too late. If they're already starting to apply for high school or for colleges and we're giving them their first CS experience in high school, we've lost a whole bunch of students."

Grantee Olivia wasn't convinced "that the other changes that needed to happen [for] K-8 were in place. I don't think that kids K-8 are getting the kind of CS that would be even appropriate for that grade level consistently."

Improve equitable outcomes among historically marginalized groups in CS. Within CPS, researchers found that Black or Hispanic students received lower grades than White or Asian students in their required CS course (McGee, 2022). For CPS students that took the AP CS A exam, Asian and White students achieved a grade of 5 (highest level) over twice as often as Black and Hispanic students (Boda, 2021). Gender differences for the AP CS A exam also exist in CPS: girls were over three times more likely to fail the exam than boys (Boda, 2021).

3.2.3 Post-high school experiences

Focus on post-high school experiences. Several interviewees noted that it is important to focus on post-high school experiences; George observed that this includes "42,000 students that have graduated with computer science in the last three years [and are] moving into city colleges. How can we make sure that those that are interested can continue to pursue [learning] opportunities?"

3.2.4 Resources

Extend resources to individual students. Many interviewees mentioned a lack of resources for some students: they lack the hardware and/or internet access necessary to study CS. Some students may not have a computer or an internet connection fast and reliable enough to use online resources for the CS courses. "For most of our students, having web-based solutions works just fine, but once you get into high school and into our more advanced coursework, you need faster, better, stronger computers to be able to do some of these more advanced courses," shared Chicago Leader and Grantee Kelly.

Even students with an adequate computer and internet connection may not have the at-home support to pursue CS. Chicago Leaders Nicole and Amelia mentioned that this affects students through their parents, families, and communities where computing may not be common: "There's a lot of school communities in Chicago where [CS] isn't a norm for parents, for families. What does it look like to equip communities to also drive growth in this area? Not only at student levels, but then increasing the capacity of adults and communities to also move with students?"

Ideally, OST programs can bring the resources needed to involve students in CS to all communities. Grantees Kathleen and Lloyd dreamt of "public city-wide Wi-Fi…[and accessible programs] providing really high-quality spaces, spaces that have the latest tech and have 3D printers as well as laptop carts. Those things are fun for young people, and they want to learn on high-quality devices, and that's also how they keep up with the tech."

> "I think that there's a lot of opportunities, but where I find the most challenges are when we coordinate experiences and we get in front of these kids, it's like, 'Okay, do they really have the technology to really be able to do what it is that we're trying to do?
>
> —GRANTEE EDWIN

3.2.5 Holistic Community Planning

Support CPS-OST provider partnering. Some of the grantees interviewed thought that partnerships between out-of-school opportunities and CPS would be an excellent way to mesh in-school and out-of-school learning. Kathleen and Lloyd wished for partnership opportunities, noting that it would

be ideal if "every student interested in CS has the opportunity for that expanded experiential learning opportunity. [This requires prioritizing] the connectivity between school-based learning and out-of-school learning."

Increase networking opportunities for CS stakeholders in Chicago. Our interviews revealed that one of the major concerns of grantees was a lack of networking and collaboration among the different CS groups in Chicago, across both the in-school and OST spaces. "Nonprofits are always struggling for capacity and there's, I think, a lack of overall networking that happens," said Grantees Aaliyah and Linda. "There's the silos of collaboration and communication… [among all of] the different organizations that are focusing on STEM." State Leader Tyson also shared this concern, noting that there is room for intentionally connecting CPS teachers and non-CPS teachers in the spirit of forming and developing an ongoing, shared professional learning community.

> "We need to be in communication if we're ultimately all working towards the same goal there. We need to be in communication about what's working, what's not working at the pipeline level.
>
> —GRANTEES LESLIE AND DENISE

Other Chicago CS mentors agreed. "I'm developing all this programming, I want to share it with other people…if there are other groups that are trying to enhance CS education, then it would be awesome if there was a community of folks that are able to collaborate with each other so we know what's going on," shared Grantee Clinton.

"There are limited funds and resources and if we're all competing for the same things, we're all doing the same things, there's probably better and more efficient ways to do it if we're in conversation with one another," Grantee Henry added. "There have been attempts to make it more formal, but just to bring all of the people doing this work together so that there's more alignment and there's a bit more of an ecosystem and there's more opportunity for collaboration and honestly for us to leverage unique strengths and not just duplicate efforts."

It's not just that OST programs want to collaborate with each other; they also want to collaborate with CPS educators and administrators to develop complementary curriculum. Grantee Daniel suggested, "I would love for the K-12 leadership to take a look at schools that are incorporating a STEM curriculum, those schools that classify themselves as STEM academies, and make that available to all the schools so that they can be able to incorporate that into curriculum, into even the science standards or common core."

3.2.6 Research

Increase research within CPS. Interviewees noted that there was an overall lack of Chicago-specific CS education research. Interviewees all wished for more to be done while also recognizing that data sharing

agreements and consistency across data are challenges that first need to be overcome. "[Chicago-area CS outcomes] would be something I would love to know more about. How we compare to other large cities, how we compare across the country, what other states are doing," remarked Grantees Aaliyah and Linda. Grantees Leslie and Denise noted that "there's no longitudinal data. It's really hard to have that longitudinal approach if you don't have [long-term funding support for longitudinal studies]."

Multiple interviewees mentioned the need for additional research to identify promising practices. Grantee Olivia asked, "What does it mean when you graduate or when you get some credential programming around CS and what are the implications of that around the workforce?" Grantee Wayne noted that "I think just maybe having more research around how to scaffold students' learning over the long haul and what does that look like? What do students really need as they continue to grow and mature in these fields?"

Support more research into K-12 CS education. Overall, interviewees wanted to see research examining student experiences, including over time (i.e., longitudinal). Several participants remarked that students' experiences need additional research. This was echoed by Grantees Leslie and Denise as well as Grantee Daniel, who stated "I wish there was more to figure out, especially in Black and Brown communities, what students think about CS, how their interests have grown over the course of their education, and if anything, how has [their experiences] contributed to their future aspirations?" This may include ethnographic research, as Leslie and Denise noted that more types of research that can tell stories of student experiences beyond numbers would be beneficial. One participant also raised the need to examine the experiences of students from low-income families. Grantee Henry noted that it would be helpful to know "where a young person starts in high school in terms of household income and when they land that first job in tech, what that means in terms of transformative outcomes, in terms of economic opportunity." This research can be tied to pedagogy, as Grantee Edwin noted that "I think it's more of a question of us coming together as educators and agreeing on a pedagogy that really supports CS teaching and learning [based on the evidence]."

4. ILLINOIS

Chicago experienced tremendous growth and change in K-12 CS education over the past decade, but the state of Illinois has been slower to add CS instruction to K-12 (Hegeman-Davis & Sewell, 2020). For example, in the University of Illinois system—the largest college system in the state—only 1.7% of its CS, Information Science, or Computer Engineering majors were Black or African American, and only 4% were Hispanic or Latine. There is a significant disparity between the overall Illinois workforce and its STEM workforce: 5% of the STEM workforce is Black/African American (Hegeman-Davis, 2021), but 14.1% of Illinois's overall workforce is Black/African American (Illinois Department of Security, 2022).

Further, while Chicago has corresponding and equitable philanthropy, public school educators, and political figures to spur the momentum of CS education, in Illinois these components are not as cohesive. Some of the most overlooked, impoverished communities in the state are outside of Chicago. Currently, the number of dedicated CPS staff toward CS education far exceeds the number of Illinois State Board of Education (ISBE) dedicated staff to the same. Further, grants are often competitive and may require dedicated and skilled grant writers to submit a proposal, yet not all school districts in Illinois have the luxury to have a grant writer on-staff. Knowing this and recognizing this disparity affords philanthropic organizations great opportunities to be of service to students at a much larger scale, with a measurable return on investment into the state's economy with specifically home-grown talent.

In this section, we complement findings from a state landscape report (Hegeman-Davis & Sewell, 2020) with interviewee responses.

4.1 CS Education in Illinois (2013-2022)

FIGURE 4 summarizes the findings across the four CAPE components (defined in Section 2).

4.1.1 Capacity

We point to several significant changes in capacity for CS education over the last decade in Illinois, including changes to legislation and changes to teacher PD opportunities.

Notable legislative changes. The primary changes that interviewees pointed to were the passing of Illinois House Bill (HB) 2170 in March 2021 and the formation of a CS task force at the Illinois State Board of Education (ISBE) in 2017 (which released an initial set of landscape data in 2018). General Interviewee Angela noted that these changes indicate that "There's more acknowledgement that computing and data science [are] something that every student needs. Computing is now embedded in literally every field. We all need to understand it at least at some basic level in order to be successful, and companies are really requiring it." HB 2170 requires all high schools to offer CS courses by the 2023-2024 school year.

As this report went to press in June 2023, three bills were currently under consideration in the House and the Senate to provide more funding and to establish microcredentials for teachers. Senate Bill 2374 provides that the ISBE "...shall establish a competitive grant program to support the development or enhancement of computer science programs in the K-12 schools," including teacher

Figure 4. Notable changes to CS education over the last ten years.

ILLINOIS–HISTORY AND STRENGTHS

CAPACITY
- Notable legislative changes
- Increased teacher professional development
- Increased interest in K-12 CS education
- Improved resources for teaching and learning CS
- Increased support from Illinois colleges & universities

ACCESS
- Increased formal CS education
- Increased integration of CS into other subject areas
- Increased out-of-school-time CS education offerings

PARTICIPATION
- (Data not available)

EXPERIENCE
- More Advanced Placement (AP) CS exam takers

> "There's more acknowledgement that computing and data science [are] something that every student needs."
>
> —GENERAL INTERVIEWEE ANGELA

training, facilities, and devices. House Bill 3909 "...provides that the State Board of Education shall establish a microcredential for teachers to receive training in introductory and intermediate computer science" including Advanced Placement courses. Related to CS education teacher professional development and endorsement, House Bill 2422 provides that subsequent teaching endorsements may be granted to licensed employees for specific content areas and grade levels as part of a pilot program and districts will be able to "self-endorse" teachers.

Increased teacher professional development. There has been an increase in resources for Illinois CS teachers. Interviewees stated that Illinois was making it easier to be certified as a CS educator and was also providing PD opportunities, credentialing, and endorsements. "Illinois has been working on educator endorsements..there are a lot of players in the State of Illinois who have developed a good model for educators' endorsements for CS," said General Interviewees Zachary and Tara. "We have a good model in place that has been referenced by a lot of folks outside of the State of Illinois as well."

Four institutions in Illinois now provide training for teaching CS. One is the Discovery Partners Institute (DPI), which started to offer a teaching endorsement in CS statewide in 2021. Further, DPI now offers PD in various workshops, including Digital Literacy, eSports, Design thinking, and Mobile App development. Illinois Leader Sarahi described that "the goal is to introduce CS education more often and do a better job of preparing teachers to teach it. It has been a big topic of conversation—who is going to teach the CS classes when not all of our institutions offer [an education focused] CS degree for teachers to pursue."

In a creative approach, Illinois Leader Tyson noted that the Illinois Math and Science Academy (IMSA) recently launched a program as a state-funded pilot aimed at providing high schools with a virtual programming course taught by IMSA staff. Local teachers earn 3 college credits that are applicable to an endorsement requirement while also serving as a dual-credit course, a course providing both college and high school credit, for on-site students.

Several Illinois universities also offer training for future CS teachers, including the University of Illinois Urbana-Champaign (UIUC), University of Illinois Springfield (UIS), Northeastern Illinois University (NEIU) and Northern Illinois University (NIU). UIUC now offers the Teaching Endorsement in Computer Science, a seven-course (24 credit hours) curriculum sequence that meets requirements for obtaining a subsequent teaching endorsement in CS. NIU offers a K-12 Computer Science Specialist certification, a fully online curriculum sequence that also meets ISBE requirements for obtaining a grades 5-12 teaching endorsement in CS, and the coursework is closely aligned with the

standards of the K-12 CS Teachers Association. NIEU offers an 18-credit CS endorsement for teachers to learn a breadth of topics in CS and relevant pedagogical practices for teaching. Finally, UIS offers a CS Endorsement, providing current teachers with computer programming, cybersecurity, networking and pedagogy for teaching those topics.

Increased interest in K-12 CS education. Statewide, interest in K-12 CS education has expanded. Illinois Leader Christine said that "There's a lot of excitement around computer science, and there are very passionate individuals who are wanting to get all students access to computer science courses." Illinois Leader Tyson stated that "The fact that we have a governor now who has gone on the record in stating that this is a known issue, the fact that the governor has convened meetings with key stakeholders" shows that the support for CS education extends to the top of Illinois's political structure. With the 2023-2024 school year, "...all high schools must provide students with the opportunity to take a computer science course aligned to the new computer science standards" (Learning Technology Center of Illinois, 2022). General Interviewee Amanda noted "that is forcing schools to take it seriously and understand that youth need that exposure before graduating to be competitive in this marketplace. I think we're at a time where our policymakers have finally recognized it and pushed schools in that direction and to make it more universally available."

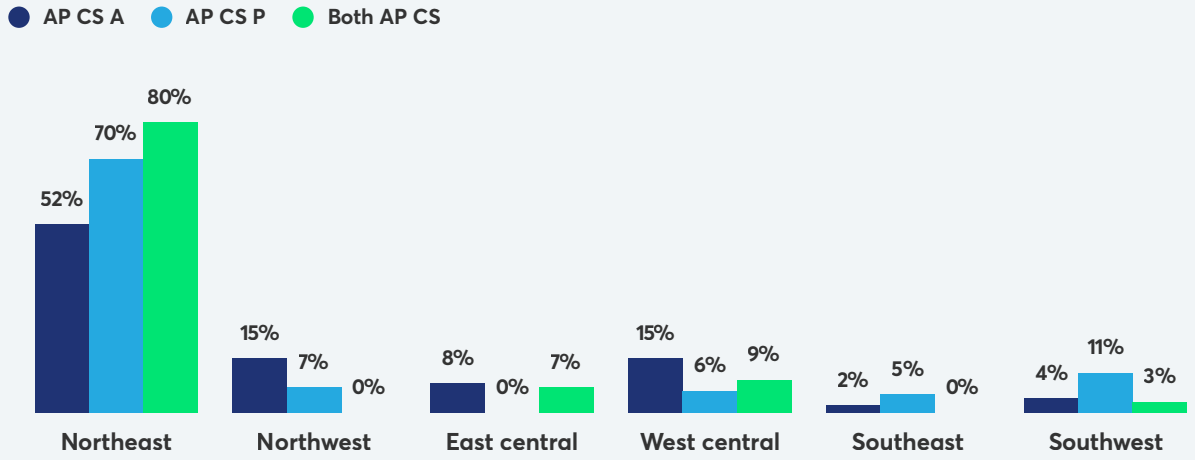
Improved resources for teaching and learning CS. Interviewees pointed out that Illinois has improved resources at its disposal to support K-12 CS education, including two CSTA Chapters (CSTA Chicago and the soon-to-be-launched CSTA Illinois). Additionally, William praised Illinois's enhanced infrastructure, saying "Obviously when you talk about CS education, you need access to devices and access to Wi-Fi and to the internet. I would say Illinois has made a lot of great progress in that broadband infrastructure overall in this state. I would call that a strength."

There are also more statewide resources for different types of CS courses and programming. "I think the strengths are just the level and the diversity of programming that's now in the space," said Jerome. "There [are] lots of different vendors and third-priority providers like us that are now enacting new programming, and there's a desire and a need for it in the space. We're here to provide that. I feel like before that, 10, 15, 20 years ago, there just weren't a whole lot of individuals focusing as much in this space or it was very antiquated."

Chicago Leader and Grantee Kelly noted that Illinois has the Illinois Student Online Privacy Protection Act (SOPPA), which protects students by preventing some educational technology companies from collecting data on students. In these instances, schools are not able to use online curriculum until the legalities of student data has been resolved through contracts.

Increased support from Illinois colleges and universities. Illinois colleges and universities are supporting K-12 CS education in the state. General Interviewee Angela mentioned two different college systems in their interview, saying that "there's a rural school network that's being led by Eastern Illinois University. They're doing amazing things for the rural community, [including] getting more kids in general but also more girls, more Black and Brown kids into Advanced Placement classes." Angela also addressed how the University of Illinois Urbana-Champaign had

Figure 5. Percent of Advanced Placement Computer Science course offerings in Illinois (Hegeman-Davis & Sewell, 2020).



to "...figure out how [to] help schools to bring Advanced Placement classes in, because then the next question is, 'if we want kids into these Advanced Placement classes, then we have to have…an introductory level of CS.'"

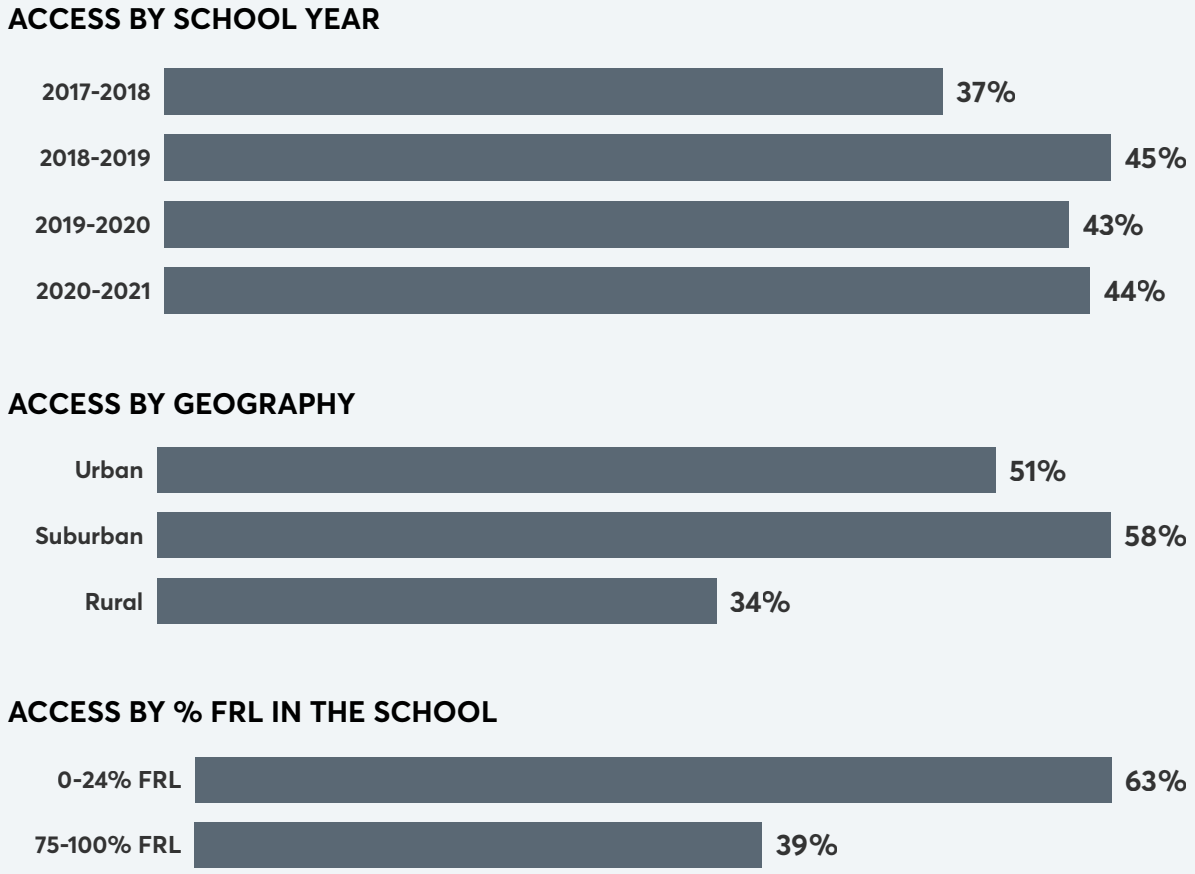
4.1.2 Access

Historical data on access to CS education across the entire state of Illinois is lacking. The partial data indicates that access to CS in Illinois has grown, though it has been primarily driven by offerings in the Chicago area.

Increased formal CS education. According to the Illinois K-12 CS Education Landscape Report (2020), 49% of administrators (n=289) reported offering CS in their schools. Further, teachers were teaching across elementary, middle and high school grade levels. Of the teachers who reported teaching CS, 82% reported teaching introductory CS courses, 46% teaching intermediate, and 51% teaching advanced (including AP) courses. Outside of the AP courses, 29% were elective Career and Technical Education courses and 24% were "other" (e.g., fine arts courses).

Of the AP CS courses, 17.5% counted as a core math class, 13% counted as a Career and Technical Education elective, and 14% were listed as "other" types of credit (such as fine arts). Unsurprisingly, given CPS's efforts over the last few years, a large portion of these CS courses were located in the northeast region of the state. The report noted that 86 school districts (just slightly over 10%) statewide offered one or both of the AP CS courses. Thirty-one districts (4%) offered both, 39 (5%) offered only AP CS A, and 17 (2%) offered AP CS Principles. With the vast majority of these courses offered in northeastern Illinois, there remains a significant need for CS courses in high schools outside of the Chicago metropolitan area. Of the 484 school districts in Illinois that were represented in the survey, participants indicated that their district (n=86) offered either one or both of AP CS A or AP CS Principles, totalling nearly 18% of districts. Fifty-eight of these 86 districts (67%) are located in the northeast region of the state

Figure 6. The 2022 State of CS Education report (Code.org, CSTA, & ECEP Alliance, 2022b) analyzes access by school year, geography, and free or reduced-price lunch status of schools in Illinois.



Data primarily provided by the Department of Education, based on the 999 schools with high school grades. The state reports low-income students rather than students who qualify for free and reduced-price meals. Participation data was masked at low counts

(i.e., Chicago and its suburbs) (Hegeman-Davis, 2021).

While access to foundational CS courses in Illinois high schools was 37% in 2017-18, it increased in 2018-19 to 45% and has remained stable since. In 2021, high school students in suburban areas had the greatest access (58%), with urban schools slightly behind (51%). Students in rural high schools had the least access (34%). Finally, schools with more than 75% of students qualifying for free or reduced-price lunch had less access to foundational CS courses than students in schools with fewer than 25% of students with that status, 39% of students with access compared to 63%, respectively.

Increased integration of CS into other subject areas. The 2021 landscape report also noted that access to CS is not limited to CS courses, and teachers have started to find creative ways to integrate CS into other subjects. This is key and aligns with previous research that teachers are finding ways to add CS that address the challenge of a lack of time in the school day for new, standalone content (Mabie, Huerta & McGill, 2023).

Availability of out-of-school-time (OST) CS learning opportunities. The 2021 landscape report indicated that respondents represented schools, park districts, museums, libraries, and youth development programs. Nearly one in four respondents indicated that their organizations offered CS learning opportunities, including Girls Who Code, Code Your Dreams, Kids Create Apps, Techsplorers, and First Robotics. Students' ages ranged from kindergarten to 15+ years, with the majority of offerings targeting students over age eight.

4.1.3 Participation

There is little to no data investigating Illinois students' enrollment or participation in CS from a historical perspective (Code.org, CSTA & ECEP Alliance, 2022b), indicating a potential opportunity to enable resources to support the collection of this data.

There is currently little research investigating Illinois students' experiences in learning CS. We include information on AP exams as an outcome of high school students' experiences learning CS.

More Advanced Placement (AP) CS exam takers. Taking the AP exam is a result of students' experiences learning CS. The number of AP exam takers are a smaller percentage of those who enroll in and take computer science courses, since not every student who takes CS decides to take the AP exam. We provide the limited set of data on participation as presented by the Illinois Handout (Code.org, CSTA & ECEP Alliance, 2022b), which is limited to the 8,576 AP CS exams taken in Illinois. The report notes that "83.5% of Illinois high school students attend a school that offers foundational CS. Of the 8,576 Advanced Placement CS exams taken in Illinois in the school year 2020-21, 32% were female."

4.1.4 Experience

Figure 7. Participation in Illinois high school Advanced Placement Computer Science Exams as presented by the Code.org, CSTA & ECEP Alliance report (2022b).

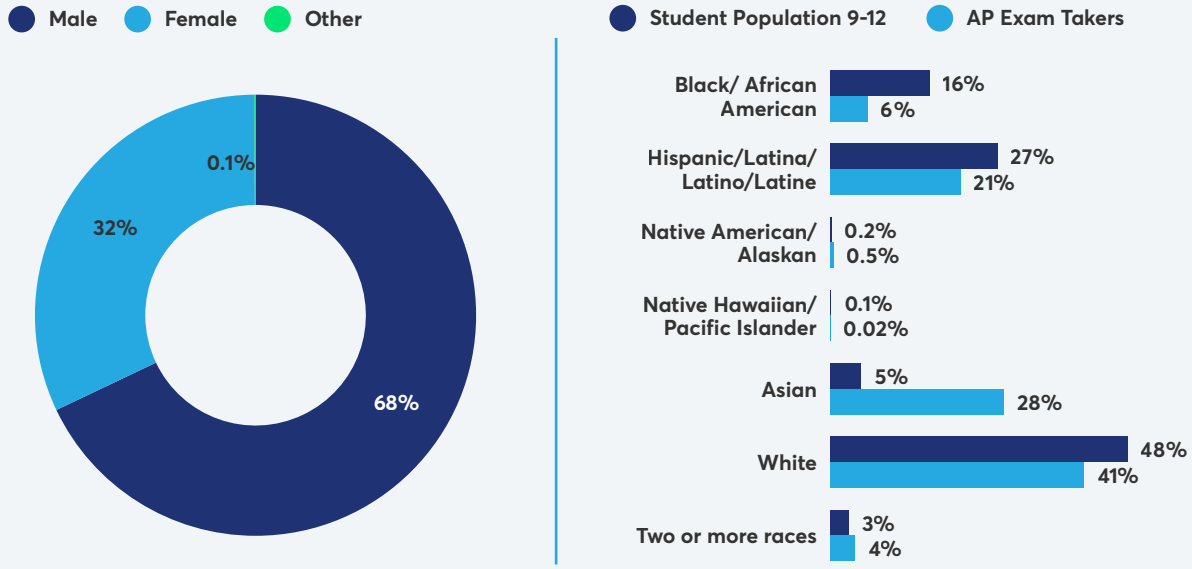
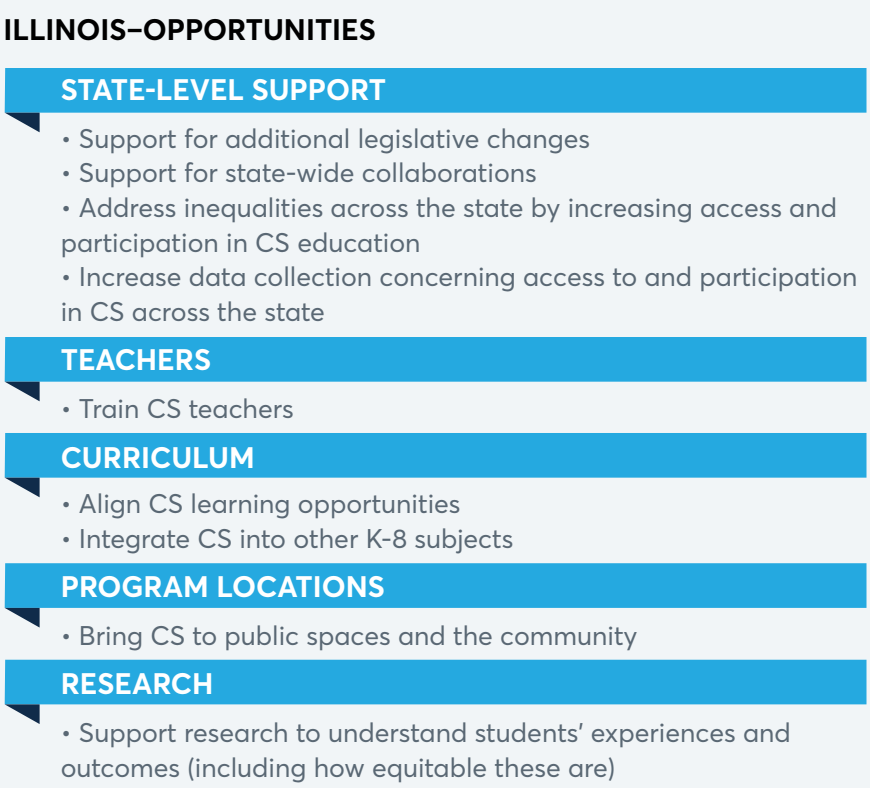


Figure 8. Summary of opportunities at the state level. Access, Participation and Experience are grouped together.



4.2 Opportunities

FIGURE 8 summarizes opportunities for Illinois K-12 CS education.

4.2.1 State-level Support

Support for additional legislative changes. Despite state legislative efforts, Illinois ranks 38th nationally for adopting the nine standards identified by the 2022 State of CS Education report (Code.org, CSTA, & ECEP Alliance) as necessary for bringing CS to all students. While House Bill 2170[1] did pass, it had no funding support for additional teacher training or for district or school implementation. As General Interviewees Zachary and Tara noted, "If you're a teacher and you need to teach CS and the state is requiring you to be endorsed, it currently requires additional schooling that costs money. Districts don't have money to reimburse in general or pay for a teacher to do that. "

This situation poses an obstacle to meeting implementation deadlines. Interviewees were

1 HB2170 requires the Illinois State Board of Education to develop learning standards for computer science and requires all school districts to ensure students receive opportunities to gain computer literacy skills starting in elementary school. Beginning in the 2022-2023 school year, high school students are required to take one year of a course that "includes intensive instruction in computer literacy".

> We need a statewide legislative ISBE partnership campaign to advocate that every single school district [makes] this an equity priority in their districts.
>
> — ILLINOIS LEADER TYSON

cautiously optimistic that more funding will be allocated. Illinois Leader Tyson noted that, "We need a statewide legislative ISBE partnership campaign to advocate that every single school district [makes] this an equity priority in their districts. What's more than that, that we fund it and that we make the funding available through ISBE." According to State Leader Tyson, CS4IL has been actively working to build these necessary partnerships.

Support for state-wide collaborations. Interviewees felt that there was a lack of collaboration between Illinois CS partners, including across organizations that ostensibly share the same common mission in bringing CS learning opportunities to all students. This includes policymakers, in-school teachers, OST programs, parents, and others across urban, suburban, and rural areas. For many respondents, the most frustrating lack of collaboration is the disconnect between OST programs and in-school programming. General Interviewee Amanda said, "we're seeing that students actually spend a majority of their time outside of school, whether that's after-school programs, weekends, or summer programs. I think better collaboration with families and out-of-school-time programs is really what's going to be needed in order to take youth to the next level."

Address inequalities across the state by increasing access and participation in CS education. Illinois Leader Tyson lamented that, "HB2170 did make CS for all one step closer in that all high schools starting this fall shall offer it. However, looking through an equity lens, how do you revise [systemic] structures?" HB2170 does not make CS a graduation requirement for every high school student; it just requires each high school to offer a class. Since CS is not a graduation requirement, Illinois will likely continue to see unequal participation across gender, race/ethnicity, disability, and other factors.

Illinois interviewees mentioned equity in K-12 CS education as an accessibility problem for rural areas that may not have the same level of resources as some urban or suburban

areas. Some of the equity issues can be seen by comparing CS courses offered in different regions of Illinois. There is a statistically significant difference between access in urban areas—such as Chicago—and rural areas (Hegeman-Davis, 2021). "In other parts of the state, internet access is still treated like a luxury. This is a significant disservice to students and teachers in rural areas, and so, that, for me, is where that equity piece comes in again," said General Interviewee Valerie. "When students can only access the internet from their school building or from their public library, that's a problem. When teachers do not have stable, secure, consistent access to broadband internet from their own homes, that's a problem." Rural and downstate teachers are often unable to attend or afford CS PD opportunities if they are offered only in the Chicago area.

Increase data collection concerning access to and participation in CS across the state. Little empirical data exists specific to Illinois CS access and participation. "There is still not great data on what's being taught to whom, where, and how those students are actually doing. We have very poor tracking systems," noted General Interviewee Angela.

> The gaps to CS education are driven by inequality and depending on [student's home] zip code.
>
> —ILLINOIS LEADER JEROME

> I try to advocate for more students to take CS and more schools to offer actual CS rather than just a typical computer class.
>
> —ILLINOIS LEADER SLOAN

"I think we have a lot of piecemeal data just in general, [but] where we are failing [students]…We need some really strong longitudinal studies that look at these different pathways that we are claiming to be promoting." An analysis of course codes can contribute to understanding the offerings throughout Illinois. By clarifying existing and adding new codes, state leaders will have a better understanding of what CS education is happening at schools throughout the state.

4.2.2 Teachers

Train CS teachers. According to the Illinois landscape report, the most significant barrier to offering CS is a lack of trained teachers, a gap stemming from the lack of funding for PD (Hegeman-Davis, 2021). The lack of pre-service training is also limiting the growth of teacher PD across Illinois. For example, two interviewees mentioned Springfield to showcase this problem. General Interviewee Valerie expanded: "I know a computer science teacher who travels to four different school buildings because they're the only person who teaches CS classes in their district." Illinois

Leader Sloan described their efforts to create a community through CSTA outside of Chicago and its suburbs: "There's often one full-time or [one] half-time teacher at scattered districts. It turns out there's almost no one teaching CS in rural Illinois."

The state of Illinois has to offer more CS PD opportunities to teachers across the state and to fund these opportunities so that teachers can learn without a financial burden. For example, General Interviewee Brooke said, "One thing we're working on with the ISBE is devising a more flexible credentialing system where maybe if you're just teaching the introductory course, you can take PD…that will qualify you to teach [a CS course]." State university and college systems could also work to address the CS teacher shortage through their programming, including offering more and more accessible endorsements in CS (Hegeman-Davis, 2021).

Across Illinois and similar to the findings in Chicago, another way to make teaching CS more attractive as a career would be to offer a more competitive salary. However, it can be difficult to pay a specific kind of teacher, such as a CS teacher, more than their peers, given union rules. Sloan also noted that the CS teacher deficit is compounded by a need for skilled CS professionals outside of the classroom. The median starting salary in Illinois for a teacher is $42,600 (Illinois State Department of Education, 2023). With over 20,000 open computing jobs in Illinois, the average salary was $84,104 (Code.org, n.d.). Sloan noted that "If you're really good at CS and you have a choice between using that with a corporation or teaching, the corporation's going to pay infinitely more. Why would you go into teaching unless you just really want to teach?"

4.2.3 Curriculum

Align CS learning opportunities. K-12 CS in-school courses offered in Illinois are primarily introductory (89%). Approximately 10% are intermediate and only 2% are advanced (Hegeman-Davis, 2021). Grantee Daniel observed that, "The State…is focusing more on the end result towards workforce development, either post-secondary education or employment, and that there's not enough of the support or emphasis for… elementary school students being able to have the CS support needed so that they can continue their interest in the middle school and then from middle school to high school." Brooke agreed, stating "K-8 still needs…CS learning pathways [to] high school."

This lack of intermediate and advanced opportunities is true of the Illinois OST space as well. While there are a wide variety of OST organizations offering instructions in robotics, app development, 3D printing, coding, video game design, and other CS-related content, the majority of these OST programs were found to focus only on the introductory level (Hegeman-Davis, 2021).

Integrate CS into other K-8 subjects. Integrating CS principles into K-8 subjects was an opportunity mentioned by most Illinois interviewees. Mirabel restated the importance of CS education in early grades: "We need to be teaching these kids at a young age from kindergarten onwards what CS is, why it's not scary, and why it's actually in their everyday life, and why they are impacted by it. I would love to see a K-12 initiative in the state. Again, Chicago Public Schools has it. That's amazing. We need to raise the tide for every student in the state." General Interviewee Angela noted that "[Teaching elementary students is] the only

way that we're really going to reach equity, and it has to start young because we have to get kids before they decide, 'I'm not a computer scientist.'"

4.2.4 Program Locations

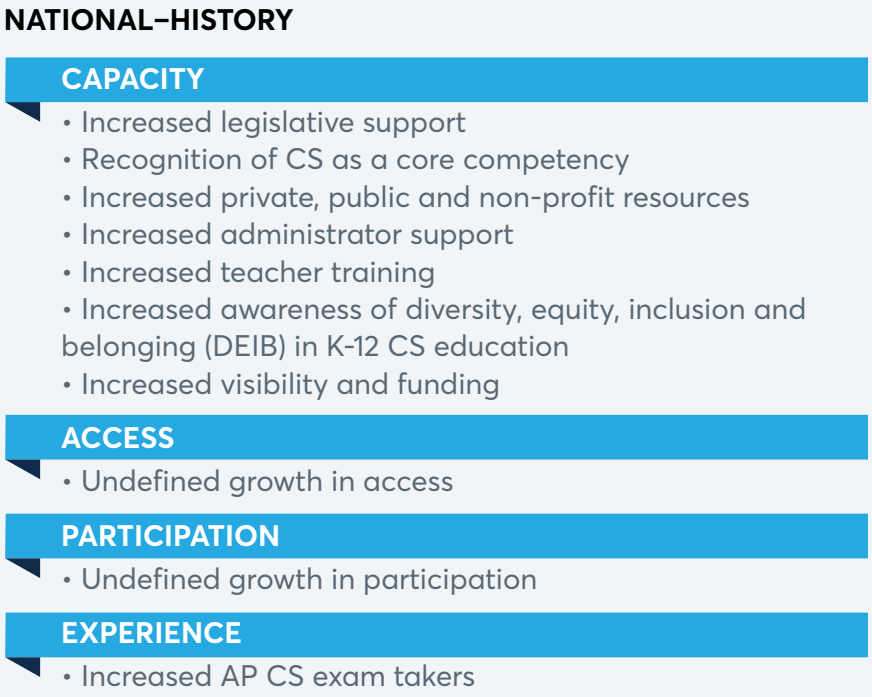
Bring CS to public spaces and the community. In addition to integrating CS, another option to make CS more accessible is to bring it into public spaces and the community where feasible. "I strongly believe in creating connections to what is actually going on in the community, whether that be with industry or corporations or libraries, or other parks and recreation ways to get students involved in the community," said Sarahi. General Interviewee Amanda added, "I think just like any competencies that you're building, whether that's math or reading, we always think that stuff starts at home, and it starts young. I think that being able to focus on how we are leveraging parents and community-based organizations and especially youth at a young age is really what's going to set Illinois students apart and make sure that when they're in high school and the later grades that they do have a strong foundation in CS literacy."

4.2.5 Research

Support research to understand students' experiences and outcomes (including how equitable these are). There is little data to determine if student CS outcomes are the same across the state. "I think it'd be wise to provide probably more pilot programs and more evaluation assessments," said Jerome, referring to the need for more evaluation of programming. "There's this strong movement to implement programming…I feel it'd be important to really step back from everything that's been accomplished from

the programming side and from the impact side, and really do an assessment and a deep dive into what's working and what's not working. Sometimes we just throw a million things at the wall without taking a step back and looking, is it really effective? Why is it effective? Really assessing and analyzing that data is probably crucial for the landscape to get better, just like anything else."

Figure 9. Increased capacity and experience at the national level. Data at the national level is not available for access and participation across K-12.



5. NATIONAL

With respect to the last ten years across the United States, the aggregate data remains thin. Since state data varies and each state's policies are different (Code.org, 2021), aggregating this data is difficult. This section draws from the 2021 State of CS Education report (Code.org, CSTA, & ECEP Alliance) and interviewees' responses to gain a broader perspective of CS education across the nation.

5.1 CS Education Nationally (2013-2022)

Although there has been tremendous growth across the nation in K-12 CS education, the empirical data surrounding it is limited. Even so, interviewees provided perspectives that were synthesized with empirical evidence, painting a thumbnail sketch of the past decade.

5.1.1 Capacity

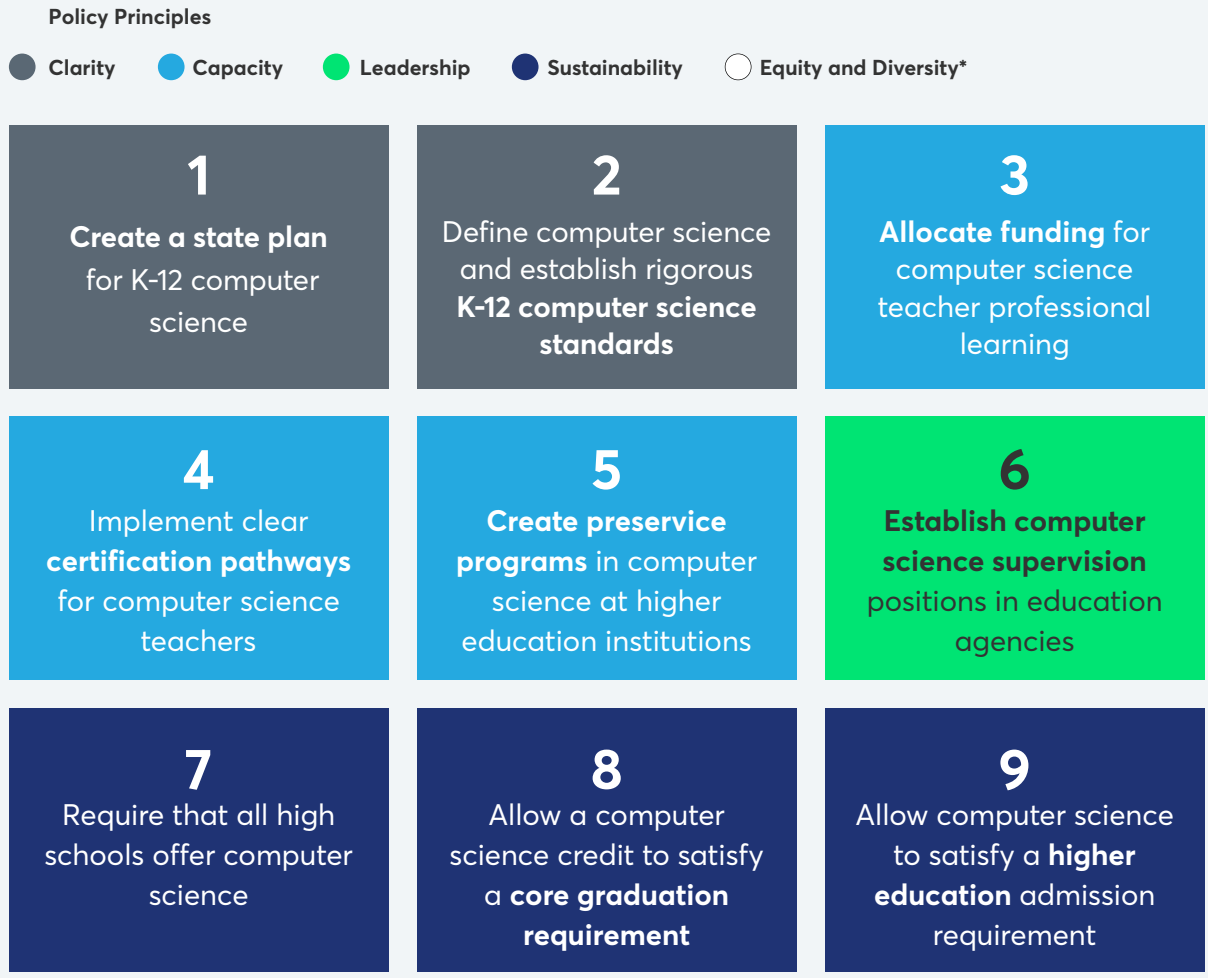
As the CS education ecosystem expands, several strengths have emerged. Nationally, capacity has grown in a few significant areas. These include increased legislative support, viewing CS as a core competency, increased resources and funding, increased number of teachers who are receiving training, and increases in DEIB efforts.

Increased legislative support. There has been an increased interest in K-12 CS education, resulting in movement across states to implement CS education mandates. The The State of Computer Science Education landscape report (Code.org, CSTA

& ECEP Alliance, 2022) describes nine policies that will change K-12 CS at the state level, including creating a state plan, allocating funding, and requiring schools to offer CS. In 2013, only a handful of states had adopted even one of the nine proposed policies. By 2022, however, all states had adopted at least one. Seven states have now adopted all nine policies, and 32 states have now put over half of the policies into place (Code.org, 2022). Further, all 50 states and Washington, DC, now allow CS to count towards a graduation requirement, with five states now requiring all high school students to take CS.

CS education has become "a part of the national conversation," according to General Interviewee Brooke, who noted that President Obama included K-12 CS education importance in his 2016 State of the Union address (Smith, 2016). At the 2021 National Governors Association convening, Arkansas Governor Asa Hutchinson made K-12 CS education a priority for the association (National Governors Association, 2021). From the federal level to the local level, "there are more teachers, administrators, and other interested individuals that understand what CS

Figure 10. Nine policies to make CS fundamental in a state (Code.org, CSTA, and ECEP Alliance, 2022).



*Equity and Diversity should be incorporated in each of the nine policies

education is," according to National Leader Janice. For William, "[T]here's more urgency around CS education than there ever has been…the private sector understands this, this is life or death for them to have this homegrown tech workforce that they need to employ and be ready."

Recognition of CS as a core competency. Nationally, organizations are increasingly viewing CS as a core competency for grades K-12, as reflected by the many states that have adopted and continue to adopt state CS education standards. Interviewees from different backgrounds also mentioned that CS should be a core competency because of how it is integrated into the world around us. "We [are] weaving technology and computing into art, into history, into everything," said General Interviewee Latres. This integration allows for students learning CS skills to be imaginative in how those skills are applied to the world around them, providing for "… opportunities for young people to learn, explore, be creative, in safe environments that are really tailored to their interests" according to Funder Trina. National Leader Pamela agreed, stating that "there's pretty widespread understanding of how CS skills can influence our daily lives." Grantee Olivia spoke positively of the change over the past decade: "..[W]e nationally are saying, 'Hey, every kid should get CS, kindergarten through 12th grade.'"

Importantly, the pandemic strongly impacted this national change, especially given the reliance on technology by CS students. Funder Sean noted that "I was initially worried that the pandemic was going to take away a lot of the momentum that we had in 2019 going into 2020…there was this big push of the use of technology because of the pandemic where everyone had to become literate around tech, which allowed for people to say, 'Oh, we should be doing even more of this, and how does CS fit into that?'"

Increased private, public, and non-profit resources. Over the past decade, the resources available to researchers and educators have rapidly increased. Code.org, CSTA, & ECEP Alliance (2021) reported that over $65MM was allocated for CS education across all states for fiscal year 2022, more than any other previous year. Major national funders and institutions, like the National Science Foundation and the Department of Education, have provided over $150MM in grants to fund programs and research. For-profit corporations have also invested in CS education's future. General Interviewee Lucy summarized: "Major corporate interest, lots of industry developing investments that CS education has gone from something that took place in schools and colleges to something that a lot of people have a lot of money invested in. The shift in the last 8 to 10 years has been very visible as we see these different corporations invent new programs with their own brand on it and bring them to schools."

Available resources go beyond monetary investments. There is more content available through nonprofit organizations and informal education spaces that can be directly used to design curricula for classes. This has resulted in a proliferation of different in-school curriculum offerings, OST programming, and opportunities for professional development. National Leader Beth said there is "a tremendous increase in the number of nonprofits that exist and that are providing those supplemental resources that are needed as we still grow and evolve the access points that happen for students."

> I love that CS for All is labeled literally 'for all' because it's not something inherent to the student. We grow our talent, we don't find our talent, we invest in our kids, we don't filter our kids.
>
> —NATIONAL LEADER HENRIETTA

Increased administrator support. More school districts are becoming interested in providing CS courses for their students, and key "decision-makers like superintendents [and] building principals are trying to figure out how to include CS" in their course offerings, according to National Leader Janice. This is also evident in the increased usage of the Strategic CSforALL[1] Resource & Implementation Planning Tool, which enables teams of district administrators, curriculum designers, and teachers to create a multi-year strategic CS plan for their district or school (CSforALL, 2023). This planning tool provides support for district administrators to know where to start in bringing CS to their students in a way that reflects their community values.

Increased teacher training. There is more support for a large population of K-12 CS educators and administrators, and General Interviewee Kimora noted that nationally there is "[a] growing number of credentialing and endorsement programs. Colleges of Education are paying more attention and trying [to] provide that support." However, in a survey of CS teachers, one in three respondents said that they are the only CS teacher at their respective schools. The percentage of sole CS teachers in schools in low-income communities was higher (40%), and it was lower for teachers in schools in high-income communities (29%) (Koshy, 2022). According to the CSTA & Kapor Center's 2021 study on the national teacher landscape study, which encompasses various educational and professional backgrounds as well as school contexts, data were collected from 2,238 PreK-12 CS teachers from across all 50 states, Washington, D.C. and Puerto Rico. Results indicated that:

- Of the surveyed CS teachers, 46% of teachers held a credential in Computer and Technical Sciences, 23% in Career Technical Education, and 1% in another STEM subject.
- Over half of respondents had 11 or more years of classroom experience (53%). Of these same teachers, considerably fewer teachers reported the same level of experience teaching CS (16%).

1 CSforALL is a non-profit organization dedicated to building the capacity for equitable CS education. CS for All is the White House initiative launched in 2016 and is also used for various labels to reference computer science for all students. CS for All (or all) reflects a movement.

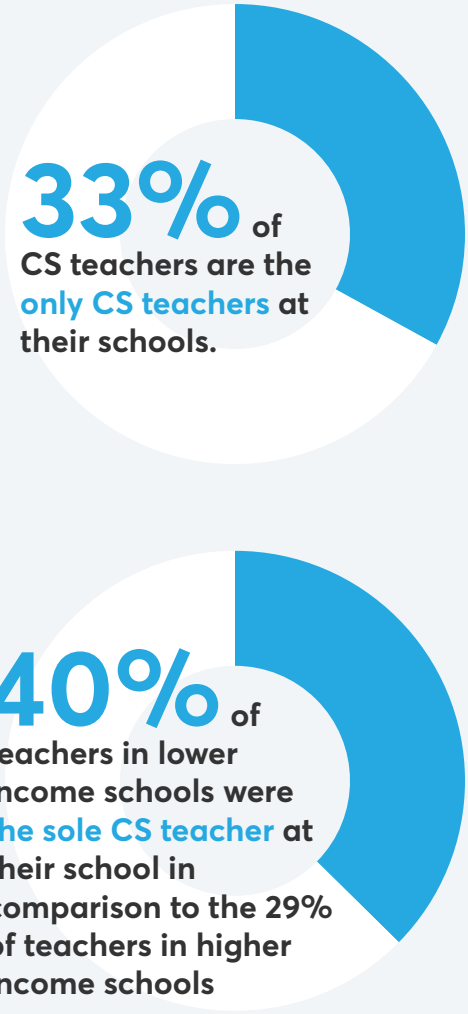
- Approximately two-thirds of teachers (61%) reported participating in a professional learning community and approximately one-third of teachers (28%) reported participating in ongoing coaching.

CS educators are also lauded by National Leader Roland for being "very active in pursuing their own knowledge and professional development, which is very important." In fact, many interviewees believed that K-12 CS teachers were particularly innovative due to the nature of the constantly changing field, and they saw this as a strength nationwide.

Additionally, the 100Kin10 STEM project met its goal of adding 100,000 STEM teachers over the last decade, supporting the increase in the number of trained STEM and CS teachers. Funders Sam and Jamie further described the changes in the field of K-12 CS teacher professional learning communities (PLC), noting that "Ten years ago I went to CSTA's conference. You could fit everyone in a room of a not-very-large building. I went this year with 1,700 people." Indeed, the CSTA annual conference in 2021 had 2,354 attendees (CSTA, 2021); in 2018, the attendance was just a third of that with 746 attendees (CSTA, 2020).

Increased awareness of diversity, equity, inclusion and belonging (DEIB) in K-12 CS education. The national landscape has been shifting to include diversity, equity, inclusion and belonging (DEIB) principles in K-12 CS education, with one study reporting that 71% of CS teachers seek out PD opportunities to enable them to bring DEIB principles into their classrooms (Koshy, 2022). National Leader Pamela shared that "The research is very clear that the gaps

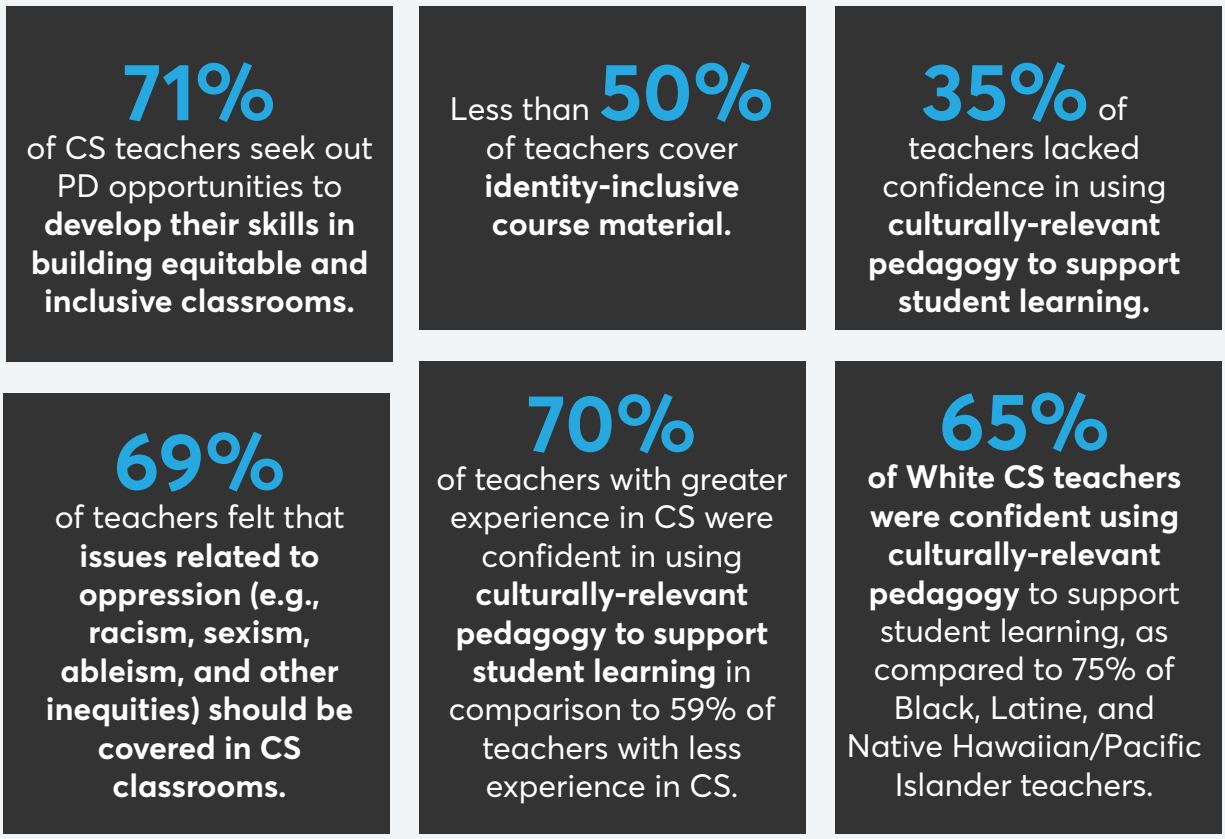
Figure 11. Teacher isolation as reported by the Kapor Center & CSTA report (Koshy, 2022, p. 2).



are about access and opportunity and belonging, not about interest or capacity. Students from historically marginalized groups in technology who have low grades in their introductory courses in college are much more likely to just drop out of their STEM majors entirely, even though there's no evidence that those introductory course grades actually predict success in the field."

Anecdotally, Funders Sam and Jamie observed "The equity issues are entirely much more foregrounded now than they

Figure 12. Teachers' use of identity-inclusive computing education practices as reported by the Kapor Center & CSTA report (Koshy, 2022, p. 3).



used to be. It was absolutely the case that if you asked somebody, 'What percentage of women do you have in your class?', they might not know or might be like, 'I guess I don't have any', and just shrug about it. Now, at least, they'd have to try to come up with some justification…the amount to which equity has been foregrounded in these conversations has changed quite a bit." National Leader Janice agreed, saying that researchers have "a much greater understanding of how to look at data with an intersectional lens…[including] race, class, and gender."

This data doesn't take into account a recent trend by some states to eliminate equity-based initiatives in their public schools. It remains unknown how new laws that are designed to stymie equity initiatives will impact DEIB initiatives nationally.

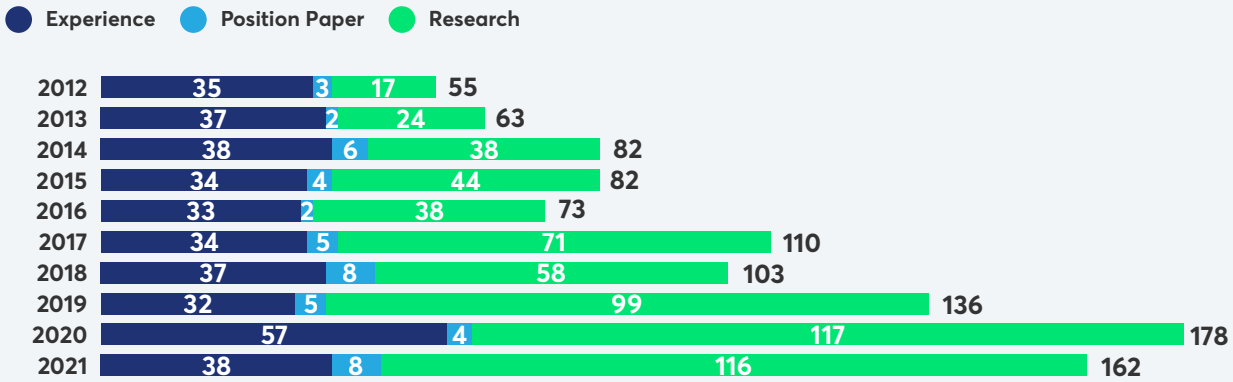
Increased interest in K-12 CS education research. Over the past decade, interviewees familiar with the CS education landscape nationally have noticed shifts in the research space. General Interviewees Zachary and Tara mentioned that the research has changed from confirming a problem exists to becoming more specific: "Those research efforts early on were just confirming here's the problem, and then it morphed into, 'Okay, we recognize that you have a plan of action to address that, now what is the impact of what you've been doing, and how do we improve on what we've been doing?'"

Previously, most research was conducted by computer scientists who were not always formally trained in how to conduct quality K-12 education research. National Leader Henrietta said "[CS education research] is [now] largely being driven by education researchers, not just computer scientists. I think that it makes for better work on the ground." General Interviewee Kimora was excited about the "folks in colleges of education interested in studying the teaching and learning of CS." Funder Sean explained that "There's been…more publicity around the role of research, and how research can help unlock additional findings and…highlight disparities." CS education research is also following an overall trend for demanding greater specificity and stringency. General Interviewee Ben further mentioned: "The funding sources and the accountability have matured…where people now want research that is reproducible and that can have a systemic effect, and it's not just a one-off project."

Increased visibility and funding. A strength of K-12 CS education nationally is its growing prominence, interest, and funding base that has been sustained through the pandemic. General Interviewee Lucy compared CS to other subjects taught in K-12, saying "Compared to K-12 in any other subject… we have funds to pay teachers stipends and to pay for travel and to create that professional learning environment that the English teachers don't have. I think that makes CS education a really unique space and really contested in terms of thinking about curriculum because [of] its large-scale efforts." According to General Interviewee Amanda: "We've seen it nationally from the Department of Education. I think that there is more recognition that [CS] is an essential competency…for any job moving forward. We're recognizing [CS education should be required], not just as an elective."

Support from national CS organizations and legislators. The prevalence of national CS organizations is a major strength that has helped pave the way for dramatic changes. "One of the strengths [of national organizations] is that CS education is bipartisan. Everyone believes that CS is important and that kids should be taught it," said National Leader Edward. "That's one of the strengths. It's by design in terms of the way that the biggest advocacy groups

Figure 13. Expansion of K-12 CS education research over the last decade across 12 CS education research conferences and journals (CSEdResearch.org, 2023).



for CS, the biggest messengers for CS, have been messaging CS." Some of these national CS organizations include leaders such as CSforALL, CSTA, the ECEP Alliance, and Code.org. One of the most notable national organizations accomplishing this change nationwide is the ECEP Alliance. Funders Sam and Jamie described ECEP as "a Broadening Participation in Computing (BPC) alliance...focused on state-level policy change. They've created a framework for holding a summit in a state and so they're really good at convening the right people, the right decision makers in order to really push CS policy forward."

5.1.2 Access

There is currently little empirical evidence outlining CS education offerings nationally, including in-school and out-of-school programs. From the Code.org, CSTA, & ECEP Alliance annual report, the number of foundational computer science courses (defined as a course offered during the school day that includes a minimum amount of time programming or coding) has increased 62% from 2016-17 to 2019-20, the last year data is available (see **FIGURE 14**). Fifty-three percent of high schools in the U.S. offer at least one CS course. This has drastically increased from 2018, when the number of high schools offering at least one CS course was 35% (Code.org, CSTA & ECEP Alliance, 2022).

The 2022 State of CS Education report (Code.org, CSTA, & ECEP Alliance) also notes that rural and urban schools and schools with higher percentages of economically disadvantaged students continue to be less likely to offer foundational computer science courses; Black/African American students, Hispanic/Latina/Latino/Latinx students, and Native American/Alaska Native students are also less likely to attend a school that offers foundational CS (Code.org, CSTA & ECEP Alliance, 2022a). Very few states report any data related to K-8 CS education, making it challenging to gauge what type of access exists to K-8 CS instruction. With respect to high schools, the report provides a thumbnail sketch of the public high schools that offer AP CS (see **FIGURE 14**) (Code.org, CSTA & ECEP Alliance, 2022a). In 2016-17, 19% of public high schools, while in 2019-20, that number rose to 30%.

Figure 14. Number of public schools offering an AP CS course (Code.org, CSTA & ECEP Alliance, 2022a).

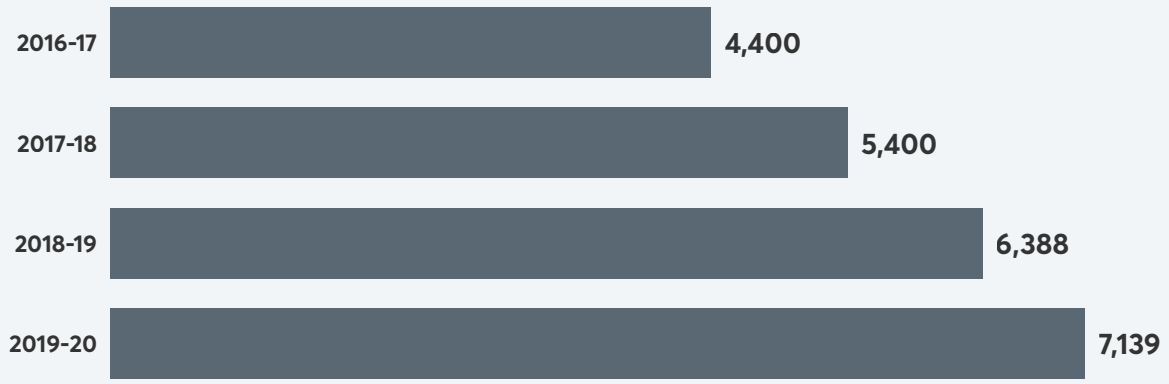
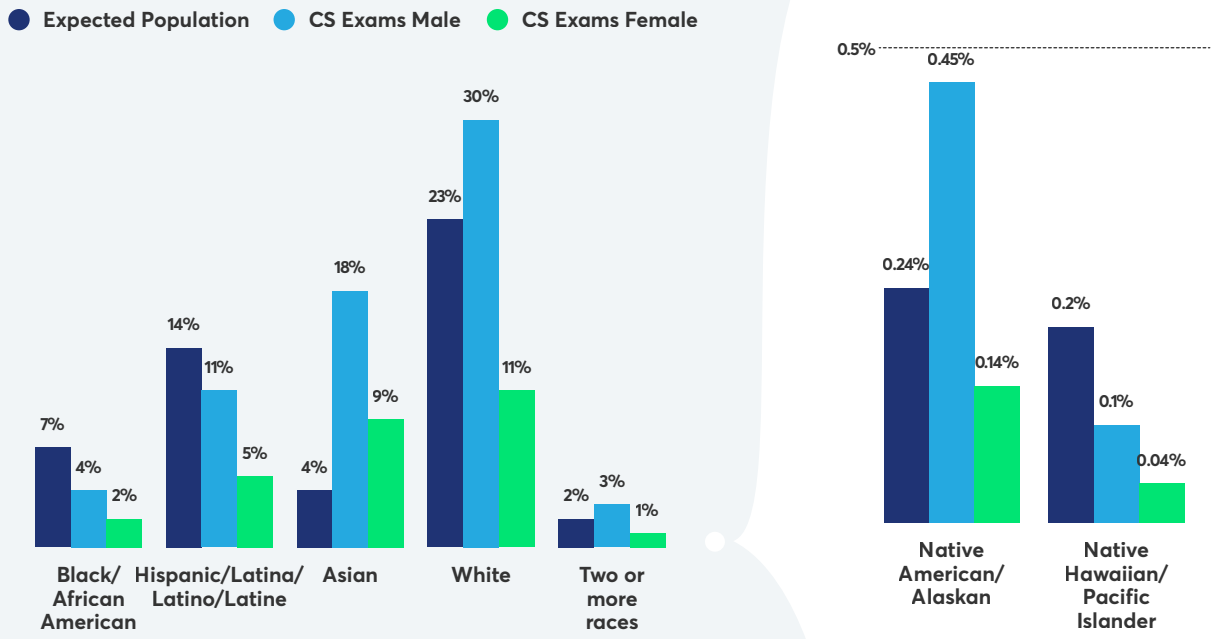


Figure 15. Population of students in high schools that offer AP CS (Code.org, CSTA & ECEP Alliance, 2022a). Expected Population per gender is based on the overall enrollment by race/ethnicity at schools that offer AP CS.



Our interviewees mentioned little relative to other topics about access to CS nationally other than there being more courses and a greater variety of courses available. However, National Leader Pamela stated, "You have many more courses right now that are relevant, that have been redesigned, that have inclusion, and they are not just the traditional intro to CS."

5.1.3 Participation

There is currently little research or data that investigates students' overall participation in CS in all 50 states. There is currently limited research or longitudinal data that investigates students' participation nationally in learning CS from a historical perspective. According to the 2022 State of CS Education report (Code.org, CSTA, & ECEP Alliance), across 36 states, 5.6% of high school students are enrolled in foundational CS courses (up from 4.7% in 2021). Though this data is not available in earlier years, the report also shares that:

- Hispanic/Latina/Latino/Latinx/Latine high school students are 1.5 times less likely than their White and Asian peers to enroll in foundational CS, even when they attend a school that offers it.
- English language learners, students with disabilities, and students from communities that are economically disadvantaged are underrepresented in foundational CS courses compared to their overall population.
- Nationally, only 32% of students in high school foundational CS courses identify as girls.
- Boys are more likely to express confidence

in learning CS than girls (73% vs. 60%). Girls are less likely than boys to express interest in learning CS (25% vs. 50%). Boys are three times as likely as girls to express an expectation to pursue a job in CS at 33% vs. 12% (Gallup, Inc. & Code with Google, 2020).

While gaps persist, participation in CS is becoming more diverse nationally. Funders Sam and Jamie mentioned that the "...AP CS principles exam has the highest participation of Hispanic and Black students of any AP STEM exam." With respect to the CAPE framework, the AP CS exam is a product of student experiences, so we present that in the Experience section. According to our interviewees, the focus on equity has been a strength. Funder Trina shared that their organization gets "requests from people who want to talk to us about how to best achieve culturally responsive and sustainable practices on a variety of different levels."

However, participation is dependent on knowledge of a course existing and, according to the Google/Gallup report (2020), Black and Hispanic students are less likely than their White peers to know whether their school even offers a CS course.

Figure 16. Number of students taking an AP CS exam for the years that the data is available (College Board, 2022a, 2022b).

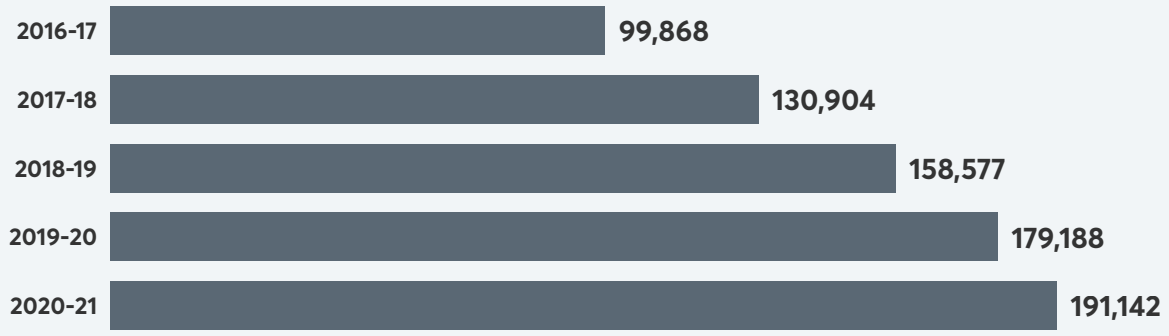


Figure 17. Advanced Placement Computer Science exam takers over the last seven years by gender, as reported by the Code.org, CSTA & ECEP Alliance report (Code.org, CSTA & ECEP Alliance, 2022, p. 23).

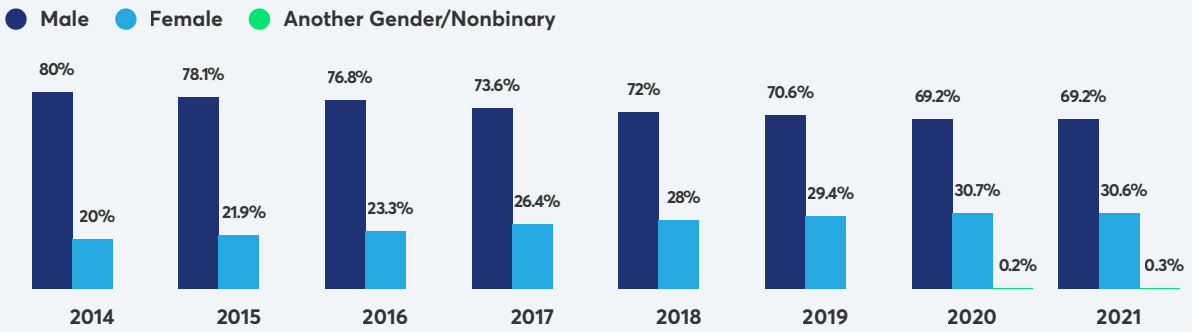
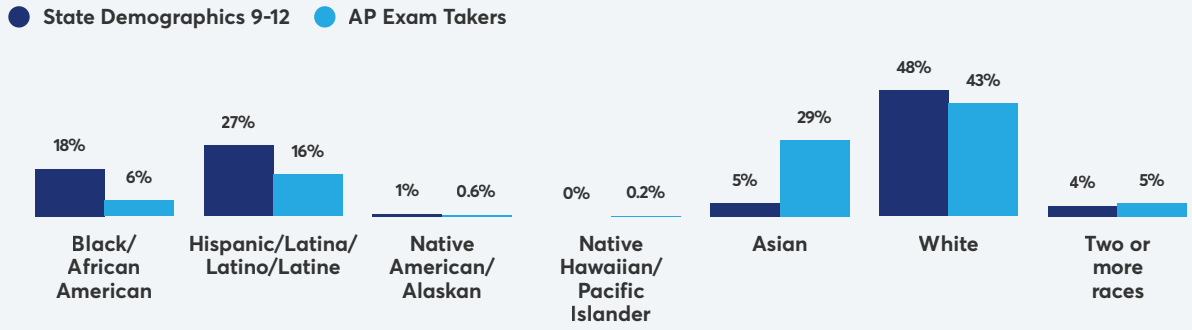


Figure 18. Advanced Placement Computer Science exam takers by race/ethnicity over the last seven years, as reported by the 2022 State of CS Education report (Code.org, CSTA, & ECEP Alliance, 2022b, p. 23).



5.1.4 Experience

There is currently little research or data that investigates students' overall experiences in learning CS across all 50 states. The only data that can be provided definitively about student experiences is presented by data from the Advanced Placement College Board (2022a, 2022b) and appearing in Code.org's report (2022). **FIGURE 16** shows the increase in the number of students taking an AP CS exam, which has nearly doubled (91%) from 2016-17 to 2020-21, the last year the data was available. Figures 17 and 18 also show the breakdown of gender and race/ethnicity of students taking an AP CS exam, showing growth across the percentage of girls taking the exam and the remaining gap for students across race/ethnicities.

Experiences are often defined by outcomes, particularly equitable outcomes, across multiple factors such as intent to persist in CS and self-efficacy (i.e., the belief that one can be successful). These factors influence student academic achievement and measuring them can lead to evidence to improve programs. Funder Trina noted that "[t]here seems to be a genuine interest in being more effective. Now that this work has taken place over the past 10 years or so, I think there's more discussion around, 'this is what we're not getting right. This is how we can be more thoughtful and proactive to ensure that we can see change.' I think there's an openness to the possibilities."

> "The question shifts to... quality. I think that that's what we're starting to see now in terms of national funding trends. Instead of this push for parity, it's more of a push for scholarship and for quality and for the last and hardest to reach."
>
> —GENERAL INTERVIEWEE ANGELA

Figure 19. A summary of opportunities for improving the national landscape of K-12 CS education.

STRATEGY
- Develop and implement a national strategy for CS education
- Grow participation of marginalized groups in CS education

TEACHERS
- Address national teacher shortage in school and out-of-school programs
- Increase teacher training with respect to diversity, equity, inclusion and belonging (DEIB)
- Increase awareness of societal impacts of CS
- Increase K-8 offerings for students

CURRICULUM
- Increase availability of resources

RESOURCES
- Increase empirical data and research

5.2 Opportunities

Many opportunities nationally were raised through this study across all the CAPE components (**FIGURE 19**), with details provided below.

5.2.1 Strategy

Develop and implement a national strategy for CS education. A concern that interviewees voiced was the lack of a national strategy for CS education, which may be contributing to inequality across the 50 states. National Leader Lamar noted that "Every state varies in their approach to implementing computer science education. Some states put funding behind implementation while others still do not

> We think about the schools where [CS education] still isn't there. What do we do to get it there? Then what do we do for schools where it is there to maintain it and expand it so that the people who take the course at that school look like the school population?
>
> —FUNDERS SAM AND JAMIE

have a plan to fund its implementation." Grantee Olivia spoke of this, saying, "There's no strategy around [whether] we start at Kindergarten...What are some ways to think about it so that you can start again to embed it in the natural fabric of how education should happen?...There are certain expectations that Common Core and Next Generation Science Standards (NGSS) [are] saying these are things that you need to have in place, but there's been loose oversight over implementation." These policies are hard to implement nationally since state Boards of Education have more power within states than the Department of Education. General Interviewee Brooke worried that the lack of national guidance is a "mix for fragmentation [and] potential duplication of efforts."

Grow participation of marginalized groups in CS education. CS still has a long way to go to have equal participation across all demographic groups across dimensions including gender, race/ethnicity, socioeconomic background, disability, LGBTQ+ identity, and more. Black and Hispanic individuals are underrepresented in STEM in America and are less likely to earn STEM degrees. Hispanic or Latine employees comprise 18% of the overall workforce but only 14% of the STEM workforce; Black or African American employees are 12% of the overall workforce but 9% of the STEM workforce (Ziker, 2023). Black students had the highest confidence when it came to learning CS material: 74% of Black students were very confident or confident in their ability to learn CS, whereas 66% of White students and 63% of Hispanic students felt the same way (Gallup, Inc. & Code with Google, 2020). However, somewhat fewer Black (65%) and Hispanic students (66%) than White students (70%) say they have ever learned CS (Gallup, Inc. & Code with Google, 2020). Further, course prerequisites like Algebra have been a barrier to students taking CS courses in high school (Torbey, Martin, Warner, & Fletcher, 2020). According to National Leader Pamela, "There's a real gap in terms of who participates in [CS classes] and which schools offer them. I would say these gaps are pretty clear and are race- and income-based."

Women are also underrepresented in CS. Nearly half of American workers are women, but women represent only 23.1% of those in technical roles across 20 large technical companies (Hupfer, Mazumder, Bucaille, & Crossan, 2021) and comprise overall 27% of the technology workforce in 2021 (National Center for Women & Information Technology, 2022). Similarly, students with disabilities are often excluded from CS learning opportunities. As Funder Sean explained: "Students with disabilities, in particular, that's a huge gap in terms of equity that often is not discussed when we have DEI conversations." People with disabilities actually enter college or university STEM programs at the same percentage as they are represented in the general population, but their number diminishes and is no longer representative in graduation rates and in the STEM workforce (Ziker, 2023).

5.2.2 Teachers

Address national teacher shortage in-school and out-of-school programs. The CSTA & Kapor Center (2021) study found that over one-quarter of teachers felt limited by their own CS content knowledge, specifically in elementary schools and lower-income schools. Interviewees who spoke to us about the national K-12 CS education landscape were particularly worried about having

> The biggest challenge is teachers. We just don't have enough teachers to teach CS, let alone women teachers of color who are teaching CS.
>
> —NATIONAL LEADER PAMELA

the teacher capacity to support the CS education they wanted to see across the nation. "I think that we're at a crisis where there are not enough people in this space to support what really needs to happen," shared Grantee Olivia. "We need qualified people that reflect communities."

Nationally, just like in Illinois and in Chicago, there is a critical need for more trained CS teachers. General Interviewee Kimora noted that this is challenging to do since "we don't yet have the infrastructure to train teachers, and so we're mainly supporting teachers in transitioning into teaching computer science."

Increase teacher training with respect to diversity, equity, inclusion and belonging (DEIB). While seven out of 10 CS teachers surveyed sought out and participated in PD opportunities for building DEIB principles into their classrooms (CSTA & Kapor, 2022), and a similar percentage (69%) believe that issues such as racism, sexism, ableism, and other inequities should be addressed in CS classrooms, fewer than 50% cover identity-inclusive course material. Incorporating equity and inclusivity into classrooms (including the need for equity and inclusivity) is important given the disproportionate participation in CS.

5.2.3 Curriculum

Increase awareness of societal impacts of CS. The CSTA & Kapor Center (2021) study found that 61% of "...teachers saw the importance of [teaching about] computing's role in perpetuating biases related to racism, sexism, and other inequities in the classroom." (p. 3) This was most prevalent among teachers in elementary, higher-income, rural, and less racially-diverse schools.

Increase K-8 offerings for students. Most of the focus on adding CS to curricula has been at the high school level. When surveyed, 55% of high school students said

their school had dedicated CS courses; that number diminished to 39% at the middle school level (Gallup, Inc. & Code with Google, 2020). Interviewees expressed concern that by high school, it can be too late for students to see themselves in the CS field. "The reality is, as we continue down this dependency and/or interdependency or just influx of CS as an undergirding to everyday life, these students then become ineligible for post-secondary opportunities because of what they didn't receive in their K-12 educational experience," summarized National Leader Beth.

5.2.4 Resources

Increase availability of resources. Inequality still exists along rural, urban and suburban divides, particularly with respect to network connectivity. The CSTA & Kapor Center (2021) study found that only 65% of teachers reported sufficient resources to teach CS, with those serving lower-income, elementary, and more racially diverse schools disproportionately affected by resource inaccessibility. National Leader Rose noted, "In the rural areas the gap is still connectivity. Even if the devices are there, the broadband technology isn't always up to speed." Technological resources vary across school districts and their budgets. "We still struggle with access to technology and quality technology at that. I know from my colleagues nationwide, we hear that a lot of districts are invested in [technology not well-suited for teaching CS]," noted General Interviewee Amanda. "[A]nother thing I hear nationwide…is there's not enough technical support for when technology doesn't work. Not all parents are able to sit down and help students fix their devices."

5.2.5 Research

Increase empirical data and research. According to National Leader Janice, "We're in a really troublesome spot right now in that the data that we've been relying on to tell a story of CS education has really been AP data." There is also very little data for grades K-8 since most data are focused on high school and the data remains insufficient to determine differences in CS education provided to students across schools, districts and states.

6. CONCLUSION

This study identified many of the significant changes in the Chicago K-12 CS education landscape. The findings from the interviewees combined with quantitative data informed the recommendations for how the Foundation can continue to support K-12 CS education in Chicago and Illinois.

These recommendations are detailed in the above sections and in the executive summary. Highlights consistent across all three regions of Chicago, Illinois, and the United States indicate a critical need for additional teacher training and understanding the impact that CS education is having on students. There is also a need for increased focus on collaboration with corporate and philanthropic communities, school systems, and out-of-school-time providers. Finally, it is clear that out-of-school-time initiatives play an important role in supporting student learning through alternate pathways and that these experiences are often community-based, meeting the needs of students in local neighborhoods.

PART 3

Impacts of CME Group Foundation Funding on K-12 Computer Science Education

CONTENTS

1. INTRODUCTION

The CME Group Foundation (the Foundation) began funding K-12 computer science (CS) initiatives in 2015. Since then, the Foundation has awarded a total of $5.4 million in grants to 36 different grantees. In 2022, the Foundation awarded $875,000 to 22 different grantees, indicating a growth in both financial support and in the number of grantees supported. The researchers examined how the support from the Foundation has influenced the landscape of CS education over the past eight years. To delineate the Foundation's impact, the researches evaluated the funded programs, referred to in this document as grantee partners (to indicate their shared mission with the Foundation) or grantees (for simplicity), using interview data combined with survey data provided by the Foundation.

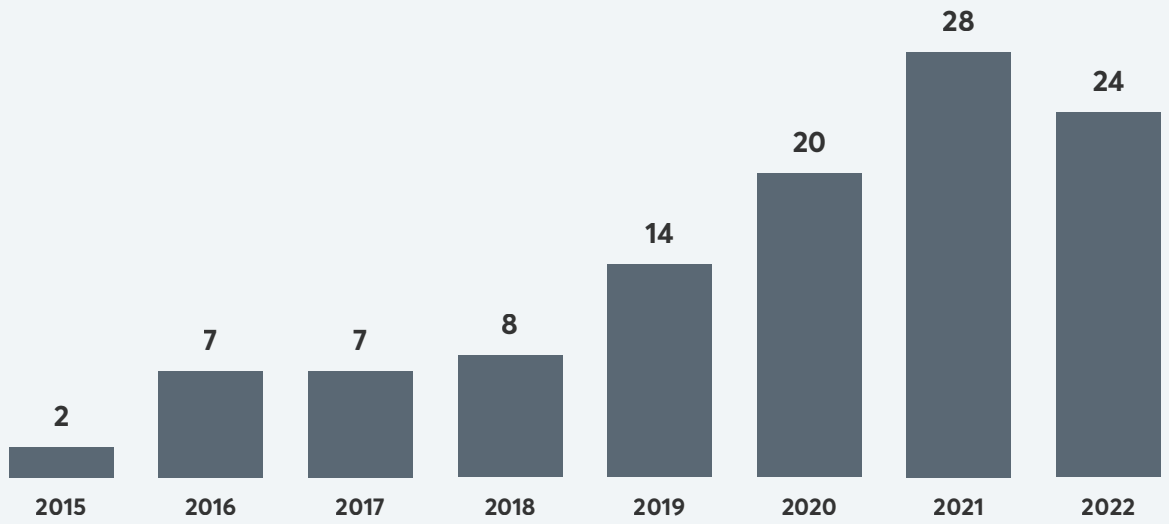
2. CHICAGO

In Chicago, the majority of the Foundation funds are directed towards capacity building efforts designed to provide additional CS education to students.

2.1 Capacity

Funding CS education in Chicago. The Foundation is the largest private funder of Chicago Public School (CPS)'s Computer Science for All (CS4All) initiative and has contributed $1,368,000 over the past eight years, averaging $171,000 per year. Due in part to Foundation support of CPS and CS4All programming, CPS's Department of Computer Science has expanded elementary CS curriculum, prepared high schools to offer introductory CS, and increased the number of high schools with intermediate and advanced CS classes. One grantee said, "Frankly, elementary CS in Chicago Public Schools wouldn't have existed without the support of CME Group Foundation. They really played an instrumental role the whole time I've been here, helping us support CS education at the elementary level." Grantee partners also praised the Foundation, saying

Figure 20. Number of organizations receiving funding from the Foundation since 2015.



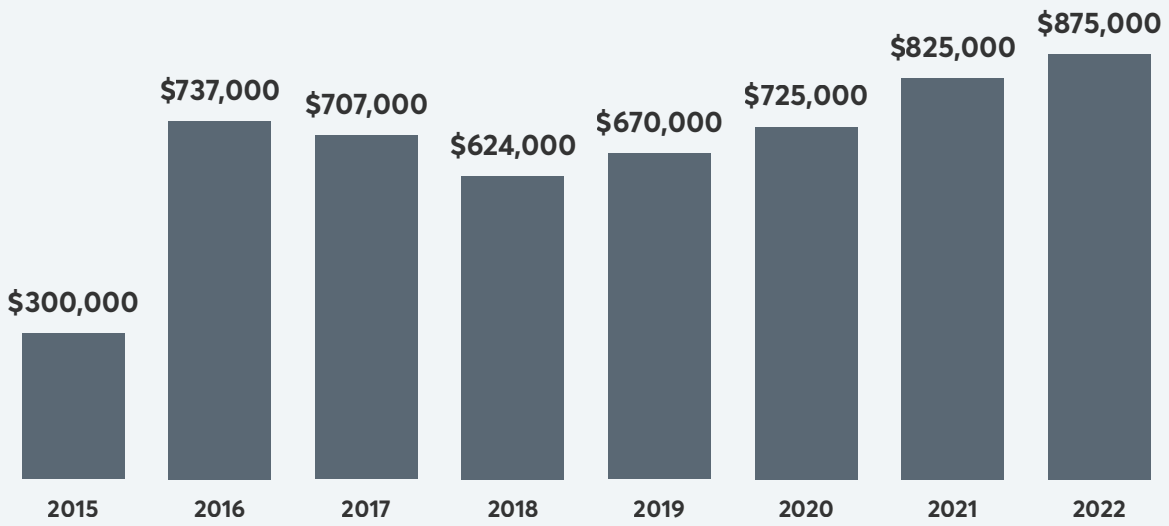
that the "grants from City Hall, CME Group Foundation, and other organizations…are also saying 'this is important to us. We're committing to help you grow this even though it isn't a requirement.' It gives us opportunities to remove as many barriers as possible for schools to opt into programming."

Furthermore, the Foundation funded DePaul University's study *Impact of CPS CS Graduation Policy on Student Access and Outcomes*. This study examined the capacity of schools to offer CS, the availability of high school CS courses, the number and demographics of students participating in CS, and how student outcomes changed after the graduation requirement. The results will inform school districts throughout Illinois as they prepare to meet the new state policy requiring all high schools in the state to offer CS by the 2023/24 school year.

The Foundation funds more than CS program initiatives. However, most of the grantees said

> "I think that the CME Group Foundation is…a good example of what it means for a corporate partner or entity to take the flag and say, *We are going to champion CS education, resource it and research it and unpack it.*"

Figure 21. Total annual funding level to grantees provided by the Foundation since 2015.



that the Foundation was their only source of CS-specific program funding.

Increasing allocation to under-resourced areas. The number one challenge that grantees wanted to address was bringing CS education to under-resourced Chicago communities. This finding was anticipated since the Foundation's Request for Proposals (RFP) noted that grants would be awarded to "predominantly low-income communities in the city of Chicago."

One grantee partner noted that "We want to be very intentional on providing young people access to these spaces that they otherwise wouldn't have access to." Another grantee echoed this sentiment: "we're talking about access…and really making this accessible to any child who wants to engage in CS development." Grantee partners created access opportunities for these under-resourced Chicago areas, with one noting that "we're providing the extra opportunities and enrichment in the [science, technology, engineering, mathematics] STEM and the CS fields that our kids don't have access to at school or outside of school just due to family income and access to resources in their communities."

Even though there is a CS graduation requirement in CPS high schools, some high schools only offer an introductory course, and some middle and elementary schools do not teach CS content. Multiple grantees also voiced concern about other pressures that students they serve face due to being in under-resourced communities. "We are really working in communities that [have] historically been challenged with high unemployment rates, low graduation rates, high violence and crime rates. Socioeconomically, we're looking at more of a low-to-middle class depending on the community that we're serving," described one grantee. Another grantee shared that, "we see that gap between where the schools or the secular education ends and where we come in."

Equity in Chicago CS education. While underrepresented CS students and under-resourced communities are usually correlated, some grantees specifically mentioned equity for underrepresented students as a goal. These grantee partners believe that CS learners in Chicago should reflect the city's diversity. This finding was anticipated since the Foundation RFP specifically sought to fund programs "focused on supporting students who are low-income and specifically underrepresented in the field of CS, such as youth who identify as girls, Black or Latinx."

Grantee partners varied in how their organization addressed equity. While some referenced underrepresented or underserved groups in general, others focused specifically on racial, gender, or socioeconomic equity. Usually, multiple groups were referenced during interviews; for example, one grantee stated that "we've been founded on a principle of really serving Black and Brown and underrepresented youth in STEM education."

> "CS is being used as a tool for understanding the world and then making sure that [students] walk away with inspiration to learn more about the tools."

Importantly, a recurring theme was that CS education did not only have to be more equitable for the sake of the CS landscape, but that equity achieved through CS education may make Chicago more equitable overall for underserved and underrepresented groups. One grantee said, "We recognize that CS is [an] important and growing field and that there's also often high-paying jobs within that field. We feel compelled to provide those opportunities to teenagers as they're exploring their talents and honing their skills and thinking about career pathways, so that they know that those are opportunities and career paths that are accessible to them as well…we serve predominantly underserved communities in Chicago, we want to make sure that teens that are underrepresented in this group are also getting access to those programs."

Overwhelmingly, grantee partners seemed to see out-of-school-time (OST) programs as a means to advance equity by filling in the gaps of in-school learning. One grantee partner noted that their OST programs are working to connect in-school learning with their OST program. Another grantee agreed, saying that their "mission is to advance racial equity in K-12 CS education. We want to make sure that kids, especially beyond the school, have opportunities to access CS education."

Student-focused CS skills. The obvious areas that grantees wanted to improve using Foundation funding was CS fluency, efficacy, and confidence for Chicago K-12 students.

Grantees engaged students by leveraging creativity when introducing different CS-related programs. None of the grantees believed teaching how to program as a standalone subject was the best way to

> We want young people to understand that technology is running through everything that we do and [impacting] how we live our lives…there's going to be more and more jobs, more career opportunities for our young people if they dive deep into understanding CS.

teach CS; all of them engaged students through other activities such as robotics, anthropology, makerspaces, app design, and more. A grantee summed up the value of this approach to "tap into creativity, getting kids to work together, and using all of that to get kids engaged with CS."

Another grantee referred to their "really targeted and focused approach towards inspiring people through the natural history and anthropology lens to care more about data science and more about coding as these tools…[which] can do a lot of different things that allow you to learn more about the world." This theme of using coding and computational thinking to better understand the world was elaborated upon: "Getting [students] excited, especially about how they can make an impact on the world by caring a lot about data and caring a lot about coding and algorithms, is really important to us."

Another interesting concept that emerged from the interviews was the idea of CS instruction prompting community-wide change based on the development of students' problem-solving skills. A grantee described this change through students' CS skills: "Our mission is to provide participatory learning through community engagement, to ultimately empower youth and community residents that we work with to be a part of change throughout the community. Ultimately, providing them with not just the tools, but opportunity for discussion, dialogue, critical thinking, so that they use these tools to effectively create self-change at the micro level, and then community change, and then ultimately, hopefully, city-wide change."

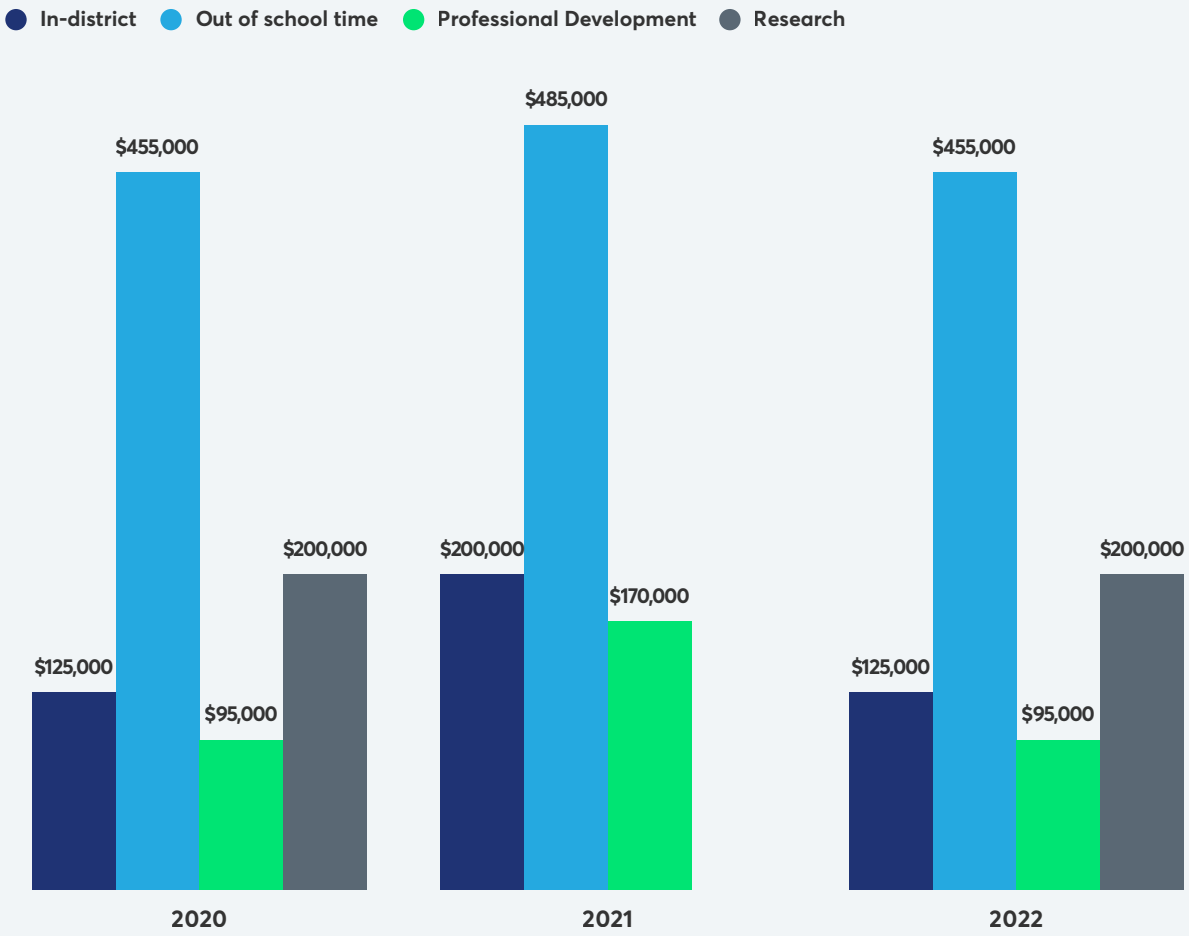
Workforce development. The Foundation grantees aimed to increase workforce skills in Chicago through giving students CS career skills. Grantees saw their mission as preparing students to have the ability to follow whatever career path they desire, with one grantee saying, "When I mention workforce development, we want to make sure that the kids that come through our doors, they reach their full potential." Grantees also saw their programs as providing skills needed to pursue

a career without college.

Grantees also raised student awareness of CS careers which can lead to more students pursuing workforce skills. Grantees viewed careers in CS as not only setting up kids for personal success but also as a way to lift the whole community: "We realized that we had a huge opportunity to be intentional about some of the offerings [to help] them be lifted out of generational poverty or a generational lack of access to resources."

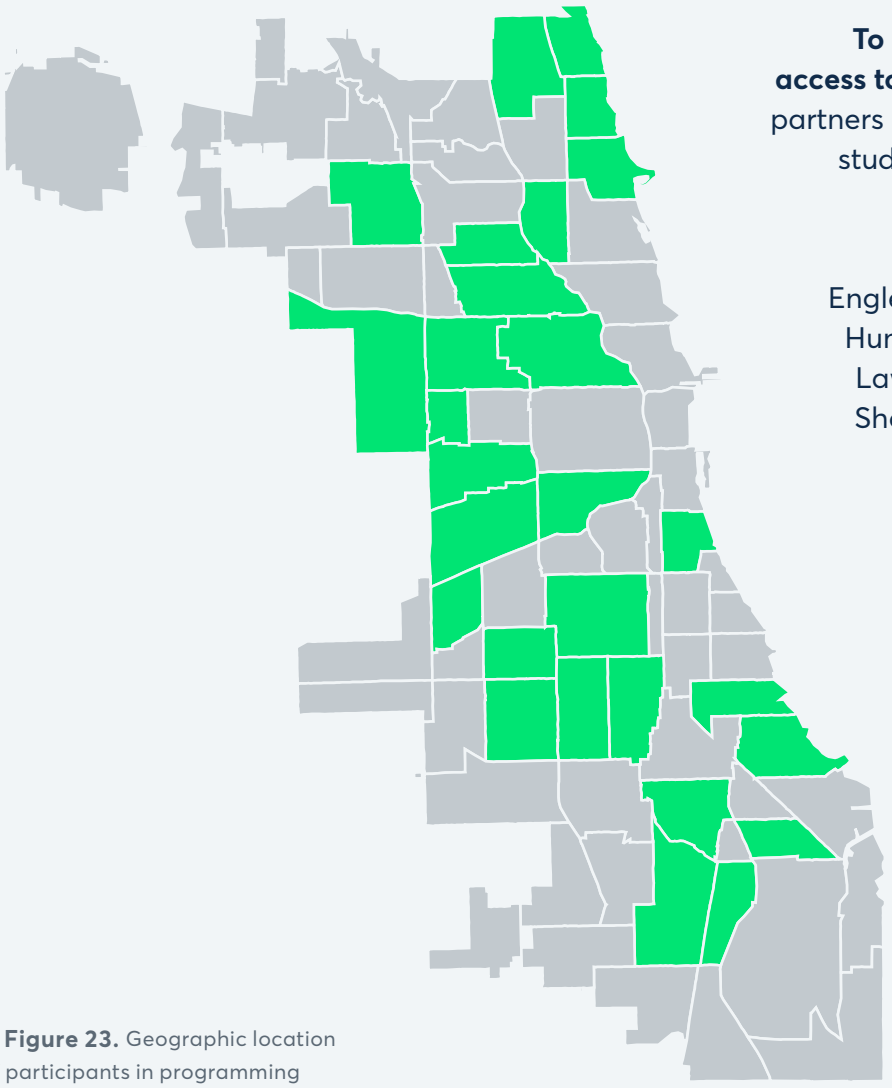
2.2 Access

Figure 22. Funding level across the various program types provided by the Foundation.



The Foundation provided both in-school and out-of-school programming (**FIGURE 22**) to create access to CS.

2.3 Participation



To increase equitable access to CS resources, our partners focused on serving students in community areas including:

Austin, Bronzeville, Englewood, Gage Park, Humboldt Park, North Lawndale, and South Shore, among others.

Figure 23. Geographic location of participants in programming supported by the Foundation.

FIGURE 23 shows the locations of students participating in programs supported by the Foundation.

The majority of participants in grantees' programs identified as Black/African American or as Hispanic/Latine. Programs funded by the Foundation also had higher participation from girls than boys. The programs predominantly focused on high school students. As shown in **FIGURE 24**, aggregated data from the programs shows that nearly 1 in 3 students were Black/African American (32%) and nearly 1 in 5 were Hispanic or Latine (20%); 52% were girls, 46% were boys, and 2% identified as nonbinary

Figure 24. Participation of students in the Foundation-sponsored activities in 2020, 2021, and 2022 by race/ethnicity.

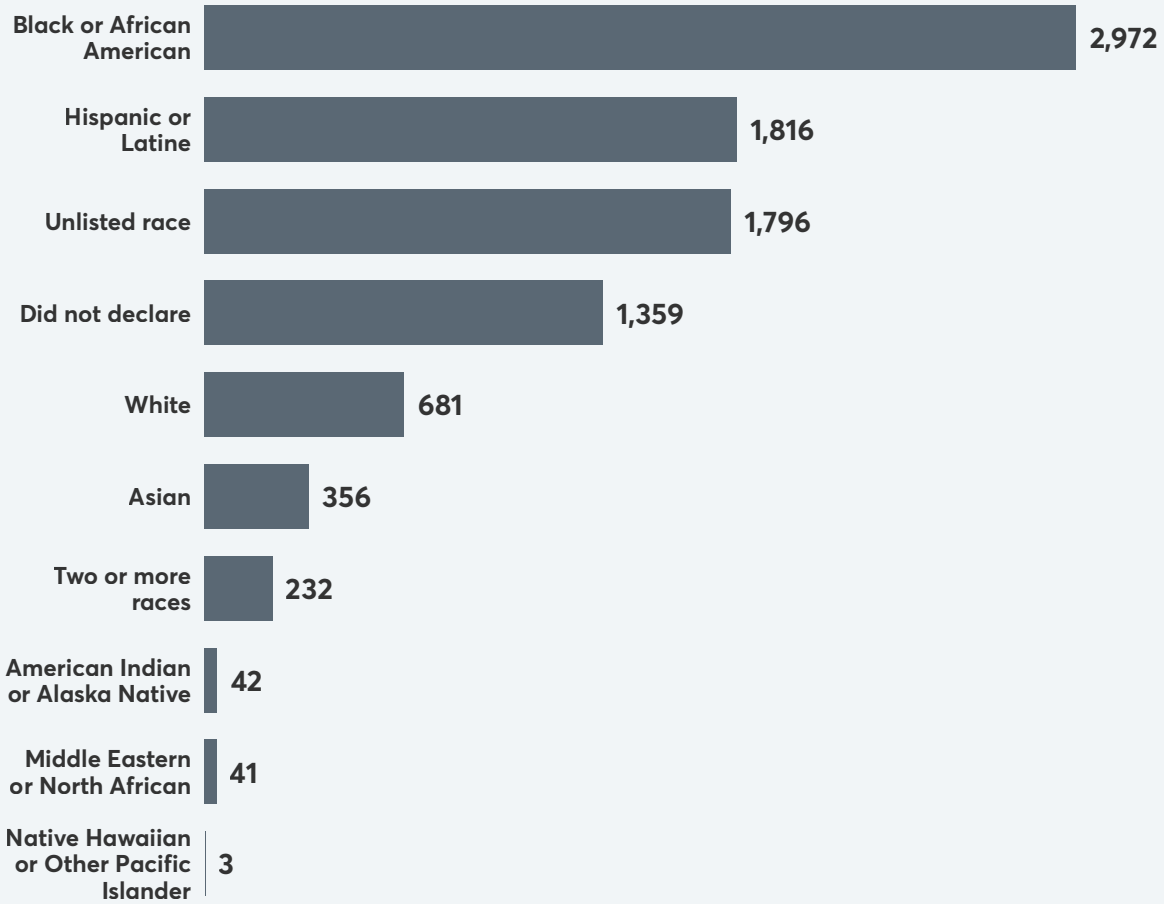
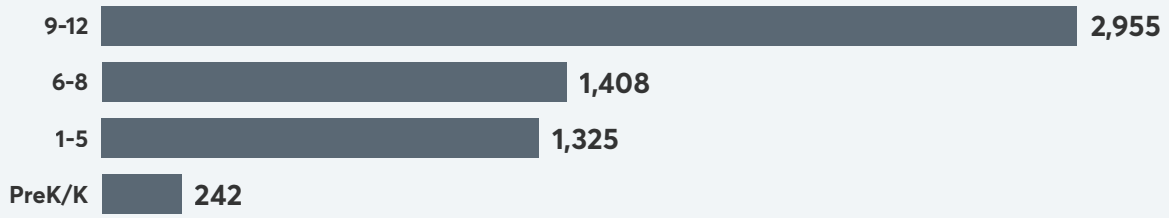


Figure 25. Participation of students in the Foundation-sponsored activities in 2020, 2021, and 2022 by gender.

Figure 26. Participation of students in Foundation-sponsored activities in 2020, 2021 and 2022 by grade levels.



or a different gender. **FIGURE 25** shows that 50% of the participants were in high school, 24% in middle school, and 26% in PreK-5.

2.4 Experience

Surveys of grantee program participants were promising, showing that the majority of students derived benefits from the programs. In 2022, the majority of participants increased their CS or STEM interest (80%), proficiency (85%), self-confidence (78%), and identity (reflecting belonging in CS) (75.1%). The majority of participants also increased their 21st century skills proficiency (71.3%). Approximately 3 out of 5 students indicated an intent to seek a career in STEM or CS (63%). Of students who

Figure 27. Increased CS or STEM Proficiency

Figure 28. Increased CS or STEM Interest

Figure 29. Increased CS or STEM Self-Confidence

Figure 30. Increased 21st Century Skills Proficiency

Figure 31. Increased CS or STEM Identity

Figure 32. Intention to Pursue CS or STEM Career

indicated that they were interested in college, 4 out of 5 (80%) were found to have enrolled in college. This data is shown across the years 2020-2022 in Figures 27-32.

3. ILLINOIS

Though the Foundation primarily provides support for youth in Chicago, it also provided grants to support capacity building for CS education across Illinois. In 2021, a $125,000 grant provided support to state-level capacity building efforts at the University of Illinois Urbana-Champaign. In 2020, a $50,000 grant provided support to the University of Illinois Urbana-Champaign to develop an Illinois K-12 CS education landscape report. The Foundation supported University of Illinois College of Education's landscape report on barriers to K-12 CS education, which highlighted the need for pre-service certification and secondary endorsement programs for CS teachers and for funding for professional development. It also explored the shortage of intermediate and advanced CS courses in and out of schools. The report has been used to highlight the need for CS education in Illinois, and it has been a source for some of the evidence in this report. Finally, the Foundation has provided $25,000 in support to the Computer Science Teachers Association (CSTA) annual conference in 2020, 2021 and 2022.

4. NATIONAL

The Foundation funded the 100Kin10 Starfish Institute ($50,000) in 2022 to further build the capacity of STEM teachers across the country. In 2021, the Foundation provided support to two national-level organizations: Project Lead the Way (downstate school grants of $25,000 in 2021 and $25,000 in 2022), which may have impacted the national curriculum for Project Lead the Way, and for STEMConnector for general operations ($25,000). For each year 2015-2018, the Foundation provided a grant of $100,000 to Code.org to support creating and curating a new nationwide K-12 computer science curriculum. This funding is significant due to the national reach Code.org has in K-12 CS education.

5. CONCLUSION

The CME Group Foundation has provided significant support across multiple schools and neighborhoods in Chicago, including in-school and out-of-school programs. Over the years, the Foundation has generously granted a total of over $5.4 million to 36 different recipients. In 2022, the Foundation again expanded its financial support as well as the number of grantees, providing $875,000 to 22 organizations. Teacher professional development (PD) has been raised as a key need, and the Foundation has been working to support those needs financially. Support has also been given for efforts within Illinois as well as nationally to provide teacher PD and to understand the landscape of CS education throughout Chicago and Illinois.

REFERENCES

Barrow, L., Freire, S., and de la Torre, M. (2020). Trends in Computer Science Education: Access, Enrollment, and Performance in CPS High Schools. Retrieved January 23, 2023 from https://consortium.uchicago.edu/publications/trends-in-computer-science-education

Boda, P.A. & McGee, S.. (2021). Broadening Participation and Success in AP CSA - Predictive Modeling from Three Years of Data. ACM Technical Symposium on Computer Science Education. Retrieved from https://doi.org/10.1145/3408877.3432421

Century, J., Lach, M., King, H., Rand, S., Heppner, C., Franke, B., & Westrick, J. (2013). Building an Operating System for Computer Science. Chicago, IL: CEMSE, University of Chicago with UEI, University of Chicago. Retrieved [date], from http://outlier.uchicago.edu/computerscience/OS4CS/

Chicago Public Schools. (2021, December 7). Chicago Public Schools Celebrates Computer Science EdWeek 2021 with a slate of scheduled events [Press release]. Retrieved January 22, 2023 from https://www.cps.edu/press-releases/chicago-public-schools-celebrates-computer-science-edweek-2021-with-a-slate-of-scheduled-events/

Code.org. (n.d.). Support K-12 Computer Science Education in Illinois. Retrieved February 5, 2023 from https://code.org/advocacy/state-facts/IL.pdf

Code.org, CSTA, & ECEP Alliance (2022a). 2022 State of Computer Science Education: Understanding Our National Imperative. Retrieved from https://advocacy.code.org/stateofcs

Code.org, CSTA, & ECEP Alliance (2022b). 2022 State of Computer Science Education: Illinois Summary Handout. Retrieved from https://advocacy.code.org/stateofcs

Code.org, CSTA, & ECEP Alliance (2021). 2021 State of Computer Science Education: Accelerating Action through Advocacy. Retrieved from https://advocacy.code.org/stateofcs

College Board. (2016). AP Exam Score Distributions. Retrieved from https://reports.collegeboard.org/media/pdf/Student-Score-Distributions-2015_1.pdf

College Board. (2018). AP CS Exam Results. Retrieved from https://newsroom.collegeboard.org/number-females-and-underrepresented-students-taking-ap-computer-science-courses-spikes-again

College Board. (2022a). AP CS A Exam Results. Retrieved from https://allaccess.collegeboard.org/ap-computer-science-exam-2021-results

College Board. (2022b). AP CS Principles Exam Results. Retrieved from https://allaccess.collegeboard.org/ap-computer-science-principles-2021-results

CPS Office of Communications. (2023, January 23). Two Dozen High Schools Across Chicago Public Schools Earn AP Computer Science Female Diversity Award. Chicago Public Schools. Retrieved February 5, 2023, from https://www.cps.edu/press-releases/two-dozen-high-schools-across-chicago-public-schools-earn-ap-computer-science-female--diversity-award/

Computer Science Teachers Association. (2020). CSTA 2019-2020 Annual Report. Retrieved January 25, 2023, from https://members.csteachers.org/documents/en-us/b6056e5d-a615-4b1c-8c8a-bd0dd9ea8b02/1/

Computer Science Teachers Association. (2021). CSTA Annual Report 2021. Retrieved January 25, 2023, from https://members.csteachers.org/documents/en-us/09bda1c0-29a4-494c-9e79-a662ae9456e5/1

CSTA & Kapor Center. (2021). The computer science teacher landscape. Retrieved from https://csteachers.org/Stories/cs-teacher-landscape-report

Dettori, L., Greenberg, R.I., McGee, S. & Reed, D.. (2015). The Impact of Meaningful High School Computer Science Experiences in the Chicago Public Schools. Research on Equity and Sustained Participation in Engineering, Computing, and Technology. Retrieved from https://doi.org/10.1109/RESPECT.2015.7296505

Dettori, L., Greenberg, R. I., McGee, S., Reed, D., Wilkerson, B., & Yanek, D. (2018, February). CS as a graduation requirement: Catalyst for systemic change. In Proceedings of the 49th ACM Technical Symposium on Computer Science Education (pp. 406-407).

Fletcher, C.L. and Warner, J. R. (2019). Summary of the CAPE Framework for Assessing Equity in Computer Science Education. Retrieved October 5, 2022 from https://www.tacc.utexas.edu/epic/research

Gallup, Inc. & Code with Google. (2020). Current Perspectives and Continuing Challenges in Computer Science Education in U.S. K-12 Schools. Retrieved from https://services.google.com/fh/files/misc/computer-science-education-in-us-k12schools-2020-report.pdf

Hegeman-Davis, R., & Sewell, M. (2021). Landscape report of K-12 computer science education in Illinois. University of Illinois College of Education.

House Bill 2170, 101st General Assembly, 2021 Reg. Sess. (Ill. 2021). Retrieved January 20, 2023 from https://ilga.gov/legislation/101/HB/10100HB2170lv.htm

Hupfer, S., Mazumder, S., Bucaille, A., and Crossan, G. (2021). Women in the tech industry: Gaining ground, but facing new headwinds. Retrieved from https://www2.deloitte.com/us/en/insights/industry/technology/technology-media-and-telecom-predictions/2022/statistics-show-women-in-technology-are-facing-new-headwinds.html

Illinois State Board of Education. (2023). Research and Data Reporting: Teacher Salary Study. Retrieved May 15, 2023 from https://www.isbe.net/Pages/TeacherSalaryStudy.aspx

Illinois Department of Employment Security. (2022). Workforce Availability Information. https://ides.illinois.gov/content/dam/soi/en/web/ides/labor_market_information/workforce_availabilityinformation/statewide.pdf

Learning Technology Center of Illinois. (2022). Legislation Brief: Computer Science Education. Retrieved May 1, 2023 from http://ltcillinois.org/wp-content/uploads/2022/11/Computer-Science-Legislative-Brief-112922.pdf

Koshy, S., Twarek, B., Bashir, D., Glass, S., Goins, R., Cruz Novohatski, L., & Scott, A. (2022). Moving towards a vision of equitable computer science: Results of a landscape survey of PreK-12 CS teachers in the United States. Retrieved from: https://landscape.csteachers.org

Martinez, A. & Christnacht, C. (2021). Women making gains in STEM Occupations but still underrepresented. United States Census Bureau. Retrieved September 23, 2022, from https://www.census.gov/library/stories/2021/01/women-making-gains-in-stem-occupations-but-stillunderrepresented.html

McGee, S., Dettori, L., & Rasmussen, A.M. (2022). Impact of the CPS Computer Science Graduation Policy on Student Access and Outcomes [report]. Chicago, IL: The Learning Partnership. https://doi.org/10.51420/report.2022.4

National Center for Women & Information Technology. (2022). By the Numbers. Retrieved from https://ncwit.org/resource/bythenumbers/

National Governors Association. (n.d.). 2021-2022 Chairman's Initiative: Computer Science Education. Retrieved January 24, 2023, from https://www.nga.org/computerscience/

Smith, M. (2016). Computer Science For All. Retrieved from https://obamawhitehouse.archives.gov/blog/2016/01/30/computer-science-all

Torbey, R., Martin, N. D., Warner, J. R., & Fletcher, C. L. (2020, February). Algebra I before high school as a gatekeeper to computer science participation. In Proceedings of the 51st ACM technical symposium on computer science education (pp. 839-844).

U.S. Census Bureau QuickFacts: United States. (2022, July 1). United States Census Bureau. Retrieved January 25, 2023, from https://www.census.gov/quickfacts/fact/table/US/PST045222

US Department of Education (ED). (2021, June 15). The Federal Role in Education. Retrieved January 24, 2023, from https://www2.ed.gov/about/overview/fed/role.html

U.S. News and World Report. (2023). High Schools in Chicago Public Schools District. Retrieved February 16, 2023, from https://www.usnews.com/education/best-high-schools/illinois/districts/chicago-public-schools-110570

U.S. News and World Report. Illinois School Districts. (2023). Illinois School DistrictsRetrieved February 16, 2023, from https://www.usnews.com/education/best-high-schools/illinois/districts#

Ziker, C., Johnson, J., & Paredes, P. (2023). The State of STEM: Challenges and Opportunities. Manhattan Beach, CA. STEMconnector.

ABOUT

Institute for Advancing Computing Education

Institute for Advancing Computing Education (IACE), formerly CSEdResearch.org, is a 501(c)(3) non-profit with a mission to improve K-12 computer science (CS) education for all children by enabling and disseminating exemplary evidence-driven research. Our organization provides research and evaluation services across the United States as well as internationally. We design, conduct, promote, support and disseminate research that K-12 educators and those that support them find relevant and actionable. These transformed research practices can then be used to identify and promote high-impact, culturally relevant practices and promote these relevant and promising practices among K-12 educators.

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