Computer Science in New York City:
An Early Look at Teacher Training Opportunities and the Landscape of CS Implementation in Schools

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EXECUTIVE SUMMARY

There is a growing call, at district, state, and national levels, for all students to have opportunities to become proficient computational thinkers and be exposed to hands-on computer science (CS) curriculum and courses throughout their educational careers. But research shows that some groups are systematically underrepresented in CS and CS education. For example, Black and Latino students are much less likely than White students to have access to CS learning opportunities in school or access to computers at home. Compared with male students, female students report less interest in and awareness of CS opportunities, and they are less likely to report having ever learned CS.

Answering the call for computer science expansion and equity, the New York City Department of Education (NYCDOE) launched the CS4All initiative in 2015, with the goal of providing meaningful, high-quality computer science education to all NYC public school students at each grade band (i.e., K-2, 3-5, 6-8, 9-12) by 2025. CS4All is currently the only district effort in the country to attempt to implement CS education at this scale. An unprecedented private-public partnership has committed to raise $81 million to support the initiative. CS4All plans to provide professional development (PD) in CS for nearly 5,000 teachers, specifically targeting those with little or no computer science background. The initiative is focused in part on increasing access to CS education among students from historically underrepresented groups—in particular girls, Black and Latino students, English Learners, and special education students.

The Research Alliance for New York City Schools, in partnership with Education Development Center (EDC), is conducting an evaluation of CS4All. The evaluation began in Year 2 of the initiative (the 2016-2017 school year) and was designed to assess the implementation of CS4All across the district; examine its impact on schools, teachers and students; and provide information that helps the NYCDOE and the CS4All Founders Committee continuously improve the initiative over time. This summary presents highlights from our first report on the CS4All initiative, describing 1) the overarching goals of CS4All and the primary strategies for pursuing those goals, 2) a broad picture of CS education and training in the City—including programs that are the result of CS4All’s early implementation, as well as preexisting efforts, and 3) teacher responses to CS4All PD, including the extent to which they report implementing what they learned.
CS4All Goals and Strategies

Based on interviews with CS4All leadership and staff, funders, and PD partners, we documented four broad goals for the initiative—reach, equity, quality, and sustainability—and the specific approaches being used to pursue these goals. We expect that while the specific policies and practices under the auspices of CS4All will evolve (indeed, some already have), these four broad goals will remain consistent and thus serve as useful guideposts for examining and understanding the initiative’s success over time.

- **Goal 1: Reach—CS for All Students.** The CS4All initiative aims to ensure that a critical mass of NYC teachers is trained in CS, enabling all schools to offer CS and all students throughout the district to have at least one robust CS experience in each grade band. Strategies to achieve this goal include offering an array of PD opportunities of varying intensity and length and creating the CS Education Manager (CSEM) role. CSEMs work with individual schools to develop CS implementation plans and provide coaching and training tailored to each school’s specific context.

- **Goal 2: Equitable Access to CS.** Achieving equity is distinct from achieving the 4All goal. Equity requires a targeted focus on reaching students from groups typically underrepresented in CS. One way that the CS4All initiative has attempted to address equity is by reviewing demographic data and specifically targeting schools that are above the citywide average in terms of serving Black and Latino students, girls, and English language learners for all of its PD (including PD geared toward incorporating CS units into existing curricula, or teaching standalone CS courses or longer course sequences).

- **Goal 3: High-Quality CS.** While reaching all students and ensuring equity are important goals of the initiative, CS4All leaders also want to ensure that the CS experiences students receive are high quality. The primary strategy designed to support quality implementation was the development of a digital resource for CS education, known as the “Blueprint.” The Blueprint, shared in Beta form in the summer of 2017 (and available online), has since been used to anchor all PD and is designed to provide user-friendly resources and support to teachers (with or without a CS background) who are interested in implementing rigorous CS education.
• **Goal 4: Sustainability.** Making CS education sustainable will require that CS4All program staff build both systemwide and within-school infrastructure that can withstand challenges, such as maintaining political will amid changes in City and NYCDOE leadership, securing funding throughout the life of the initiative, and the ongoing evolution of the CS education field. Strategies to achieve sustainability include the addition of CS education in the NYCDOE’s STARS system, which schools use to report course characteristics and enrollment data, and the creation of about 20 CS education staff positions within the Department that are not dependent on outside, private funding.

Our interviews surfaced inherent challenges in pursuing each of these goals and also highlighted ways in which CS4All’s ambitious priorities sometimes compete with one another. For example, how might expanding the reach of CS to all schools and teachers limit the initiative’s capacity to provide targeted support for the highest-need schools? And how might efforts to achieve both of these goals dilute the quality of CS instruction? Looking ahead, CS4All may find that difficult tradeoffs are necessary to manage the initiative’s priorities.

**Districtwide Landscape of Computer Science Training and Instruction**

To provide a snapshot of the CS education landscape in NYC one year into CS4All’s efforts, we drew on a telephone survey of a representative sample of NYC public schools as well data from the STARS scheduling system. Because we are interested in understanding the full landscape of CS opportunities across the City, we collected data from both “initiative schools” that participated in CS PD provided through CS4All and “non-initiative schools” that either participated in CS PD provided by organizations outside of CS4All or did not participate in any CS PD. Key findings from this analysis include:

• **According to the landscape survey, an estimated 43 percent of responding schools could identify a specific CS PD that their teachers had attended during the 2015-2016 school year.** An additional 10 percent reported they sent their teachers to CS PD, but could not identify the provider. This included PD that was sponsored by CS4All and PD that schools sought out on their own, outside of the initiative. Not surprisingly, as shown in Figure ES-1, the percentage of schools that reported
sending their teachers to an identified CS PD was higher among CS4All initiative schools (69%) than among non-initiative schools (37%).

- Schools participating in the first two years of the initiative (2015-2016 and 2016-2017) served fewer proportions of students historically underrepresented in CS (i.e., Black and Latino students, students with higher levels of economic needs, and students with relatively weak prior academic performance), compared with schools not yet involved in the initiative. CS4All has recently focused more intently on recruiting schools that serve high proportions of underrepresented students. This can be seen, for example, in the schools recruited to join the FSC-based Cohort Model program during the 2017-2018 school year (see page ES-xiii for more information about this program). As shown in Figure ES-2, the schools recruited for the Cohort program serve more underrepresented and low-performing populations than non-initiative schools. While this analysis does not include all schools that will be recruited to participate in CS4All this year, it is an indication of the initiative’s intensive outreach to a group of high-need schools, which is a promising step in pursuit of CS4All’s equity goals.
An estimated 55 percent of schools reported offering students some kind of specific CS instruction during the 2016-2017 school year, according to the landscape survey. An additional estimated 9 percent of schools reported that they offered CS instruction, but the survey respondent was not able to report in detail about the content of that instruction. This is very different from the 25 percent of schools citywide that, according to STARS data, offered CS instruction during the 2016-2017 school year. We believe it is likely that STARS data underreport CS instruction because many schools may not have been aware of the relatively new process for indicating CS instruction in STARS. At the same time, it is possible that our landscape survey results overestimate the prevalence of CS instruction, especially if schools that were offering CS were more likely to respond to the survey than those that were not (although we tried to mitigate this risk in our recruitment efforts). In addition, neither the landscape nor STARS data give enough information to determine whether or not the CS instruction documented is in fact offering students a meaningful unit of CS—CS4All’s
goal. In future years of the evaluation, we will continue working with CS4All to refine the information we are collecting and analyzing about CS instruction in schools.

- The percentage of schools offering identified CS instruction, according to the landscape survey, was higher among CS4All initiative schools (79%) than among non-initiative schools (50%), with an additional 7 and 10 percent respectively offering non-identified CS instruction. According to STARS data, 72 percent of CS4All initiative schools offered CS instruction in 2016-2017, which is fairly close to the 79 percent reported in the survey. In contrast, STARS data show that only 15 percent of non-initiative schools offered CS instruction—substantially less than the 49 percent we found in the survey. It is possible that schools participating in CS4All PD were more aware of the importance of tracking CS instruction in STARS. Still, the large difference between the two data sources for non-initiative schools raises important questions about how schools define “CS.”

- A similar percentage of schools offered identified CS instruction in upper elementary (53%), middle (60%) and high school grades (52%). Within elementary schools, administrators programmed students in grades K-2 for CS less frequently (33%) than students in grades 3-5. STARS data show the highest level of CS instructional offerings in high schools (35%), then middle schools (24%), then elementary schools (20%, K-5).

- According to the landscape survey, NYC schools that offered CS instruction served fewer students from underrepresented groups and fewer high-needs students than schools not offering CS. On average, schools offering CS served a lower percentage of Black and Latino students (an 18 percentage point estimated difference) and had a lower economic need index (a 7 percentage point difference) than schools not offering CS. Elementary and middle schools offering CS had a higher percentage of students scoring proficient on state tests in math and English Language Arts, while high schools offering CS had a higher on-time graduation rate, compared with high schools not offering CS. We found a similar pattern of CS-offering schools serving more advantaged populations when we analyzed STARS data.
• According to the STARS data, schools that offered CS in 2016-2017 enrolled 28 percent of their students in such courses, on average. As discussed above, CS4All’s goal is for students to have at least one meaningful unit of CS in each three- or four-year grade band. While it is difficult to assess this goal with only one year of programming data, the goal makes clear that we should expect approximately one fourth of high school students and one third of elementary and middle schools to receive CS instruction each year. We found that the percentage of students enrolled in CS varied widely depending on the grades served. Though a smaller proportion of elementary schools offered CS instruction than middle and high schools, elementary schools that did offer CS tended to enroll a larger proportion of their students. The median CS enrollment was 39 percent for students in grades K-2 and 63 percent for students in grades 3-5, while it was just 21 percent among middle schools, and 11 percent among high schools.

• Key groups of students are underrepresented in CS courses. Using the STARS data, we looked at the background characteristics of students who took CS courses and found demographic disparities similar to (but somewhat less pronounced than) those found nationally. Within schools that offer CS, students who took CS were less likely to be: female; Black or Latino; students with disabilities; English language learners; eligible for free lunch; and students with low prior performance on state math and ELA tests.

CS4All PD and Teachers’ Implementation of Computer Science

In addition to surveying the broad landscape of CS education across NYC, we also gathered more detailed information from teachers who participated in CS4All PD in the 2015-2016 school year, asking about their experience with the PD, as well as subsequent implementation of CS in their school. Key findings included:

• Overall, teachers rated the CS4All PD highly, with a majority reporting that it increased their CS knowledge and skills, and that what they learned would be useful in the classroom. In our survey, 93 percent of respondents agreed or strongly agreed that the PD increased their computer science skills. Similarly, 95 percent agreed or strongly agreed that they could use what they learned at the training to positively impact the
achievement of their students. Most teachers also responded favorably to questions about the quality of the PD, reporting that the goals of the PD were clearly stated, the activities were well organized and facilitated learning, and the facilitators were knowledgeable and well prepared.

- **Most of the teachers surveyed (80%) reported teaching CS in the 2016-2017 school year, either as a stand-alone course or integrated into other subject areas.** Among the few teachers who were not implementing CS, we heard several prominent themes in their responses to an open-ended question about why they were not doing so. These included a lack of ability to teach or integrate CS, competing academic priorities, lack of support to implement CS, and that they were not the designated CS teacher in the school.

- **Most teachers (90% of those implementing CS) reported that they modified what they learned in the PD to some extent.** Teachers predominately reported modifying the curriculum to differentiate instruction or adjust materials to different needs and ability levels.

- **The most commonly identified supports were colleagues from other schools who had attended the same PD, administrators at their own school, and other teachers in the school.** A total of 63 percent of survey respondents indicated that the colleagues they attended the PD with were a support to a “moderate” or “large” extent, while 59 percent said school administrators were supportive, and 49 percent said other teachers in their schools were. As compared to middle and high school teachers, a larger proportion of elementary school teachers reported that teachers in their school were supportive (elementary: 63%; middle: 36%; high: 45%).

- **The most commonly reported challenges were competing priorities and, relatedly, a lack of time to implement CS.** According to our survey, 66 percent of surveyed teachers cited competing priorities as a challenge, and 54 percent said a lack of time hindered their ability to implement CS. It is encouraging that the least commonly cited challenges overall were a lack of student interest in CS (14%) and teachers’ limited understanding of how to implement CS in their classrooms (16%).
• Broadly, teachers from high-need schools reported less support and more challenges in implementing CS instruction. Five out of the seven supports we asked about fit this pattern, as did 11 out of the 13 challenges. Figure ES-3 below shows the supports and challenges that had statistically significant differences associated with school economic need. Compared to teachers from schools with low economic needs, teachers from schools with high economic needs were less likely to report receiving support from their administrators, school or network technology specialists, or other teachers in their schools. In a similar vein, teachers from schools with high economic needs were more likely to report challenges to the implementation of CS, including a lack of parental support, a lack of administrative support, and a lack of student interest in CS.

Figure ES-3: Selected Supports and Challenges by School Economic Need, 2016-17 School Year

Source: Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2017 Teacher Survey and from the NYC DOE.

Note: The Economic Need Index is a measure of the socioeconomic status of the school population, based on the percent of students in temporary housing, eligible for HRA, and eligible for free lunch. Low Economic Need N = 86; High Economic Need N = 86. Differences were statistically significant at the 0.05 level.
**Recommendations**

As we study and reflect on the initial years of CS4All, we find that several components of the initiative are providing a strong foundation for its implementation and sustainability long-term. In particular, the creation of the Blueprint, the addition of CS Education Managers throughout the district, the inclusion of CS in STARS, and the provision of CS PD to address each of CS4All’s three strands (unit, course, sequence) across the grade bands speaks to the systemic nature of the initiative and its potential to meet its short- and long-term goals. In addition to developing and refining these approaches further, we recommend the following to build on the progress that has already been made:

- **Make explicit how the three PD strands (unit, course, and sequence) are expected to achieve the larger goals of the initiative.** As discussed above, the CS4All initiative has four main goals, and is using varied strategies to pursue those goals, in the context of the larger educational ecosystem. An explicit theory of action for the initiative that includes logic models for each of the three programmatic strands could clearly demonstrate how the elements of those programs are supposed to work together to achieve the initiative’s goals. This information could be used to communicate expectations to program participants; to develop scenarios that show the variety of ways that schools can engage in meaningful, sustained CS instruction; and to articulate specific short- and long-term benchmarks by which to measure success.

- **Identify promising strategies to engage schools that predominantly serve students underrepresented in CS.** Both our survey data and STARS suggests that there is room for improvement in terms of providing CS courses or training to students and teachers in high-need schools. We know from our work with the CS4All team during this current school year that they are increasingly targeting their recruitment efforts toward schools with larger populations of students who are underrepresented in CS. In addition, we suggest that there may be effective ways of encouraging these schools to engage in CS and supporting them during implementation. For instance, the CS4All team may consider more targeted communication and relationship-building with administrators from these schools or experimenting with different strategies to test which ones are more effective. It might be particularly useful to share examples of existing schools in similar
contexts that view CS4All goals as consistent with—and supportive of—their larger school goals and priorities.

- **Mitigate the most common challenges cited by schools and teachers.** Teachers across grade bands (and 66% of all teachers surveyed) indicated that competing school priorities were a challenge to implementing CS in the classroom. CS4All should consider how CSEMs might work with school administrators to integrate a focus on CS into a school’s School/Comprehensive Educational Plan (S/CEP). vii Staff might help administrators set SMART viii goals (i.e., specific, measurable, achievable, results-focused, and timebound) to create action plans, and ensure that CS-related activities are aligned to elements of the Framework for Great Schools. By including CS-related initiatives in the S/CEP, administrators might be in a better position to balance competing priorities.

The CS4All team might also consider establishing mechanisms to help address infrastructure challenges (e.g., lack of technology and bandwidth) that are preventing some schools from implementing and sustaining CS. Sufficient technology infrastructure was noted as a barrier to school participation by a substantial number of surveyed schools. How can the NYCDOE utilize the technology audit that was recently conducted across schools to ensure more equitable access to technology and sufficient bandwidth for CS programming? Are there ways that the CS4All team can better understand and support the needs of schools in terms of their technology infrastructure, including computers and tablets, software, reliable Internet access, and ongoing assistance for technology users?

- **Learn from the most promising models of PD.** Through a combination of our evaluation efforts and CS4All’s own process for monitoring teacher feedback about PD, the CS4All team should identify promising strategies used by PD providers that have been particularly successful in supporting implementation. For example, we found that teachers who participated in SEP or SEP Jr. and Code Interactive ECS were more likely to adapt materials, after controlling for other factors. What are the features of these trainings that are contributing to teachers’ ability to integrate and modify materials? Once other successful features have been identified across other PD supports or models (perhaps through planned variation), CS4All should encourage vendors to integrate those into their own practices and materials.
• **Provide additional resources for schools and teachers through school-based profiles or case studies.** To scale the benefits of the initiative and promote sustainability over time, the CS4All team (with the support of the initiative evaluators) should consider documenting the steps that exemplary schools take within each of the three program strands. This work could be used to create “school profiles” or “case studies,” accessible from the Blueprint website, that other schools might use as guides when they begin to implement CS. The guides would include examples that focus not only on successful implementation, but on how school teams and program managers solved problems along the way and learned from mistakes, as well as PD and curriculum materials to help schools that are seeking out these resources. While the Blueprint serves as the central resource for CS implementation across the entire City, these guides might provide more targeted advice for individual schools or communities. The profiles might be organized by school characteristics, so new schools can look to the experiences of schools with similar circumstances. The profiles might also help build institutional knowledge and mitigate the challenges of staff turnover (in schools and in NYCDOE offices).

**Moving Forward**

Since its launch in 2015, CS4All has begun to build a foundation for infusing CS into schools across New York City. Activities have included providing a wide range of PD experiences to teachers; hiring a full CS4All team, including CSEMs who work closely with schools in different regions of the City; and developing a CS Blueprint that defines meaningful CS education and offers examples of high-quality CS units. There are some early indications that these efforts are beginning to change the landscape of CS education in the City. Schools that participated in CS4All’s training were much more likely to report implementing CS than other NYC schools that have not yet participated. Teachers generally reported positive feedback about the CS4All PD, saying it increased their CS knowledge and skills and would be useful in the classroom.

Still, there is a long way to go for the initiative to meet its ambitious training and implementation goals, and many opportunities to adjust as the initiative grows. One of the most notable aspects of CS4All is the program staff’s commitment to a continuous improvement process. CS4All leaders have been clear about their interest...
in learning from early evaluation findings—and from experience—and making changes that will strengthen the initiative. One example of this is the development of a new model for providing the unit PD that prepares teachers to integrate CS into other subjects. The FSC Computer Science Cohort Model is an approach to providing PD across the City aimed at helping teachers integrate a unit of CS into existing courses, in place of the existing STEM Institute. In the Cohort Model, CSEMs work with district superintendents and field support centers to select schools in their region that serve high percentages of underrepresented students. CSEMs then collaborate with school teams made up of both administrators and teachers over the school year. They work together to create a CS vision for the schools, match schools to PD partners, conduct trainings among cohort schools, do school-based coaching and lesson planning, and host community CS events.

The initiative is also taking steps to promote sustainability by developing three CS teacher leadership pathways. The first is the Teacher Trainer Track, in which teachers lead PD sessions offered by the CS4All team and work with the team and partners to ensure quality PD. A second pathway is the Blueprint Track, through which teachers will prepare materials to be published on the Blueprint, review curriculum, and provide feedback on the existing resources presented there. Finally, teachers within the Community Builder Track will host Slack chats, coordinate intervisitations between schools, and coordinate borough communities of practice. All of these programs are aimed at establishing professional CS learning communities to help sustain CS education in the future.

To learn about these multifaceted elements of the initiative, the next phase of our evaluation includes case studies in a small subset of schools. These case studies—of schools engaged in both SEP and SEP Jr., CS Course PD, and the Cohort Model described here—will be designed to help the CS4All staff understand what schools are experiencing, how these programs are working, and how they can be improved. We are also preparing to launch the student assessment piece of our evaluation by developing a theory of action and specific research questions about student outcomes, based on existing research and prior measures of CS knowledge and skills. We will use our case study sites to pilot instruments that may be used to assess key student outcomes, including measures of CS knowledge and skills, academic achievement and engagement, and relevant non-cognitive outcomes, such as students’ sense of belonging, and awareness of computing careers and applications. As with our evaluation of CS4All’s implementation, our assessment of student outcomes will
illuminate how CS4All affects different groups of students, particularly those who are typically underrepresented in computer science and other STEM fields. Finally, we will continue to examine student enrollment in CS courses through STARS, exploring important questions about students’ access to and participation in CS and also providing feedback about how to improve this tracking system.

While it is still early in our evaluation, we hope the findings in this report, the questions they raise, and the various successes and challenges highlighted will help support the development of CS4All in New York City—and inform the work of other districts around the country engaged in similar efforts.
Executive Summary Notes

i Computational Thinking refers to “the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent.” (Wing, 2010).


iii This and other findings from the landscape survey are estimates based on results from a representative sample of schools. We have calculated the margin of error associated with each estimate, reported in Appendix B. The percentages reported should be interpreted as involving some uncertainty, like a political poll’s result would be followed by the clause “plus or minus 3 percent.” We italicize all landscape estimates to remind the reader of this uncertainty.

iv The percent of schools offering CS at each grade band is calculated out of all schools serving that grade level. E.g., for grades 6-8, the denominator includes schools serving grades K-8, 6-8, and 6-12. The denominator is different for each bar, and some schools are included in multiple denominators. Statistics offered in the text give the percent of schools offering identified CS instruction. The additional percent of schools by grade level offering non-identified CS instruction is: K-2 8 percent; 3-5 13 percent; 6-8 10 percent; 9-12 7 percent.

v We rely on STARS data for this analysis because it is the only source of information about individual student enrollment.

vi The percent of students enrolled in CS by school varied widely. Therefore, we report median enrollment rather than mean, as it provides a better indicator of the typical school enrollment.

vii For more information, see:
http://schools.nyc.gov/community/OSFEP/CEP/CEP.htm

viii For more information, see:
CHAPTER 1: INTRODUCTION

The last 10 years have been marked by an explosion of computing across almost every industry and a dramatic increase in jobs that require computational skills, especially in Science, Technology, Engineering and Math (STEM) fields. Over the next 10 years, the computer science industry, in particular, is projected to grow by 20 percent, according to the U.S. Bureau of Labor Statistics (U.S. Department of Labor Statistics, 2018). Furthermore, it is widely agreed that the use of computational concepts and methods—problem solving, designing systems, refining the steps in a process, and tinkering toward creative solutions—are relevant in nearly every discipline, profession, and industry. Thus, there is a growing call, at district, state, and national levels, for all students to have opportunities to become proficient computational thinkers and be exposed to hands-on computer science curriculum and courses throughout their educational careers.

However, while most students, parents and educators support and see the value in computer science (CS) education, nationally only 60 percent of schools offer any CS courses to students, and even fewer schools (40%) offer classes that teach programming and coding. In fact, just six states require secondary schools to offer CS, and only 10 states have established rigorous K-12 CS standards.

Research shows that some groups of people are systematically underrepresented in CS and CS education. For example, Black and Latino students are much less likely than White students to have access to CS learning opportunities in school or access to computers at home. Female students face additional social barriers: Compared with male students, they report less interest in and awareness of CS opportunities, and they are less likely to report having ever learned CS in grades 7-12.

An increasing number of policymakers, business leaders and educators see it as a both practical and moral imperative to confront these disparities. They seek to empower underserved students and communities to participate as creators—and not just consumers—in a digital world. Broadening participation in STEM and computer science can strengthen the workforce and arm students with skills to help solve important problems in society.

Answering the call for computer science expansion and equity, the NYC Department of Education (NYCDOE) launched the CS4All initiative in 2015, with the goal of providing meaningful, high-quality computer science education to all NYC public school students in each grade band (i.e., K-2, 3-5, 6-8, 9-12) by 2025. An unprecedented private-public partnership between the City of New York, the NYC
Department of Education, and a group of nonprofit organizations led by CSNYC has committed to raise $81 million toward the initiative. The initiative includes plans to scale up CS professional development (PD) for nearly 5,000 teachers, specifically targeting those with little or no computer science backgrounds. The PD is aimed at helping teachers learn new programs and pedagogies in CS education, as well as methods for integrating computer science into existing courses. The overall vision is that this training will translate into high-quality CS instruction, which will in turn increase student participation and improve student outcomes in CS.

The NYCDOE aims for CS4All’s instruction to extend well beyond the technical skills commonly associated with initial CS learning experiences. Rather, the initiative is premised on the idea that through CS education, students will learn broader skills such as computational thinking, problem-solving, critical thinking, collaborating with peers, as well as creating and communicating with technologies. Each of these skills are important for the evolving demands of the job market.

CS4All is currently the only districtwide effort in the country to attempt to implement CS education at such a large scale. As one of eight initiatives under the NYCDOE’s Equity and Excellence agenda, CS4All is explicitly designed to increase access to CS education among students from historically underrepresented groups—in particular, girls, Black and Latino students, English Learners, and special education students—and to positively influence a range of outcomes, including CS knowledge and skills, computational thinking, problem-solving, academic engagement, and eventually students’ pursuit of CS-related majors and careers. Lessons from CS4All promise to help build the growing knowledge base about K-12 CS education, informing future efforts here in NYC and around the country.

**Evaluating CS4All**

In 2016, the CS4All Founders Committee—which includes representatives from the NYCDOE, City Hall, the Fund for Public Schools, CSNYC, the Robin Hood Foundation, and the Robin Hood Learning and Technology Fund, and Math for America (MfA)—selected the Research Alliance for New York City Schools to provide an independent evaluation the initiative, in collaboration with Education Development Center (EDC). Our evaluation began in Year 2 of the initiative (the 2016-2017 school year) and is designed to assess the implementation of CS4All across the district; examine its impact on schools, teachers and students; and provide information that helps the NYCDOE and the Founders Committee continuously
improve the initiative over time. The evaluation is currently designed around five research priorities:

- **Implementation**: Document how teachers, schools, and the district are participating in and experiencing CS4All, across three primary mechanisms for delivering CS—1) “units” designed to help teachers incorporate CS into existing curricula, 2) standalone “courses” such as AP Computer Science, and 3) “sequences,” such as the Software Engineering Program (SEP and SEP Jr.). (See Table 1 on page 6 for more information about these programs.)

- **Teacher training**: Document the reach and quality of CS4All trainings, understand how and to what extent teachers use and adapt practices learned through the trainings, and document factors that support or prevent teachers from participating in trainings or using their CS training in the classroom.

- **Student tracking**: Measure and track students’ exposure to a range of CS activities, and assess how equitably CS offerings are being distributed across the City (in terms of demographics and geography) and whether, within that distribution, students from underrepresented groups are accessing CS offerings in substantial numbers.

- **Student assessment**: Assess the impacts of CS programming on short- and long-term student outcomes, including CS content knowledge and practices; CS engagement and self-efficacy; academic achievement; CS course-taking; AP CS course enrollment; and student choice of CTE high schools and programs, as well as CS- and STEM-related postsecondary courses of study and employment.

- **Longitudinal lens**: Document the extent to which and under what conditions CS4All can be sustainable beyond the life of the initiative. In particular, this work will examine the expansion of PD and student course offerings and enrollment over time, systems for monitoring and supporting quality, teacher retention, and sustainability of CS programming across NYC schools.

### About this Report

This initial report aims to paint a broad picture of CS education in the City—including programs that are the result of CS4All’s early implementation, but also preexisting efforts. The goals of the report are to illuminate the current state of CS education in
NYC, highlight early issues and challenges for the initiative, and create a starting point for examining how the landscape of CS education changes over time, as CS4All evolves.

The report focuses on the first two research priorities outlined above (i.e., implementation and teacher training) and draws on our data collection efforts during the first year of the evaluation, the 2016-2017 school year (as noted, this was second year of the initiative). We set out to examine how the initiative was rolled out in schools across the City, as well as how professional development was organized, how it was accessed by teachers, and how it shaped their classroom practices. The data sources we draw on for this report include:

- **Interviews with CS4All leadership**, including members of the Founders Committee, external partners, and the NYCDOE’s CS4All staff. As part of our interviews with CS4All staff, we spoke with a number of field-based Computer Science Education Managers (CSEMs) and PD providers.

- **A telephone survey with a large, representative sample of NYC schools**, which included schools participating in CS4All trainings and those not. This survey explored schools’ current CS course or program offerings and participation in CS professional development.

- **A survey of teachers who had received CS4All PD**, to understand more about how they were implementing the CS training they received, additional supports needed to implement CS in the classroom, teachers’ disposition toward CS (e.g., seeing the value and usefulness of CS instruction), and areas where they believe they need additional support.

- **Data from the NYCDOE’s Student Tracking and Registration System (STARS)**, which provides a record of courses offered at all NYC schools. We used STARS data to learn more about CS course offerings across the City’s schools and students’ enrollment in these courses.

- **A review of relevant documents**, such as theories of change, PD materials (e.g., goals, objectives, agendas), and supporting resources provided to teachers and administrators as part of the CS4All initiative.

Drawing on these various data sources, this report provides a broad look at CS education across the City, including the CS4All initiative’s early implementation at the district level, training opportunities offered, and the ways that training may have begun to influence teacher practice. While it is clearly too soon to say whether CS4All
is achieving its intended goals, this report explores how the initiative has been rolled out to date, as well as the context in which it is developing, and suggests some possible directions for the next few years of CS4All. The remainder of the report is organized as follows:

**Chapter 2, “Goals and Strategies,”** draws on our review of documents and interviews with the CS4All staff (including CSEMs) and, to a lesser extent, PD providers to describe the four major goals of CS4All—reach, equity, quality, and sustainability. We highlight specific approaches the initiative is using to advance each goal and discuss related challenges and tradeoffs.

**Chapter 3, “Districtwide Landscape of Computer Science Offerings and Training,”** provides a snapshot of the CS education landscape in NYC one year into CS4All’s efforts. This analysis draws on our telephone survey of a representative sample of NYC public schools, as well as data from the STARS scheduling system, to describe the number of schools participating in training and offering CS and the type of CS courses being offered. The chapter also examines the characteristics of schools offering CS and the characteristics of students taking CS, compared to their classmates who are not.

**Chapter 4, “CS4All PD and Teacher Implementation of Computer Science”** provides more detailed information from teachers about PD and CS implementation in schools. These data are based on a survey of 225 teachers—from 159 schools—who attended one of five CS4All PD programs offered in the 2015-2016 school year. The chapter examines teacher ratings of CS PD, teacher confidence in their ability to implement CS, teacher implementation and modification of CS PD and curricula, and factors that teachers see as supporting or hindering their implementation of CS.

**Chapter 5, “Discussion,”** provides recommendations that stem from the findings presented in the earlier chapters. This final discussion also highlights how the initiative has evolved in response to gaps identified in its first two years, as well as future directions for CS4All and for our evaluation.

Taken together, the findings presented in this report provide some useful early benchmarks that can be used to examine the CS4All initiative’s progress and development over time. In addition, we hope this report informs the work of other districts and educators around the country who are attempting to improve and expand CS education.
<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Engineering Program (SEP)</td>
<td>The Software Engineering Program is a multi-year, multi-grade, comprehensive computer science education program for students in grades 6 to 12. PD for teachers includes a 2-week summer institute, 10 Saturday follow-ups during the school year, and “hackathons”.</td>
</tr>
<tr>
<td>SEP Jr.</td>
<td>The Software Engineering Program Junior is a computer science program for kindergarten through 5th grade students that balances direct instruction with open-ended creative computing. PD includes a five-day summer institute, as well as four optional and five mandatory Saturday follow-ups during the school year.</td>
</tr>
<tr>
<td>STEM Institute</td>
<td>The 2015-16 STEM Institute offers workshops on a variety of computer science topics for teachers of grades K-12. PD includes a four-day workshop; some providers offer materials and online or in-person follow-up with teachers implementing what they learned.</td>
</tr>
<tr>
<td>Code Interactive: AP CS Principles</td>
<td>A full-year, entry-level course that introduces students in grades 9-12 to the foundations of modern computing through a blended learning environment. PD for teachers includes a five-day summer workshop and four Saturday follow-ups during the school year.</td>
</tr>
<tr>
<td>Code Interactive: Exploring Computer Science (ECS)</td>
<td>A year-long, introductory curriculum aimed at broadening CS participation of underrepresented students in grades 9-12. Teacher PD includes a five-day summer workshop and five Saturday follow-ups during the school year.</td>
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CHAPTER 2: CS4ALL GOALS & STRATEGIES

Like many initiatives in NYC—a district with over 1,800 schools serving 1.1 million students—CS4All is ambitious in its scope and scale. It is the nation’s largest public-private partnership in service to computer science education, with support from a range of foundations, corporations, nonprofits, and individual donors. These resources are essential, as CS4All aims to train nearly 5,000 teachers and bring CS education to all of the City’s students within a 10-year span (from 2015 to 2025). The aspiration is that all NYC public school students will receive at least one meaningful, high-quality CS learning experience at each grade band.

Beyond this general framework, CS4All is driven by several complementary and sometimes competing goals. Based on interviews with CS4All leadership and staff, funders, and PD partners, we have organized these goals into four key areas: reach, equity, quality, and sustainability. Below, we describe each of these goals and highlight the specific approaches the initiative is using to pursue them. We expect that while the specific policies and practices under the auspices of CS4All will evolve over time (and have already), these four broad goals will remain consistent and thus serve as useful guideposts for examining and understanding the initiative’s challenges and successes.

Data Sources

In the winter, spring, and summer of 2017, we conducted a series of interviews with members of the NYC CS4All community, including:

- Nine representatives of organizations on the Founders Committee,
- Five CS4All staff members from the NYCDOE (called CS4All staff below),
- Six NYCDOE CS Education Managers (CSEMs),
- Four professional development providers from SEP, SEP Jr., and Beauty and Joy of Computing, and;
- Representatives from seven of the partner organizations that provided training during the STEM Institute in the 2016-2017 school year.

Interviews were approximately one hour long and audio recorded. The interviews with CS4All staff and Founders Committee members were structured using a protocol that covered the following topics:
• Vision and goals for the initiative,
• Strategies to achieve that vision,
• Challenges to achieving that vision,
• Ideas for ensuring the sustainability of the initiative, and
• Benchmarks for understanding whether CS4All is on track.

Our interviews with CSEMs and PD providers/partners were structured using a protocol that addressed:

• Their relationships with the NYCDOE, CS4All, and the schools with which they work;
• The services and supports they provide to teachers, students, schools, and other stakeholders;
• Their goals for the work;
• Their methods for evaluating whether they are achieving those goals;
• What challenges they have faced in their work so far; and
• Strategies for overcoming those challenges.

Our team coded the interview data using a scheme that focused on understanding the relationship between program goals and program implementation (see the Appendix). Below we discuss the four core goals of CS4All, as described to us by interviewees, and detail the strategies that the initiative employed in pursuit of those goals during its first two years.

**Goal 1: Reach—CS for All Students**

The CS4All initiative aims to ensure that a critical mass of NYC teachers is trained in CS, enabling all schools to offer CS and all students throughout the district to have at least one robust CS experience in each grade band. The CS4All staff recognized at the onset of the initiative that—with more than 1,800 schools and very few teachers who have experience in CS—success rested on training a sufficient number of teachers across the City and ensuring that they have the knowledge and skills needed to effectively teach CS. CS4All staff set a goal of training nearly 5,000 teachers by the end of the 10-year initiative and developed a number of strategies designed to increase the likelihood that every school would be able to offer high-quality CS to its students.
**Strategies**

*Offering a diverse selection of PD experiences.* One strategy the CS4All initiative has used is to offer an array of PD opportunities of varying intensity and length. The different forms of PD are aligned with the initiative’s three primary mechanisms for delivering CS in schools: At the highest level of intensity, CS4All PD aims to prepare teachers to lead a multi-year, multi-grade sequence, such as the Software Engineering Program (SEP). SEP provides CS instruction to students in grades 6-12 and includes lessons in computer programming, robotics, web design and physical computing, as well as opportunities to engage in CS outside of school, such as hackathons and work experiences. The next level of PD prepares teachers to teach a CS course, such as AP CS Principles or Exploring Computer Science, over a semester or a year. The third level of PD prepares teachers to implement a unit in which CS is integrated into other course content, such as math or science, over a number of weeks or months. The *course* and *unit* PD are available in a variety of forms delivered by multiple providers. Some CS4All leaders believed this multi-pronged approach would increase buy-in, because it would enable teachers and school leaders to decide how CS could fit into their specific educational context. As one Founders Committee member stated:

> We’ve chosen to do something very unique here in New York City. In every other school district that we’ve encountered in the nation, the district sets a single course, a single curriculum, a single outcome. New York City’s not a one-size-fits-all town…We’ve actually chosen to go the route of ownership at the school level.

This approach is more complicated to administer than one that trains all teachers on a particular CS curriculum, but it allows for greater flexibility in how teachers learn CS and more autonomy for school administrators in how they implement CS education in their schools. In the view of many of the CS4All stakeholders that we interviewed, this variety was necessary for meeting the needs of a school system as large and diverse as New York City.

*Prioritizing PD for teachers who are new to CS.* As noted above, the NYCDOE intends to achieve the 4All goal in part by training nearly 5,000 teachers to provide CS education. To make efficient use of limited resources, the district has prioritized recruiting teachers who have not previously received CS PD, and targeted schools that did not already offer CS courses. This strategy is intended to increase the overall number of teachers exposed to CS and to boost the number of schools with the capacity to offer some form of CS instruction. (Moving forward, the CS4All team will be working with schools and teachers over multiple years to scale and sustain CS in schools).
Creating the CS Education Manager role. To help individual schools create CS implementation plans appropriate for their specific contexts, CS4All staff identified the need for CS Education Managers (CSEMs), who could get to know the different schools in various areas of the City. Brought on board during the 2016-2017 academic year, CSEMs provide coaching and training to teachers and guidance about building schools’ capacity to offer CS. They also develop relationships with school administrators, superintendents and other district stakeholders to help make them aware of the initiative. By focusing on a particular region, CSEMs are in a strong position to work with educators to design CS PD and implementation approaches that meet the needs of particular schools and communities. Starting in the 2017-2018 school year, the CSEMs are focusing on schools in the new Cohort Model (see Chapter 5 for more information). For courses and sequences, this work is now being done by the CS4All Program Managers.

Goal 2: Equitable Access to CS

Ensuring equitable access to CS education is another central goal of CS4All. A number of CS4All stakeholders noted that achieving equity is distinct from achieving computer science “for all.” Equity requires a targeted focus on reaching students from groups typically underrepresented in CS, including girls, Black and Latino students, English language learners and special education students. Interviewees noted that schools serving high numbers of these students often have other pressing priorities, such as raising test scores or improving graduation rates. As a result, leaders of these schools may be reluctant to participate in new initiatives. In addition, schools serving these populations often lack resources, such as laptop carts, bandwidth, and technical support. School leaders in low-resource schools might question whether they have adequate technology infrastructure for successful CS implementation. Overcoming these challenges requires a separate set of strategies.

Strategies

Targeting schools with high percentages of students underrepresented in CS. Although the NYC school system in general serves a large population of students from groups that are underrepresented in CS, such as Black and Latino students (who make up almost 70 percent of the City’s school population), the demographics from school to school vary a great deal. One way that the CS4All initiative has attempted to address equity is by reviewing demographic data and specifically targeting its PD (for sequences, courses and units) toward schools that are above the citywide average in
terms of the enrollment of Black and Latino students, girls, and English language learners.

**Tailoring CS PD and programs to school needs.** Another method CS4All has used to promote equity is to make an effort to reach schools where they are, physically, instructionally, and technically. In creating the regionally based CSEM role, the initiative highlighted the importance of offering PD in locations that are convenient for teachers in the outer boroughs. The CSEMs were able to provide introductory CS PD to small groups of teachers in schools across the City. CSEMs also worked with local stakeholders to tailor CS programs to each school’s priorities, context, and resources, in an effort to ensure that CS instruction is meaningful and useful for those schools. As noted, moving forward, most of the CSEMs’ efforts will be focused on the schools in the Cohort Model.

**Goal 3: High-Quality CS**

While reaching all students and fostering equity are important goals of the initiative, CS4All leaders also want to ensure that the CS experiences students receive are high quality. By 2025, CS4All aims to provide every student in the district with a “meaningful” CS education experience in each grade band. Strategies to ensure high-quality CS instruction include the development, rollout, and use of a *Blueprint for CS Education* as well as processes to recruit and develop strong CS PD providers.

**Strategies**

**Creating the Blueprint for CS Education.** One strategy designed to support quality implementation was the development of a digital resource for CS education, which became known as the “blueprint.” Working with a number of stakeholders, including teachers, industry representatives, and researchers, the CS4All staff created the Blueprint “to define computer science, and what is a robust experience of CS” for students in different grade bands. This Blueprint, shared in Beta form in the summer of 2017 and available online, has been used to anchor all PD since July 2017 and will be used to guide CS implementation in schools moving forward. As a complement to in-person professional development, the Blueprint is designed to provide user-friendly resources and support to teachers (with or without a CS background) who are interested in implementing rigorous CS education.

The current version of the Blueprint provides teachers with CS sample units across grade levels, concrete tools for incorporating CS into their instruction, and actionable responses to common questions or topics of interest (e.g., How might I evaluate
student progress?, culturally responsive CS). The Blueprint also describes three core components (and subcomponents) of a meaningful unit of CS education:

- **Perspectives** (explorer, creator, innovator, citizen): The different stages of CS learning describe how and why your students will tackle a computing task.

- **Practices** (analyzing, prototyping, and communicating): The interdependent methods and skills students will need to master in order to solve a problem, answer a question, or express themselves.

- **Concepts** (abstraction, algorithms, programming, data, and networks): The big ideas students will explore in the process, and better understand when they’re done.

Using these core components, the Blueprint defines a meaningful unit of computer science instruction as including the following set of student experiences and outcomes:

1. A creative application of computing connected to students’ interests,
2. An open-ended performance task,
3. Hands-on experience with one Practice,
4. At least three Concepts,
5. A Perspective aligned to students’ grade level,
6. At least one outcome from each Practice,
7. At least one outcome from three Concepts; and
8. At least one outcome from each level of Webb’s Depth of Knowledge.

While the Blueprint is already informing much of the work of both CS PD providers and educators teaching CS, the NYCDOE plans to continue to refine and develop it based on feedback from educators.

**Developing and making available high-quality CS training.** Achieving high-quality CS in schools depends in part on providing high-quality PD for teachers. Interviewees emphasized the importance of carefully selecting the partners that provide PD through a rigorous RFP process, which requires vendors to address the Blueprint and instructional approaches, such as project-based learning and culturally relevant instruction. After PD providers have been selected, the NYCDOE monitors the quality of their PD through the collection of teacher feedback on the training itself and the extent to which it enables them to implement CS in the classroom (see more in Chapter 4). The CS4All Partnerships Team (see below) collects data and uses CS standards (set by the Academics Team, also described below) to provide PD partners...
with feedback and develop their capacity to meet teachers’ needs. This team also hosts meet-ups for vendors to share “best practices” around teacher training.

Finally, the NYCDOE uses a number of communication strategies to help ensure that teachers become aware of opportunities to work with well vetted and highly developed PD providers. The CS4All team shares this information through a growing mailing list of teachers who have already participated in a CS4All PD session. In addition, CS4All uses various other DOE channels, such as a weekly newsletter to principals, and a newsletter sent by the CS4All team to teachers who are currently participating and have participated in CS4All PD to get the word out about CS training opportunities.

**Goal 4: Sustainability**

CS4All is intended not only to provide high-quality CS during the 10-year life of the initiative, but also to put systems in place to make CS a sustainable priority in NYC schools and, as one Founders Committee member described, “something that’s normal for schools to do.” Making CS education sustainable will require that CS4All program staff build both systemwide and within-school infrastructures that can withstand challenges, such as maintaining political will amid changes in City and NYCDOE leadership, securing funding throughout the life of the initiative, and adapting to the ongoing evolution of the CS education field.

**Strategies**

**District-wide tracking of CS courses.** Interviewees noted that for CS to become a standard part of instruction, the NYCDOE needs to have the mechanisms in place to convey to schools that CS education is an important component of a school’s curriculum and programming. One such mechanism is the inclusion of CS education in the NYCDOE’s STARS system, which schools use to report course characteristics and enrollment data (see Chapter 3 for more information). Starting in the 2015-16 school year, the NYCDOE introduced new functionality in STARS to allow school-based staff to indicate that particular courses included instruction in CS. In the 2016-2017 school year, they did so by checking one or more boxes in the following list: physical computing, maker activities, robotics, web design and development, block-based programming, game design, text-based programming, mobile app development, data and data science. (The CS4All team has since stripped away these options, since some staff weren’t familiar these concepts. Now, they are asked to name the CS course and describe the topics it covers.) The administrator or teacher
entering information in STARS is also asked to note the amount of time throughout the term that a course devoted to CS. Interviewees believe that the inclusion of this list alongside the other core subject areas sends a message to schools about the importance of CS education. Moreover, STARS data are available for the entire City, and can be aggregated at the student, teacher, or school level. Administrative data from STARS will thus allow the Department to understand which students, teachers, and schools are engaging in CS instruction.

**Dedicated CS staff.** Another strategy that CS4All leaders have used to make the initiative sustainable is to create about 20 CS education staff positions within the Department that are not dependent on outside, private funding. The staff are organized into the following teams:

1. **Implementation:** This team consists of Computer Science Education Managers who oversee field operations and school implementation.

2. **Partnerships:** This team works with external partners to support teacher training. Oversight includes selecting and managing PD providers as well as nurturing industry ties.

3. **Communications:** This team manages district-wide communications strategy for internal and external stakeholders. They work to inform teachers of PD opportunities, ensure consistent messaging for teachers within each PD program, and liaise with DOE communications and external relations team and fundraisers.

4. **Operations:** This team oversees internal operations, including the process of providing teachers’ “per session” (compensation) for training, and PD event management. (While Partnerships works with PD partners around curriculum and quality, Operations handles contracts, invoicing, and tracking.)

5. **Academics:** This team develops the CS standards and curriculum for professional development and classroom implementation.

6. **Research:** This team supports formative and summative research, evaluation, and strategic planning for computer science education. This team also leads the design, implementation and internal maintenance of data management systems to track and report on CS implementation citywide.
Discussion

The CS4All stakeholders we interviewed expressed clarity about the overarching goals of the initiative—including reach, equity, quality, and sustainability—and described a number of strategies they are using in pursuit of those goals. Our conversations also unearthed some challenges and trade-offs that have emerged in the first two years of the initiative. For example, to advance the goal of bringing CS instruction to all schools citywide, the initiative is offering a range of different program and training opportunities (rather than selecting one curriculum or pathway, which is more typical in smaller districts). Providing a range of PD options with different goals and methods of instruction may make it more difficult to communicate a coherent vision for CS education in the City (a challenge that might be mitigated by the cross-cutting nature of the Blueprint). CS4All is also prioritizing the training of teachers who are new to CS (rather than only or largely focusing on teachers with a CS background). This is meant to help expand CS opportunities to schools and classrooms not currently offering CS. But finding teachers who are willing to learn a new content area can be a challenge. Given that teachers face many other non-CS related requirements and responsibilities, it may be difficult, over the long term, to recruit enough of them to achieve CS4All’s goals (particularly after the initial set of motivated teachers have already participated).

In terms of equity, the initiative has increasingly targeted PD efforts toward schools that serve a higher proportion of underrepresented students. Further, the CSEM role is designed, in part, to provide more tailored support to meet the needs of these schools and their students. However, the schools that serve more underrepresented students often face myriad challenges. As we discuss in Chapters 3 & 4, the schools that serve the highest-need populations may find it difficult to prioritize CS in the face of other issues, including chronic absenteeism, limited resources, and very low achievement in the math and reading. For principals in these schools, CS4All may seem like a mandate that requires a lot of time and resources they simply do not have to spare. Reaching these school leaders will likely require effective communication about how CS can be compatible with their existing priorities (including how CS can advance their students’ short- and long-term goals).

CS4All has emphasized the importance of ensuring that CS instruction is not only far reaching but also of high quality. A key strategy for achieving this goal has been the creation, development, and ongoing refinement of the Blueprint—an online repository for teachers that outlines the elements of meaningful CS instruction and provides tools and resources for real classroom use. The initiative has also increasingly
focused on developing and tracking the quality of CS training provided by external partners, including a more demanding RFP process and a system for providing feedback to help partners improve the PD they are offering. One of the challenges to achieving high-quality CS education is that experts don’t necessarily agree about what CS education should entail. Some believe that CS education should focus on a theoretical understanding of high-level CS concepts. However, others define high-quality CS education more broadly as helping students develop computational thinking (CT) skills—such as problem solving, systems thinking, and analytical reasoning—which are core to computer science but are also applicable to other disciplines. Such broad definitions of CS and CT point to an additional challenge—namely, how to assess the outcomes of high-quality CS education, particularly given CS4All’s interest in reaching students in multiple grade levels. Increasing the numbers of high school students who take AP CS courses and perform well on those exams will serve as one measure of the initiative’s success. However, interviewees acknowledged that there are no simple ways to assess the development of broad CT abilities like problem-solving, especially in the elementary and middle school grades.

Finally, CS4All aspires to achieve sustainability beyond the 10-year lifespan of the initiative. In addition to creating the Blueprint (which is designed to serve as a resource for years to come), the NYCDOE has made changes to the STARS system, so schools can record information about CS courses and indicate when other courses include CS content. Initiative leaders see this as a critical signal to schools about the importance of offering CS. The STARS data will also allow the NYCDOE to track students’ exposure to CS over time. Another strategy the NYCDOE has used to promote sustainability is to create CS staff positions within the district office that are independent of initiative funding. Despite these strategies, one main challenge to ensuring the longevity of CS4All is the ever-shifting nature of the political environment. Changes in leadership could impact the prioritization of CS in NYC schools, as well as the resources and funding available for the initiative. An additional challenge is turnover among the faculty and leadership within schools. If the educators who are trained in CS and supportive of CS education leave their schools—or even more worryingly, the system—then the initiative could quickly lose momentum. This is particularly difficult to address, considering the current lack of clear pathways for educators who want to become licensed as CS teachers.

One interviewee explained:

*The idea is that, at the end of 10 years, new teachers come into the pipeline already trained. We’re not training them. If there aren’t education schools that*
have either computer science pathways or computer science classes, we’ll end up where we are now, which is the district having to train everyone.

As the initiative evolves, it will be important to grapple with both the inherent challenges of pursuing each of these goals and the ways in which these priorities may be at odds with one another. For example, how might expanding the reach of CS to all schools and teachers limit the initiative’s capacity to provide targeted support for the highest-need schools? And how might efforts to achieve both of these goals dilute the quality of CS instruction? These are questions we hope to keep examining as the initiative evolves.
CHAPTER 3: DISTRICT LANDSCAPE OF COMPUTER SCIENCE OFFERINGS AND PROFESSIONAL DEVELOPMENT

Documenting the state of CS education in NYC at this nascent stage of CS4All is important for understanding the development of the initiative over time. CS4All’s goal is for all students to receive at least one meaningful unit of CS instruction in each grade band—K-2, 3-5, 6-8, and 9-12—by 2025. This chapter explores schools’ participation in CS training opportunities and their offering of CS instruction across the City. It also examines the extent to which students from historically underrepresented groups have had access to CS.

Some of the CS professional development available in NYC predates, or is provided independent of, the CS4All initiative. Because we are interested in understanding the full landscape of CS opportunities across the City, we collected data from both “initiative schools” that participated in CS PD provided through CS4All and “non-initiative schools” that either participated in CS PD provided by organizations outside of CS4All or did not participate in any CS PD at all.

Drawing on a survey of NYC schools, as well as data on course characteristics and enrollment from the NYCDOE STARS system, this chapter addresses the following questions:

• How many NYC schools sent teachers to CS PD (offered by CS4All or other providers) in 2015-2016?

• How many NYC schools offered CS instruction the following year, in 2016-2017?

• How has the reach of CS4All evolved over time?

• What are the characteristics of schools offering CS instruction?

• What are the characteristics of NYC students who received CS instruction?

For each of these questions, we look at overall averages as well as variation based on grade bands (K-2, 3-5, 6-8 and 9-12), student and school characteristics (e.g., race/ethnicity, gender, economic need, academic performance), and initiative status (i.e., initiative schools and non-initiative schools). Examining these differences allows us to explore potential gaps in access to CS education.
Data Sources

Data in this chapter come from two key sources: 1) a landscape survey administered in the winter and spring of 2016-2017 (which focused on PD attended in the previous school year and CS instruction offered in the current year), and 2) CS course data from the NYCDOE STARS system for the 2016-2017 school year.

The Landscape Survey

The sample for the landscape survey was composed of 621 NYC public schools, including all 234 schools identified by CS4All as having attended initiative-provided professional development in 2015-2016 (“initiative schools”). The remaining 387 schools in our sample were randomly selected from each community school district (CSD) and grade configuration in the City (“non-initiative schools”).

In total, 344 of the 621 completed the survey, for an overall response rate of 55 percent. Of the 344 schools that responded, 156 were initiative schools (for a response rate of 65 percent), and 188 were non-initiative schools (for a response rate of 49 percent).

We weighted the responses from both groups to represent NYC schools overall (see the Appendix for more details), excluding charters, Districts 75 (which exclusively serves students with moderate to severe disabilities) and District 79 (which is composed of alternative schools and programs). The responding schools come from all other CSDs and all grade bands, and represent a variety of school sizes and admissions types.

The landscape data were gathered through a phone survey conducted by trained survey data collectors. Phone surveys have been shown to be more effective than online surveys when gathering information about complex topics, such as CS, where potential respondents may not share a common understanding of key phrases and concepts (Dillman, 2014). Our research team trained the data collectors in standard definitions of computer science, as well as how to probe respondents to ensure accurate and consistent collection of information about CS PD and offerings. Throughout the survey period, the research team met with data collectors to address questions arising through the survey phone calls and to calibrate their understanding of key metrics on an ongoing basis.

Landscape respondents were primarily principals and assistant principals, but in some cases, school leaders designated a teacher to respond, as the person most familiar with CS in the school. It is notable that this person was almost never the teacher who had attended PD or offered CS instruction. For this reason, some respondents were not
familiar with the details of the PD that the school had participated in (e.g., the provider, content, intensity, or duration of the PD), or the particulars of the CS content the school covered in its courses. We discuss how we address this limitation in our data below. Moreover, we have no information about the quality of PDs from this survey.

As with all self-reported data, the respondents may have been influenced by social desirability bias (i.e., answering in a way that may be deemed as more acceptable by others). It is possible, for example, that respondents felt pressure to report engagement with computer science, given that this was the topic of the survey. However, we attempted to phrase questions in ways that encouraged respondents to be candid, and when reaching out to sampled schools that had not yet responded to the survey, we made it clear that we wanted speak with them even if they did not offer CS. Some respondents were even explicit about not wanting to provide CS instruction or vocal about their critiques of the initiative, suggesting that social desirability likely did not play a large role in those interviews.

**STARS**

We obtained course characteristics and enrollment data from the NYCDOE STARS system, which was designed to support course scheduling (see also Chapter 2). STARS data are available for all district schools and can be aggregated at the student, teacher, and school levels. Starting in the 2015-2016 school year, new functionality was introduced in STARS to allow school-based staff to indicate that particular courses included instruction in CS. This captured stand-alone CS courses and courses in which the CS content was integrated into another subject area, such as math or science. CS tracking in STARS is relatively new, and there is likely some variability in how school personnel are inputting these data into STARS.

Overall, our analysis of STARS data yielded much lower citywide estimates of CS instruction than the landscape survey. This may be due in part to the possibility that schools contacted to participate in the landscape survey were less likely to respond if they did not offer CS, as discussed above. Further, our analysis of STARS data highlighted inaccuracies that could lead to undercounting CS instruction in some cases (e.g., we found some courses with titles clearly indicating CS, such as “Intro to Programming/JAVA 1,” that were not coded as CS), and over-counting CS instruction in others (e.g., schools that coded all of their courses as including CS instruction).

To explore the discrepancies between the two data sources, we compared them for schools that responded to the landscape survey. We found that for schools that
participated in CS4All PD (i.e., initiative schools), the two data sources tended to agree. For non-initiative schools, there was less agreement. We hypothesize that CS4All schools, as a result of their participation in the initiative, were better informed about how to indicate CS classes in STARS than non-initiative schools. Given the limitations in the STARS data, coupled with the nature of the landscape survey—one-on-one conversations in which the administrator could probe the information being provided—we rely largely on the landscape survey estimates to assess CS implementation in schools. We also highlight areas where STARS data yielded notably different results. STARS is the only data source we have with student-level information, so we turn to it when analyzing the characteristics of students taking CS.

It is important to note that both the landscape survey and STARS data were collected in the second year of CS4All. While this provides a useful picture of CS education in the early stages of the initiative, it is impossible to fully disentangle how much of the CS in NYC is due to CS4All and how much would have existed without the initiative. In this report, we begin to explore these differences by examining PD participation and CS course offerings for both initiative and non-initiative schools. Future reports will build on this information to investigate how the City’s CS landscape has changed over time, as CS4All evolves.

How Many NYC Schools Sent Teachers to CS PD in 2015-2016?

A key strategy for achieving CS for all students in NYC is ensuring that a critical mass of NYC teachers are trained in CS content and instructional methods, enabling more schools to offer it and more students to learn it. Nationally, the lack of teachers with the capacity to teach CS is widely cited as a barrier to offering CS instruction to more students (US DOE, 2014). New York State, along with most others, does not offer teaching licenses specific to CS, although the Board of Regents is exploring the possibility of adding one in the future. Further, most educators and administrators believe teachers need extensive training or coursework in CS to successfully teach the subject (Google and Gallup, 2015). Yet, on a national scale, the state of CS teacher preparation has been described as “deeply flawed” and inadequate to address the growing demand for such training (CSTA, 2013). Further, according to one study, most PD is provided by institutions of higher education with little or no involvement from schools or districts. The disconnect between PD opportunities and local context limits the extent to which opportunities are aligned with and relevant to the needs of the district and its schools (Century, et. al., 2013).
To address the gap in skill and capacity to teach CS and meet the specific needs of NYC schools, the CS4All initiative offered a diverse selection of PD experiences designed to prepare them to lead multi-year CS sequences, year-long CS courses, and meaningful CS units integrated into other courses. As described above, the NYCDOE targeted teachers who had not previously received CS PD and schools that did not already have CS teachers or courses. Some schools sought out other CS training for their teachers, beyond that offered by CS4All. Below, we draw on data collected through our landscape survey to estimate the extent to which teachers in NYC schools received CS PD in the 2015-2016 school year.

According to the landscape survey, an estimated 43 percent of responding schools could identify a specific CS PD that their teachers had attended during the 2015-16 school year (see Figure 1 on the next page). An additional 10 percent reported they sent their teachers to CS PD, but could not identify the provider. This included PD that was sponsored by CS4All and PD that schools sought out on their own, outside of the initiative (see the textbox on page 26 below for a list of providers). Not surprisingly, the percentage of schools that reported sending their teachers to an identified CS PD was higher among CS4All initiative schools (69 percent) than among non-initiative schools (37 percent), as shown in Figure 2 on the next page. In both groups, when we include schools that reported sending teachers to CS PD but could not identify the provider, the figures are about 10 percent higher. It is notable that only 69 percent of the schools DOE identified as having sent teachers to training reported doing so in our survey. It is possible that in some cases the landscape survey respondent was not aware of teachers from their school who had attended CS4All PD; another possibility is that teachers may have been trained while teaching at one school in 2015-2016 and then moved to another school in 2016-2017 (when the survey was conducted).

It should be noted that the landscape survey was designed to gather information on a wide range of PD types, with varying intensity and duration. While CS4All offers some one-day workshops, initiative leaders believe these are unlikely to arm teachers with all the skills and knowledge needed to effectively teach CS, so they see these as an introduction to motivate further engagement with CS in the future. A fourth of schools reported receiving CS PD that spanned two or more days, including 51 percent of initiative schools and 20 percent of non-initiative schools. About 14 percent of schools reported receiving a one-day CS PD, including 15 percent of initiative schools and 14 percent of non-initiative schools. Finally, about 3 percent of all schools reported participating in PD that was aimed at preparing teachers for brief
periods of instruction, known as “Hour of Code.” We include these and other “light touch” PD experiences in our reporting, even though an Hour of Code does not satisfy CS4All’s goal of a meaningful unit of CS instruction, because we hypothesize that for both teachers and students, they could serve as a low-stakes introduction to CS that could build motivation for more intensive learning in the future.

Most schools sent just one or two teachers to CS PD. The most common response for number of teachers attending was one or two (45 percent of schools) (Figure 3 on the next page). However, a significant minority of schools (7 percent) sent seven or more teachers for PD. Some of this variation was by design. For example, schools were required to send teams of teachers to SEP and SEP Jr. training. Other PD opportunities did not have such requirements and were often attended by a single teacher from a school.
The proportion of schools sending teachers for identified CS PD was generally similar across grade bands. As shown in Figure 4 above, the percentage of schools participating in an identified CS PD was almost identical among schools serving grades 3-5 (40 percent), middle grades (42 percent) and high schools (40 percent).\textsuperscript{11}\ Elementary schools sent K-2 teachers somewhat less frequently to CS PD (32 percent) than 3-5 teachers (40 percent).

Because landscape survey respondents were often administrators and did not always know the details of what PDs teachers attended, we turned to the NYCDOE’s PD attendance records to examine the types of CS4All-offered PD teachers at initiative schools attended. During the 2015-2016 school year, the most commonly attended type of CS4All initiative PD was the STEM Institute, with 238 teachers from 167 schools attending. This amounts to 11 percent of all NYCDOE schools. The STEM Institute included 15 different CS PD offerings designed to help teachers offer CS units in their classrooms.
In addition, 179 teachers participated in PD that leads to the implementation of multi-year CS sequences (i.e., SEP and SEP Jr.). Another 144 participated in PD that leads to implementation of CS courses, such as AP CS. (See Table 2 below.)

According to the landscape survey, a wide variety of organizations provided CS PD outside of CS4All to both initiative and non-initiative schools. The most common providers were Code.org (mentioned by 20 respondents) and Google (15 respondents); all other providers were mentioned by five or fewer respondents. The textbox on the next page provides a complete list.

### Table 2: Number of Teachers and Schools Attending CS4All PD, by Type, 2015-2016

<table>
<thead>
<tr>
<th></th>
<th>Number of Teachers</th>
<th>Number of Schools</th>
<th>Percent of Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Units</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEM Institute</td>
<td>238</td>
<td>167</td>
<td>57.2</td>
</tr>
<tr>
<td><strong>Courses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Code Interactive – AP Computer Science Principles</td>
<td>26</td>
<td>23</td>
<td>7.9</td>
</tr>
<tr>
<td>Code Interactive – Exploring Computer Science</td>
<td>26</td>
<td>24</td>
<td>8.2</td>
</tr>
<tr>
<td>Beauty and Joy of Computing (AP CSP)</td>
<td>60</td>
<td>57</td>
<td>19.5</td>
</tr>
<tr>
<td>Technology Education and Literacy in Schools (TEALS)</td>
<td>32</td>
<td>25</td>
<td>8.6</td>
</tr>
<tr>
<td><strong>Sequences</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Software Engineering Program Junior (SEP Jr.)</td>
<td>73</td>
<td>13</td>
<td>4.5</td>
</tr>
<tr>
<td>Software Engineering Program (SEP)</td>
<td>106</td>
<td>41</td>
<td>14.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>523</td>
<td>292</td>
<td>100</td>
</tr>
</tbody>
</table>

**Source:** Research Alliance calculations based on data obtained from the NYC Department of Education.

**Note:** Percent of schools is based on 1,558 DOE schools serving districts 1-32. Teachers may have attended more than one training, therefore the number includes duplicates.
How Many NYC Schools Offer CS?

Trained and qualified CS teachers are only one avenue toward CS4All. To meet the 4All goal, NYC schools must ensure that they have the necessary technology, have programmed CS offerings into their school schedule, and recruit students to take advantage of these offerings. To establish an early measure of the initiative’s progress toward achieving its goal of reaching all students at each grade band, we looked at the percentage of schools across NYC that offered CS instruction during the 2016-2017 school year.

We pay particular attention to how rates of offering CS differ between the schools participating in the CS4All initiative—i.e., those that the DOE reported as attending CS4All PD in 2015-2016—and non-initiative schools. Further, we examine different
methods of offering CS (i.e., stand-alone courses or CS integrated with other subject areas), and the kinds of CS content covered.

An estimated 55 percent of responding schools reported offering students some kind of specific CS instruction during the 2016-2017 school year, according to the landscape survey. An additional estimated 9 percent of schools reported that they offered CS instruction, but the survey respondent was not able to report in detail the content of that instruction (see Figure 5 on the next page). (See the textbox, “What Counts as Computer Science?” page 29 for more details about the definition of CS instruction that we used; see Figures 9 and 10 on page 30 to learn more about the specific content of CS instruction reported in the landscape survey).

This is very different from the 25 percent of schools citywide that, according to STARS data, offered CS instructions during the 2016-2017 school year. As discussed above, both STARS and the landscape have strengths and limitations as data sources. We believe it is likely that STARS data under-reports CS instruction because many schools may not have been aware of the relatively new process for indicating CS instruction in STARS. At the same time, it is possible that our landscape survey results overestimate the prevalence of CS instruction. This could be the case if schools that were offering CS were more likely to respond to the survey than those that were not (although we tried to mitigate this risk in our recruitment efforts). It is also the case that the survey was more inclusive of different kinds of CS instruction, including “light touch” CS experiences, than the STARS data. The Research Alliance and the NYCDOE are both working to learn more about the discrepancies between the two data sources, and to ensure that the survey and the STARS system both capture valid, reliable information about CS instruction in future years of the initiative.

It is also notable that at present neither the landscape nor STARS data provide enough information to determine whether or not the CS instruction documented is in fact offering students a meaningful unit of CS—CS4All’s goal. We do not have information on the duration, content, or rigor of the instruction. In the future, we will work together with CS4All to find develop ways of measuring progress toward this important goal.

As shown on Figure 6 on the next page, the percentage of schools offering identified CS instruction according to the landscape survey was higher among CS4All initiative schools (79 percent) than among non-initiative schools (50 percent) with an additional 7 and 10 percent respectively offering non-identified CS instruction. According to STARS data, 72 percent of CS4All initiative schools offered CS instruction in 2016-2017, which is fairly close to the 79 percent reported in the survey.
In contrast, STARS data show that only 15 percent of non-initiative schools offered CS instruction—substantially less than the 49 percent we found in the survey. It is possible that schools participating in CS4All PD were more aware of the importance of tracking CS instruction in STARS. Still, the large difference between the two data sources for non-initiative schools raises important questions about how schools are defining “CS.”

Across the City, we found some variation in schools that offer CS based on grades served. Consistent with our findings about CS PD, a similar percentage of schools offered identified CS instruction in upper elementary (53 percent), middle (60 percent) and high school grades (52 percent) (Figure 7 on page 29). Within elementary schools, administrators programmed students in grades K-2 for CS less frequently (33 percent) than students in grades 3-5. STARS data show the highest level of CS instructional offerings in high schools (35 percent), then middle schools (24 percent), then elementary schools (20 percent, K-5).
What Counts as “Computer Science”?

In this and other studies (see for example, Wilson et. al., 2010), confusion over what counts as CS is a common theme. One way the landscape survey data collectors tried to ensure they were gathering reliable information about CS instruction was to ask about the specific subject of stand-alone courses and the specific CS skills taught in integrated courses. With this information, we assessed whether courses that the survey respondents reported as CS courses met the research team’s criteria. Consider two examples: In one, the stand-alone course subject “technology” includes a wide variety of topics, some of which may not fit within CS. In another example, a respondent told the survey administrator, “I'm not sure what they're doing, but I know it's computer science.” In both situations, we did not count these as schools providing “specific CS instruction.” However, we did include them in the additional 9 percent of schools that reported offering CS, but couldn’t provide details about course content.

For a school to be counted as offering “specific” CS instruction, the landscape respondent had to report that the course addressed one or more of the CS topics discussed below (see Figures 9 and 10). NYC CS4All’s Blueprint and the broader CS literature both confirm that these topics fall within the definition of CS. Still, it is possible that some of the skills and subjects that we accepted as CS may not reflect the most conservative definition.
The landscape survey asked school representatives about two types of CS instruction: stand-alone courses, such as AP CS and SEP, and courses where CS content was integrated into another subject area, such as integrating computer programming into an algebra course. In CS4All initiative schools, stand-alone courses were more common than integrated courses (an estimated 69 percent offer stand-alone courses, versus 38 percent offering integrated courses), although some schools offer both types of instruction (Figure 8 on page 29). This may reflect a greater number of PD opportunities for stand-alone courses and sequences such as SEP and SEP Jr., as well as challenges associated with integrating CS into other subject areas. In contrast, non-initiative schools were more likely to report integrating CS content (34 percent) than offering stand-alone courses (27 percent).

The CS topics and skills covered in stand-alone and integrated courses varied substantially across schools. For stand-alone courses, the most commonly cited topics were programming (43 percent), introduction to CS (26 percent), and Scratch (19 percent) (see Figure 9 below).

**Figure 9: Among Schools Offering Stand-Alone Courses, Course Subjects/Topics, 2016-2017 School Year**

- Programming: 43.1%
- Introduction to CS: 25.9%
- Scratch: 18.9%
- Robotics: 14.8%
- AP CS Principles: 8.7%
- AP CS A (Java): 6.2%

**Figure 10: Among Schools Offering Integrated Courses, CS Skills Taught, 2016-2017 School Year**

- Text Based Programming: 35.7%
- Block Based Programming: 29.2%
- Hour of Code: 27.4%
- Physical Computing: 26.2%
- Robotics: 22.7%

**Source:** Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2016-17 Landscape Survey.

**Note:** "n" indicates the number of schools in the survey sample and "N" indicates the number of schools the sample schools are representing.
For the integrated courses, schools reported focusing on a variety of CS skills, including text-based programming (36 percent; this includes programming languages, such as Java, that use letters, numbers and symbols to create commands), web design and app development (29 percent) and block-based programming (27 percent; this includes programming languages such as Scratch that use “drag and drop” blocks representing commands) (see Figure 10 on page 30). The STARS system uses a similar categorization of course content, called CS properties, and analysis of these data show the same three most frequent skills as the landscape data: text-based programming, web design and app development, and block-based programming. The subject area of the courses into which CS content is being integrated also varied widely. While the STEM fields of math and science figured prominently, CS was also integrated into English Language Arts, social studies, and arts instruction, suggesting some innovative practices (see Figure 11 below; note that respondents could give multiple responses if applicable).

Figure 11: Among Schools Offering Integrated Courses, Subjects into Which CS Was Integrated, 2016-2017 School Year

Source: Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2016-17 Landscape Survey.

Note: "n" indicates the number of schools in the survey sample and "N" indicates the number of schools the sample schools are representing.
How is the Reach of CS4All Evolving?

To explore how the reach of CS4All is evolving to focus on expanding access to CS instruction for underrepresented populations, we compared the demographic and performance profiles of schools that began participating in CS4All PDs in 2015-2016, those that joined in 2016-2017, those that were recruited to join one of CS4All’s PDs (the CS Cohort PD) during the 2017-2018 school year, and schools that have not yet had any involvement in the CS4All initiative.

As Figure 12 below shows, schools participating in the first two years of the initiative (2015-2016 and 2016-2017) served fewer proportions of students historically underrepresented in CS (i.e., Black and Latino students, students with higher levels of economic needs, and students with relatively weak prior academic performance), compared with schools not yet involved in the initiative. It is worth noting that the Software Engineering Program (SEP) began before the CS4All initiative was launched, and schools in that program were inherited by the initiative. Recruitment for the initial SEP cohort focused primarily on school motivation and readiness, rather than the proportion of underrepresented students.

Figure 12: Comparison of Demographics and Academic Performance of Successive Waves of Schools Participating in CS4All

Source: Research Alliance calculations based on administrative data obtained from NYCDOE.
Note: * indicates a statistically significant difference between all other NYC schools and the starred category at the p<0.05 level. Schools that participated in CS4All over multiple years are grouped with their initial year of participation. Because the 2017-18 Cohort Recruit Schools are primarily elementary and middle schools, we do not display an average graduation rate. The Economic Need Index is a measure of the socioeconomic status of the school population, based on the percent of students in temporary housing, eligible for HRA, and eligible for free lunch.
Student demographics were taken into account for SEP Jr. and courses where there were more applicants than seats. The STEM Institute was initially first-come, first-served, but this changed with the schools recruited to join the Cohort Model program during the 2017-2018 school year (see Chapter 5 for more information). As shown in Figure 12, the schools recruited for this program serve more underrepresented and low-performing populations than non-initiative schools. While this analysis does not include all schools that will be recruited to participate in CS4All this year, it is an indication of the initiative’s intensive outreach to a group of high-need schools and is a promising step in pursuit of CS4All’s equity goals.

What Are the Characteristics of NYC Schools Offering CS Instruction?

From the beginning, promoting equity in access to CS instruction has been one of CS4All’s key goals. Research shows that female, Black, and Latino students generally face greater barriers to CS participation. Specifically, Black and Latino students are less likely than White students to have access to CS learning opportunities in school or access to computers at home (Margolis, Estrella, Goode, Holme, and Nao, 2010). Female students are less likely than male students to report interest in and awareness of CS opportunities, and are less likely to report having ever learned CS (Wang, Hong, Ravitz, & Hejazi Moghadam, 2016). Furthermore, low-performing schools whose students have high levels of economic need are less likely to offer CS instruction (Margolis et al, 2010). Given this national and local context, a careful assessment of equity is important to understanding CS4All’s progress.

In this report, we look at equity from a number of vantage points. First, we use the landscape survey and STARS data to look at the population of students served in schools that reported offering CS in 2016-2017, compared with those that did not. In the next section, we examine the CS enrollment of individual students within schools.

NYC schools that reported offering CS instruction on the landscape survey served fewer students from underrepresented groups and fewer high-needs students than schools not offering CS. As shown in Figure 13 below, on average, schools offering CS served a lower percentage of Black and Latino students (a 15 percentage point estimated difference) and had a lower economic need index (a 5 percentage point difference). Elementary and middle schools offering CS had a higher percentage of students scoring proficient on state tests in math and English Language Arts (an 8 and 4 percentage point difference, respectively). High schools offering CS had a higher percentage of their students graduate high school on
Differences associated with race, state test score proficiency and on-time graduation were all statistically significant. We found a similar pattern of CS-offering schools serving more advantaged populations when we analyzed STARS data, and these differences were statistically significant as well.

### What Are the Characteristics of NYC Students Receiving CS Instruction?

Equity in access to CS is best assessed on two fronts: First, by comparing the demographics across schools that do and do not offer CS instruction (as we did in the previous section); and, second, by examining participation within schools that offer CS, comparing the demographics of students who do and do not take CS courses. For this within-school analysis, we used student-level STARS data\(^{15}\) to assess students’ course-taking patterns in 2016-2017. Below we describe the percentage of students in each school, on average, who are enrolled in CS (in either a stand-alone or integrated CS course), as well as the characteristics of those students. Because CS can be seen as a

![Figure 13: Comparison of Demographics and Academic Performance of Schools Offering and Not Offering CS Courses, 2016-2017 School Year](image)

**Source:** Research Alliance calculations based on administrative data obtained from NYCDOE.

**Note:** * indicates a statistically significant difference between all other NYC schools and the starred category at the \(p<0.05\) level. Schools that participated in CS4All over multiple years are grouped with their initial year of participation. Because the 2017-18 Cohort Recruit Schools are primarily elementary and middle schools, we do not display an average graduation rate. The Economic Need Index is a measure of the socioeconomic status of the school population, based on the percent of students in temporary housing, eligible for HRA, and eligible for free lunch.

<table>
<thead>
<tr>
<th></th>
<th>All Schools</th>
<th>Elementary/Middle Schools</th>
<th>High Schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Black and Latino</td>
<td>70.9</td>
<td>12.5</td>
<td>78.8</td>
</tr>
<tr>
<td>% English Language Learner</td>
<td>56.2</td>
<td>15.5</td>
<td>40.5</td>
</tr>
<tr>
<td>% Special Education</td>
<td>64.2</td>
<td>14.0</td>
<td>31.1</td>
</tr>
<tr>
<td>Economic Need Index</td>
<td>58.8</td>
<td>11.8</td>
<td>39.3</td>
</tr>
<tr>
<td>% Proficient in Gr3-8 Math</td>
<td>36.1</td>
<td>36.1</td>
<td>40.5</td>
</tr>
<tr>
<td>% Proficient in Gr3-8 ELA</td>
<td>38.5</td>
<td>39.3</td>
<td>40.5</td>
</tr>
<tr>
<td>Graduation Rate</td>
<td>63.6</td>
<td>63.6</td>
<td>63.6</td>
</tr>
</tbody>
</table>
challenging topic, some schools might only enroll the most academically accomplished students for CS classes, or might be influenced by racial or gender stereotypes about which groups of students are interested in and would benefit from CS instruction. The information in this section begins to shed light on the extent to which schools are providing their students with equitable access to CS.

According to the STARS data, schools that offered CS in 2016-2017 enrolled 28 percent of their students in such courses, on average. As discussed above, CS4All’s goal is for students to have at least one meaningful unit of CS in each three- or four-year grade band. While it is difficult to assess this goal with only one year of programming data, the goal makes clear that we should expect approximately one fourth of high school students and one third of elementary and middle schools to receive CS instruction each year. We found that the percentage of students enrolled in CS varied widely depending on the grades the school served. Though a smaller proportion of elementary schools offered CS instruction than middle and high schools, those that did tended to enroll a larger proportion of their students in CS. The median\textsuperscript{16} CS enrollment was 39 percent for students in grades K-2 and 63 percent for students in grades 3-5 among the 165 elementary schools that offered CS. The median CS enrollment was just 21 percent among the 87 middle schools, and 11 percent among the 142 high schools (see Figure 14).

**Figure 14: Median Percent of Students Enrolled in CS Courses per School by Student Grade Band, 2016-2017 School Year**

![Image of bar chart showing median percent of students enrolled in CS courses per school by grade band]

**Source:** Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2016-2017 Landscape Survey.

**Note:** Gr 9-12 N = 142; Gr 6-8 N = 87; Gr 3-5 N = 165; Gr K-2 N = 165.
Key groups of students are underrepresented in CS courses. Using the STARS data, we looked at the background characteristics of students who took CS courses and found demographic patterns similar to (but somewhat less pronounced than) those found nationally. Within schools that offer CS, students who take CS are less likely than students who don't take CS to be:

- Female;
- Black or Latino;
- Students with disabilities;
- English language learners;
- Eligible for free lunch; and
- Students with low prior performance lower performance on state math and ELA tests.

Table 3 on the next page shows the percentages of students with various characteristics (by grade, gender, race, etc.) who were enrolled in CS courses. It also highlights where students within a category were disproportionately likely to take CS. For example, the table shows that 39 percent of grade K-2 students in these schools are taking CS, compared with 63 percent of grade 3-5 students. This means older elementary students disproportionately take CS. We would expect the percent to be the same if students of both grade bands were enrolled to an equal degree.

All of the differences we found are statistically significant, except the differences between students who are and are not eligible for free- or reduced-price lunch. The magnitude of the differences varies, however, and it is generally small. The smallest differences were for students receiving special education services, ELL services, and free lunch. The largest differences were between students with lower and higher prior academic performance. Differences in the prior performance of students who took CS versus those who did not were smaller for elementary and middle schools than high schools, likely because high schools often offer CS as an elite course (see the Appendix for full details).
Table 3: Percent of Students Taking CS within Schools, by Key Student Characteristics, 2016-17 School Year

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade Band</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K-2</td>
<td>38.8</td>
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<tr>
<td>3-5</td>
<td>63.4</td>
<td>55,711</td>
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<td>6-8</td>
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<td>9-12</td>
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<td><strong>Gender</strong></td>
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<td>Female</td>
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<td>Male</td>
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<td><strong>Race/Ethnicity</strong></td>
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<tr>
<td>Black</td>
<td>25.4</td>
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<tr>
<td>Latino</td>
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<tr>
<td>Asian</td>
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<td>79,019</td>
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<tr>
<td>White (reference)</td>
<td>31.9</td>
<td>62,494</td>
</tr>
<tr>
<td><strong>Disability Status</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Students with Disabilities | 27.6 | 55,669 | *
| Students without Disabilities | 28.4 | 282,554|
| **English Language Learner Status** |       |        |
| English Language Learners | 27.8 | 41,253 | *
| Non-English Language Learners | 28.3 | 296,970|
| **Free/Reduced Priced Lunch Eligibility Status** |       |        |
| Free/Reduced Price Lunch | 27.2 | 296,970|
| Not Eligible         | 29.6  | 188,806|
| **Prior ELA Performance** |       |        |
| Level 1              | 22.5  | 55,480 |
| Level 2              | 23.21 | 83,025 |
| Level 3              | 26.75 | 60,139 |
| Level 4              | 28.27 | 30,353 |
| **Prior Math Performance** |       |        |
| Level 1              | 21.55 | 62,898 |
| Level 2              | 22.64 | 75,782 |
| Level 3              | 25.82 | 49,960 |
| Level 4              | 31.18 | 43,813 |

**Source:** Research Alliance calculations based on data obtained from the NYC Department of Education.

**Note:** * indicates the percent of students taking CS is statistically significantly different from the percent of students in the category below (p < .05) for all comparisons, except for race/ethnicity comparisons. For race/ethnicity comparisons, the reference category is White.
Based on the national landscape of CS instruction conducted by Wang, Hong, Ravitz, and Hejazi Moghadam (2016), the differences found in NYC are smaller than we might have expected. For example, Wang et al. found a 7 percentage point difference between girls and boys who reported ever learning any CS nationally, compared with a 3 percentage point difference between NYC girls and boys taking a CS course in 2016-2017. Similarly, at the national level, the difference in ever learning any CS between Latino and White students was 11 percentage points, whereas in NYC the difference in CS course-taking for 2016-2017 was 6 percentage points.¹⁷

Summary

At this early stage of the initiative, our survey findings suggest that some kind of CS instruction is available in a wide swath (over half) of NYC schools, through stand-alone courses and CS integrated into other subjects. Though CS instruction was more prevalent in the CS4All initiative schools, the sizable percentage of non-initiative schools sending teachers to CS PD and offering coursework suggests a real desire to implement CS across the district.

When we explored differences by grade band, we saw schools sending more teachers of grades 3-12 to CS PD than teachers of grades K-2. Similarly, schools offered CS instruction more frequently to students in grades 3-12 than students in grades K-2. However, elementary schools with CS offerings, on average, provided CS to larger proportions of their students. The differences found in average enrollment by grade band may stem from a number of factors: It could reflect the larger size of upper-grade schools (requiring more CS courses to be offered to serve a larger population). Further, this pattern could stem from the fact that upper-grade schools often track students into different courses according to their interests and academic performance. Partly as a consequence, gaps in CS enrollment by student demographic characteristics and prior performance are larger in middle and high schools than in elementary schools.

Looking at demographics and achievement levels across schools, our findings suggest that PD offered in the 2015-2016 and 2016-2017 school years the initiative has not yet expanded CS instruction to many schools serving the most disadvantaged populations, an important goal of CS4All. Schools offering CS tend to serve proportionately fewer historically underrepresented and more advantaged students than other NYC schools. There are a number of potential reasons for this. For some CS4All programs, simply meeting application requirements (such as the number of teachers and administrators volunteering to take part in the program) required strong
organizational capacity, which is often found in better-resourced schools, serving more advantaged communities. Further, low-performing schools under pressure to raise test scores and/or graduation rates may not be in a position to prioritize CS. The intensive outreach by CS4All in 2017-2018 to a group of higher-need schools is a promising indication that future efforts will target more disadvantaged populations.

Looking within schools, our analyses show that the demographic patterns CS4All aims to combat exist in NYC. In 2016-2017, proportionately fewer students from historically underrepresented groups were enrolled in courses that include CS instruction. However, it is important to note that this was only the second year of the initiative. Further, it is encouraging that, compared to some estimates of the national landscape of CS instruction, the disparities found in NYC are comparatively small. It is also encouraging that, in keeping with CS4All’s goal of reaching all grade bands, a considerable proportion of NYC’s elementary schools participated in PD and offered CS instruction. This stands in contrast to many efforts around the country that focus on CS at the high school level. As the initiative progresses, it will be important to continue to assess the extent to which CS access is equitable both across and within schools.
CHAPTER 4: CS4ALL PD AND TEACHERS’ IMPLEMENTATION OF COMPUTER SCIENCE

In addition to surveying the broad landscape of CS education across NYC, we also gathered more detailed information from teachers who participated in CS4All PD, asking about their experience with the PD, as well as subsequent implementation of CS in their school. This chapter relies on our analysis of data from 225 teachers (representing 159 schools) who attended one of five key CS4All PD programs in 2015-16 and responded to our survey. The five programs we focused on represent the primary DOE-sponsored PD opportunities offered in 2015-16: the Software Engineering Program (SEP), SEP Jr., STEM Institute, Code Interactive: AP CS Principles, and Code Interactive: Exploring Computer Science (ECS) (see descriptions of these programs in Chapter 1). The chapter addresses the following questions:

- How did teachers rate the quality and utility of CS PD programs?
- How confident were teachers in their ability to implement CS?
- To what extent did teachers convey a “growth mindset” about CS learning?
- To what extent have teachers who received CS4All PD subsequently implemented it in the classroom?
- What factors do teachers see as supporting or hindering implementation of CS?
- How do supports and challenges differ for schools with high economic need and low academic performance?

Data Sources

This chapter draws on the 2017 survey of teachers who participated in CS4All PD. We also use the landscape survey and interviews of CSEMs to provide a more nuanced understanding of the findings. The teacher survey was administered online between April and July of 2017, 12 to 15 months after the STEM Institute, SEP Jr., and Code Interactive PDs were completed. SEP engages teachers in multiple years of PD, so these teachers were still participating in the PD when they responded to the survey. The survey was sent to the 446 teachers (from 241 schools) who had attended one of the five CS4All PD programs during the 2015-16 school year. A total of 225 teachers
from 159 schools responded, for a 50 percent response rate. Through a mix of open- and closed-ended questions, the survey addressed issues related to the quality of PD teachers had received and teachers’ attitudes and beliefs regarding CS instruction. The survey also asked teachers about supports and barriers to implementing CS in schools and in the classroom. Our analysis consisted of qualitative analysis of open-ended answers focused on identifying common themes and descriptive analyses of teachers’ response to close-ended questions of interest. To analyze differences in responses across teacher groups, we ran regressions controlling for teacher characteristics (gender, experience, CS expertise), school level, and PD program attended. Responses of STEM institute teachers are not included in comparisons by PD type because the other PDs were much longer in duration and intensity, and therefore not similar enough to make comparisons meaningful. (See the Appendix for more information on methodology and data collection.)

**How Did Teachers Rate the CS4All PD?**

The CS4All PD offerings are aimed at helping teachers learn new programs and pedagogies in CS education, as well as methods for integrating CS into existing courses. Teachers are then responsible for putting this training to use—helping students learn CS concepts, practices, and perspectives, and helping students connect their CS learning across subject areas and grade bands, as well as to their personal interests in and out of school. For that learning and connection-making to occur, teachers must be adequately prepared and supported to integrate CS knowledge with their existing areas of content expertise, and to help students build CS experiences into academic and career pathways over time. Ensuring the quality and depth of the PD that teachers experience will be crucial to the success of the CS4All initiative.

Our survey was designed to gather information about teachers’ perspectives on the quality and utility of the PD they received. Nearly half of teachers (47%) surveyed reported that they did not have a CS related degree or certification or prior experience in the CS profession, confirming that many teachers participating in CS4All PD have limited CS knowledge. Given this, and because the initiative’s PD offerings often require a substantive time commitment that can span multiple weeks, months, and even years, it is critical that teacher engagement and commitment are high. If teachers’ experiences are positive, they will be more likely to be engaged in the PD and committed to implementing what they learned when they return to the classroom.
Overall, teachers rated the CS4All PD highly, with a majority reporting that it increased their CS knowledge and skills, and that what they learned would be useful in the classroom. In our survey, 93 percent of respondents agreed or strongly agreed that the PD increased their computer science skills. Similarly, 95 percent agreed or strongly agreed that they could use what they learned at the training to positively impact the achievement of their students. Most teachers also responded favorably to questions about the quality of the PD, reporting that the goals of the PD were clearly stated, the activities were well organized and facilitated learning, and the facilitators were knowledgeable and well prepared. Agreement with statements about the PD quality were high regardless of the type of PD teachers attended or teacher characteristics (such as age, gender, grade level taught, and prior experience), with no statistically significant or substantive differences remaining once we controlled for teacher and school characteristics.

How Confident Are Teachers in Their Ability to Teach CS?

Because CS is a new content area for many teachers, we sought to assess their level of confidence in teaching CS, following their participation in the CS4All PD. Beyond learning essential content knowledge and relevant pedagogical approaches, the CS4All PD offerings aim to increase teachers’ confidence in their ability to reach and engage their students in powerful and exciting CS concepts and practices. Teachers who are confident in their capacity to teach computer science are better positioned to implement what they have learned in PD—and to help their students see computer science as an interesting and exciting field (Caprara et. al., 2006; Ross, Hogaboam-Gray, & Hannay, 2001). Furthermore, to meet CS4All’s goals, teachers must feel confident in their abilities to teach CS well to a wide range of students, especially students who have historically had limited access to CS (e.g., girls, Black and Latino students, students with disabilities, and others).

The majority of teachers reported feeling somewhat confident in their abilities to teach computer science. Our measure of confidence included 18 items, with statements like, “I know how to teach important computer science concepts effectively,” and “I know how to facilitate students’ interest in computer science.” Teachers were asked to report their agreement with each statement on a five-point scale, ranging from “strongly disagree” to “strongly agree.” Overall, the average teacher scored a 3.89 (based on a 5-point scale) on our confidence measure, very close to “agree” on our scale. For 13 of the 18 measure’s statements indicating confidence, between 70 percent and 95 percent of teachers
indicated that they agreed or strongly agreed. Examples include: confidence in knowing how to facilitate students’ interest in CS, discussing with students how CS connects to daily life, and making CS relevant to students from diverse backgrounds. Statements where less than 70-percent of teachers agreed or strongly agreed had to do with confidence in knowing CS concepts and teaching them effectively, assessing computing projects, and tailoring content to meet the needs of students receiving special education.

Looking across grade bands, we found that elementary teachers reported greater confidence in their ability to teach computer science than middle and high school teachers. On average, elementary teachers scored 4.02, while middle and high school teachers scored 3.80 and 3.83, respectively. Controlling for other differences between the groups, these differences were statistically significant. Otherwise, agreement with statements about confidence were high regardless of teacher and school characteristics and the type of PD teachers attended.

Do Teachers Have a “Growth Mindset” about CS Learning?

Prevalent stereotypes about who engages in computer science have the potential to limit participation. For example, a 2015 Google and Gallup study found that students, parents, and teachers often believe that boys are more interested in learning computer science than girls, and furthermore, that boys are more likely to be successful in their learning of CS. The CS4All initiative, and the CS4All teacher PD, strive to counter these prevailing stereotypes by providing teachers with resources designed to engage a broad range of students, confronting the perception that CS is out of reach for many students, and educating teachers about culturally relevant instructional strategies. We hypothesize that teachers’ growth mindset is an important mediating factor in facilitating student learning in CS. Teachers who believe that all students can learn CS and that CS is not an innate skill, but rather something that can be developed and improved with effort, are more likely to be able to motivate students and counter stereotypes about who does CS. We assessed teachers’ growth mindset by asking them the extent to which they agreed with four statements about learning CS (see Figure 15 on the next page).

Most teachers reported a strong growth mindset about students’ CS learning. A majority of teachers (86 to 96 percent) either disagreed or strongly disagreed with statements such as, “Only students who are naturally smart in computer science will truly excel in it” and “Challenging students in computer science
won’t make them smarter.” Disagreements with these statements suggests teachers do not believe CS skills and aptitude are fixed and therefore may be more likely to implement strategies that foster a growth mindset, such as praising effort and teaching students to learn from mistakes.

After controlling for teacher and school characteristics, there were no differences in growth mindset by PD program or grade band.

**Are Teachers Who Received CS PD Implementing It in the Classroom?**

Most of the teachers surveyed (80%) reported teaching CS in the 2016-2017 school year, either as a stand-alone course or integrated into other subject areas. Among the 20 percent teachers who were not implementing CS, we heard several prominent themes in their responses to an open-ended question (n=26) about why they were not doing so. These included a lack of ability to teach or integrate CS, competing academic priorities, lack of support to implement CS, and that they were not the designated CS teacher in the school (each response was mentioned by between five and seven teachers).

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**Figure 15: Growth Mindset Responses, 2016-17 School Year**

- **Aptitude for computer science is something that can't change very much.** 90.8%
- **Challenging students in computer science won't make them smarter.** 92.3%
- **There are computer science skills that some students are not capable of learning.** 84.5%
- **Only students who are naturally smart in computer science will truly excel in it.** 96.1%

Source: Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2017 Teacher Survey.

Note: N = 207
Are Teachers Adapting What They Learned in PD?

Since NYC schools and classrooms are so diverse and varied, it is essential that teachers have the capacity to adapt what they learn in PD to meet the needs of their own classroom and students. These adaptations may include differentiation to meet the needs of students with different levels of experience with CS, modifications of the materials to make them more accessible for English learners or students with disabilities, or adaptations to accommodate the existing technology or other resources available in the classroom. Teachers may also find that students have difficulty using the curriculum materials or lesson activities provided at the PD, and may feel that they need to make revisions to support greater engagement and understanding among their students.

Most teachers (90% of those implementing CS) reported that they modified what they learned in the PD to some extent. Teachers predominately reported modifying the curriculum to differentiate instruction or adjust materials to different needs and ability levels. For example, teachers who responded to an open-ended question about adaptation noted they modified the curriculum to meet the needs of students with disabilities or ELLs by scaffolding (in which students are provided supports and models that are gradually removed until the students can perform the task independently), differentiating instruction, or adjusting pacing. Other teachers noted that they modified the curriculum by using additional resources, such as Scratch and Scratch Jr., robots, and resources provided by vendors such as Code.org, Code Interactive, Globaloria and Khan Academy.

Teachers participating in SEP and SEP Jr. were more likely to adapt what they learned than their peers, after controlling for other factors. A total of 86 percent and 78 percent of SEP and SEP Jr. teachers, respectively, reported adapting what they learned to a moderate or great extent, while 66 percent of Code Interactive teachers reported the same. We also found that teachers with more years of experience teaching—in any subject area—adapted what they had learned less than their peers who were newer to teaching. A total of 93 percent of teachers with less than five years of experience reported modifying what they learned to a moderate or great extent, while just 62 percent of teachers with 15 or more years of experience did the same. (Differences related to type of PD and teacher experience were statistically significant.)
What Factors Support or Hinder Teachers’ Efforts to Implement CS?

Our teacher survey examined factors that support and hinder high-quality CS implementation in schools and classrooms. Teachers were asked about the extent to which a list of individuals or resources supported their ability to implement CS in their classrooms. They were also asked about the extent to which they faced a number of specific challenges in implementation. Their responses to these questions may suggest strategies that CS4All can use to provide additional and more effective support to teachers, thereby increasing the likelihood that the initiative’s efforts can be sustained over time.

Supports

In implementing CS in their classrooms, teachers reported drawing support from a variety of sources. The most commonly identified supports were colleagues from other schools who had attended the same PD, administrators at their own school, and other teachers in the school. A total of 63 percent of teacher survey respondents indicated that the colleagues they attended the PD with were a support to a “moderate” or “large” extent, while 59 percent said school administrators were supportive, and 49 percent said other teachers in their schools were. As compared to middle and high school teachers, a larger proportion of elementary school teachers reported that teachers in their school were supportive (elementary: 63%; middle: 36%; high: 45%). Similarly, elementary teachers found school or network technology specialists more supportive than teachers at other levels (elementary: 53%; middle: 38%; high: 45%).

We did not find differences in reported supports by PD type, with one exception: More teachers who attended Code Interactive ECS and AP CSP PDs reported that community-based resources (e.g., CSNYC meetups and members of the meetups) were supportive to a moderate or large extent (42% for ECS, 40% for AP CSP), as compared to teachers that attended other programs (12-22% of teachers).

Challenges

The challenges to implementing CS cited by surveyed teachers were similar to those found in other studies (see for example, Google and Gallup, 2016), as well as by the schools responding to our landscape survey. The most commonly reported challenges were competing priorities and, relatedly, a lack of time to implement. As shown in Figure 16 below, 66 percent of surveyed teachers cited
Figure 16: Selected Challenges Overall and by Teacher's Grade Band, 2016-2017 School Year

- Competing priorities
- Lack of time to implement
- Lack of curricular materials
- Lack of alignment with course curriculum
- Lack of alignment with Danielson
- Lack of expertise in CS pedagogy and strategies
- Lack of expertise in CS content
- Lack of internet access
- Lack of parent/guardian support
- Lack of administrative support
- Limited understanding of how to implement CS in my class
- Lack of student interest in CS

Source: Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2017 Teacher Survey.

Note: All Teachers N = 169, Elementary School Teacher N = 65, Middle School Teacher N = 47, High School Teacher N = 56.
competing priorities as a challenge, and 54 percent said a lack of time hindered their ability to implement CS. It is encouraging that the least commonly cited challenges overall were a lack of student interest in CS (14%) and teachers’ limited understanding of how to implement CS in their classrooms (16%). We see strong levels of student engagement in CS and teacher confidence in their own CS knowledge as basic pre-requisites for successful CS learning.

While these challenges were reported less frequently than others, high school teachers were more likely to report them than elementary and middle school teachers. High school teachers were also more likely to report being challenged by lack of expertise in content and pedagogy, lack of materials, and lack of administrative support. We speculate that these challenges are related to the higher degree of difficulty associated with the CS content at the upper grade levels, as well as the duration and intensity of the CS offerings at the upper grades (i.e., more yearlong courses and multi-year sequences rather than individual activities and units). Further, a decrease in level of interest as students progress through middle and high school is not surprising as it follows a pattern documented more broadly in STEM subjects (see for example, Krapp & Prenzel, 2011; Osborne, Simon, & Collins, 2003).

In examining differences by PD type after controlling for other factors, teachers participating in SEP reported lower levels of several challenges than their peers who attended other trainings. For example, teachers who attended SEP PD were less likely to report that lack of time affected implementation (33%) as compared to teachers who attended other PD types (59-82% for teachers attending other programs). This may be due to the multi-year support that SEP teachers receive. In contrast, teachers attending Code Interactive ECS experienced more challenges to implementation than their peers participating in other PD programs. One possible explanation for this result is that Code Interactive presents their ECS program and curriculum as an introductory CS course, so teachers attracted to this course may have less CS expertise and confidence at baseline than teachers attending other programs, and may be less familiar with where and how to access resources.

How Do Supports and Challenges Differ for Schools with High Economic Need and Low Academic Performance?

Because of CS4All’s commitment to increasing access to CS instruction for historically underrepresented groups, we explored whether there are differences in the levels of support and challenges that teachers report, depending on the economic need and academic performance of their schools. For each variable, we divided the
schools of responding teachers into two groups: first, high-economic-need and low-economic-need schools, then high-performance and low-performance schools. About three quarters of high-economic-need schools are also low-performing schools.

Broadly, teachers from high-need and low-performance schools report less support and more challenges in implementing CS instruction. Five out of the seven supports we asked about fit this pattern, as did 11 out of the 13 challenges. Figure 17 shows the supports and challenges that were statistically significantly different by school economic need. Compared to teachers from schools with low economic needs, teachers from schools with high economic needs were less likely to report receiving support from their administrators, school or network technology specialists, or other teachers in their schools. In a similar vein, teachers from schools with high economic needs were more likely to report challenges to implementation of CS, including a lack of parental support, a lack of administrative support, and a lack of student interest in CS.

Source: Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2017 Teacher Survey and from the NYCDOE.

Note: Low ENI N = 86; High ENI N = 86. Differences were statistically significant at the 0.05 level.
As with schools with high economic needs, teachers from low-performing schools reported less support and more challenges, though in a few different areas (see Figure 18). In particular, teachers from low-performing schools were less likely to report teachers from outside their school were supportive; they were more likely to report a number of challenges, including a lack of parental support, a lack of student interest in CS, a lack of expertise in CS content, and a lack of expertise in CS education pedagogy and instructional strategies.

**Summary**

Overall, teachers were very positive about the quality and usefulness of the CS4All PD they attended, regardless of the type of PD program. The teacher survey data suggest that overall, teachers who participated in the PD are somewhat confident in their ability to teach CS and possess a “growth mindset” orientation toward CS.
learning. These are dispositions that we believe are necessary to implement high-quality CS in the classroom. Elementary teachers reported greater confidence in ability to teach CS, and fewer challenges, than middle and high school teachers. This may be related to the requisite knowledge and degree of difficulty associated with middle and high school level CS instruction. Because we did not measure teachers’ attitudes and beliefs about CS prior to their participation in the PD, we are not able to determine if the positive findings about confidence and growth mindset reflect attitudes that teachers had before attending the training, or an improvement, possibly as a result of the PD.

Findings from the teacher survey also suggest that most teachers were able to implement CS in their classroom following the PD training. Those who reported they were not able to implement CS in their classrooms said they were challenged by lack of ability, competing priorities, and lack of support. In addition, several teachers said they did not teach CS because they were not currently the designated CS teacher for the school. This finding, which also happens in subjects other than CS, highlights how teachers trained in CS can be reassigned to another subject from year to year, potentially diluting the impact of PD. Teachers who were able to implement CS also cited challenges, most notably competing priorities (e.g., state exam preparation) and a lack of time for CS.

Most teachers who implemented CS reported adapting and modifying the curriculum to meet the needs of individual students, though more experienced teachers were less likely to do so than less experienced teachers. This may reflect a hesitancy on the part of experienced teachers to change their practices or experiment with new strategies.

We also found that the challenges and supports associated with implementation varied by PD type and characteristics of schools. These differences provide insight about supports that might be strengthened and areas that may need additional attention. They also emphasize the need for PD providers to take into consideration teachers’ background and prior experience with CS when designing and delivering training.

Schools with high economic need and lower achievement reported fewer supports and greater challenges in implementing CS. While our survey could not investigate why these patterns emerged, it is possible that priorities are somewhat different at schools with low versus high levels of economic need and performance. At high-economic-need schools, staff may be focused on meeting students’ basic needs; at low-performing schools, staff may prioritize traditional academic subjects—particularly those with accountability stakes for students, teachers, and the school as a whole—over computer science. Similarly, parents and students at high-need and
low-performing schools may be less inclined to focus on CS learning, given other priorities. Finally, the challenges teachers from low-performing schools reported around their lack of CS content and pedagogy may reflect the fact that low-performing schools frequently have difficulty recruiting and retaining highly skilled teachers (Lankford, Loeb, and Wyckoff, 2002).

The challenges reported by teachers in our survey are similar to those reported by other studies of CS efforts (Google Inc. & Gallup Inc., 2016). Looking forward, it will be important for CS4All to consider how needed supports and challenges may differ for schools that adopt CS later on (and who perhaps are less likely to have a ‘champion’ or strong staff and parent buy-in for the efforts), or that serve students with higher needs and fewer resources (e.g., lower-performing, higher-poverty schools). The next chapter provides a discussion and recommendations to the initiative to address these and other challenges.
CHAPTER 5: DISCUSSION

Based on findings from Chapters 2, 3, & 4, we propose below a set of recommendations and questions for the Founders Committee and the NYCDOE to consider as the initiative continues to evolve in the coming years. In addition, we provide a brief overview of the most prominent upcoming developments for the initiative, as well as a description of how we hope to complement these efforts with a set of evaluation activities that will inform the NYCDOE, other districts across the country, and the burgeoning field of CS education.

Recommendations

As we study and reflect on the initial years of CS4All, we find that several aspects of the initiative provide a strong foundation for its future implementation and sustainability. In particular, the creation of the Blueprint, the addition of CS Education Managers throughout the district, the inclusion of CS in STARS, and the provision of CS PD addressing units, courses, and sequences, across the grade bands, speak to the systemic nature of the initiative and are promising steps toward meeting CS4All’s short- and long-term goals. In addition to developing and refining these approaches further, we suggest the following recommendations to build on the progress that has been made to date:

1. **Make explicit how the three PD strands (unit, course, and sequence) are expected to achieve the larger goals of the initiative.** As discussed in Chapter 2, the CS4All initiative has four main goals, and is using varied strategies to pursue those goals in the context of the larger educational ecosystem. An explicit theory of action for the initiative that includes logic models for each of the three programmatic strands, could clearly demonstrate how the elements of those programs are supposed to work together to achieve the initiative’s goals. This information could be used to communicate expectations to program participants; to develop scenarios that show the variety of ways that schools can engage in meaningful, sustained CS instruction; and to articulate specific short- and long-term benchmarks by which to measure success.

2. **Identify promising strategies to engage schools that predominantly serve students underrepresented in CS.** Both our survey data and STARS suggests that there is room for improvement in terms of providing CS courses or training to students and teachers in high-need schools. We know from our work with the CS4All team during the current school year that they are increasingly targeting their recruitment efforts toward schools with larger populations of
students who are underrepresented in CS. In addition, we suggest that there may be effective ways of encouraging these schools to engage in CS and supporting them during implementation. For instance, the CS4All team may consider more targeted communication and relationship-building with administrators from these schools or experimenting with different strategies to test which ones are more effective. It might be particularly useful to share examples of existing schools in similar contexts that view CS4All goals as consistent with—and supportive of—their larger school goals and priorities. Schools that are already successfully engaged in CS4All may serve as a model for other, similar schools. (See Recommendation 5 below for more about how these models might be collected and presented.)

As we noted in Chapter 4, teachers from schools with high economic needs were more likely to report a lack of parental support and a lack of student interest in CS. Culturally responsive practices might be a means by which to improve parental support and student interest in CS. For example, CSEMs might work with administrators to host school “CS nights” or “CS workshops” (already part of the Cohort Model described below). These events could be held at several points during the school year as a way to introduce parents to CS principles, engage them in discussions about career and college pathways, and even give them opportunities to practice some CS skills. Working with the initiative evaluators, the CS4All team might also draw on the existing literature about culturally relevant pedagogy to identify promising practices for CSEMS to integrate into the implementation plans they are constructing with schools.

3. **Mitigate the most common challenges cited by schools and teachers.** Teachers across grade bands (and 66% of all teachers surveyed) indicated that competing school priorities were a challenge to implementing CS in the classroom. CS4All should consider how CSEMs’ might work with school administrators to integrate a focus on CS into a school’s School/Comprehensive Educational Plan (S/CEP). Staff might help administrators set SMART goals (i.e., specific, measurable, achievable, results-focused, and timebound) create action plans, and ensure that CS-related activities are aligned to elements of the Framework for Great Schools. By including CS-related initiatives in the S/CEP, administrators (and PLCs) might be in a better position to balance competing priorities.

The CS4All team might also consider establishing mechanisms to help address infrastructure challenges (e.g., lack of technology and bandwidth) that are
preventing some schools from implementing and sustaining CS. Sufficient technology infrastructure was noted as a barrier to school participation by a substantial number of surveyed schools. How can the NYCDOE utilize the technology audit that was recently conducted across schools to ensure more equitable access to technology and sufficient bandwidth for CS programming? Are there ways that the CS4All team can better understand and support the needs of schools in terms of their technology infrastructure, including computers and tablets, software, reliable Internet access, and ongoing assistance for technology users?

4. **Learn from the most promising models of PD.** Through a combination of our evaluation efforts and CS4All’s own process for monitoring teacher feedback about PD, the CS4All team should identify promising strategies used by PD providers that have been particularly successful in supporting implementation. For example, teachers who participated in SEP or SEP Jr. and Code Interactive ECS were more likely to adapt materials, after controlling for other factors. What are the features of these trainings that are contributing to teachers’ ability to integrate and modify materials? Given the importance of modifying materials to meet the needs of specific learners, it is important that all CS-related PD prepare teachers to make adaptations. Once other successful features have been identified across other PD supports or models (perhaps through planned variation), CS4All should encourage vendors to integrate those into their own practices and materials.

5. **Provide additional resources for schools and teachers through school-based profiles or case studies and professional learning communities.** To scale the benefits of the initiative and promote sustainability over time, the CS4All team (with the support of the initiative evaluators) should consider documenting the steps that exemplary schools take within each of the three program strands. This work could be used to create “school profiles” or “case studies,” accessible from the Blueprint website, that other schools might use as guides when they begin to implement CS. The guides would include examples that focus not only on successful implementation, but on how school teams and Program Managers solved problems along the way and learned from mistakes, as well as PD and curriculum materials to help schools that are seeking out these resources. While the Blueprint serves as the central resource for CS implementation across the entire City, these guides might provide more targeted advice for individual schools or communities. The profiles might be organized by school characteristics, so new schools can look to the experiences of schools with
similar circumstances. The profiles might also help to build institutional knowledge and mitigate the challenges of staff turnover (in schools and in NYCDOE offices).

As the initiative unfolds, CS4All staff may also integrate training that prepares teacher teams (including school technology specialists) to work as members of professional learning communities (PLCs) to implement and modify materials from PD, and to give one another feedback on lesson implementation. As noted, the most commonly identified supports for CS implementation were colleagues from other schools who had attended the same PD, administrators at their own school, and other teachers in the school. Ensuring that a member of the school administration is a part of the PLC might also reinforce that type of support, which we have found to be especially challenging for teachers in high-economic need schools.

Moving Forward: Future Directions for CS4All

Since its launch in 2015, CS4All has begun to build a foundation for infusing CS into schools across New York City. Activities have included providing a wide range of PD experiences to teachers; hiring a full CS4All team, including CSEMs who work closely with schools in different regions of the City; and developing a CS Blueprint that defines meaningful CS education and offers examples of high-quality CS units. There are some early indications that these efforts are beginning to change the landscape of CS education in the City. Schools that participated in CS4All’s training were much more likely to report implementing CS than other NYC schools that have not yet participated. This was true for both stand-alone CS courses and the integration of CS instruction into a wide variety of other subjects. Teachers generally reported positive feedback about the CS4All PD, saying it increased their CS knowledge and skills and would be useful in the classroom.

Still, there is a long way to go for the initiative to meet its ambitious training and implementation goals, and many opportunities to adjust as the initiative grows. One of the most notable aspects of CS4All is the program staff’s commitment to a continuous improvement process. CS4All leaders have been clear about their interest in learning from early evaluation findings—and from experience—and making changes that will strengthen the initiative.

One example of this is the development of a new model for providing the unit PD that prepares teachers to integrate CS into other subjects. The previous model had
individual teachers sign up for CS PD sessions offered during the STEM Institute, which took place during the February and summer breaks. Our interviews with CS stakeholders, such as CS Education Managers and PD providers, suggested that, after the STEM Institute, teachers sometimes returned to their schools with little follow-up support or awareness of how to connect what they learned to the larger school priorities and practices. In response to this feedback, and with the input of the CSEMs, CS4All created what they are calling the FSC Computer Science Cohort Model, a new approach to providing PD across the City aimed at helping teachers integrate a unit of CS into existing courses, in place of the existing STEM Institute.

In the FSC CS Cohort Model, CSEMs work with district superintendents and field support centers to select schools in their region that serve high percentages of underrepresented students. CSEMs then collaborate with school teams made up of both administrators and teachers over the school year. They work together to create a CS vision for the schools, match schools to PD partners, conduct trainings among cohort schools, do school-based coaching and lesson planning, and host community CS events. CS4All leaders intend to closely monitor this new model to determine if it leads to stronger buy in and implementation at schools that participate.

The initiative is also taking steps to promote sustainability by developing three CS teacher leadership pathways. The first is the Teacher Trainer Track, in which teachers lead PD sessions offered by the CS4All team and work with the team and partners to ensure quality PD. A second pathway is the Blueprint Track, through which teachers will prepare materials to be published on the Blueprint, review curriculum, and provide feedback on the existing resources presented there. Finally, teachers within the Community Builder Track will host Slack chats, coordinate intervisitations between schools, and coordinate borough communities of practice. All of these programs are aimed at establishing professional CS learning communities to help sustain CS education in the future.

To learn about these multifaceted elements of the initiative, the next phase of our evaluation includes case studies in a small subset of schools, aimed at learning much more about the quality of training and implementation. These case studies—of schools engaged in both SEP and SEP Jr., CS Course PD, and the Cohort Model described above—will be designed to help the CS4All staff understand what schools are experiencing, how these programs are working, and how they can be improved. We have selected eight schools thus far that serve high percentages of Black and Latino students and that are diverse in terms of grade level (i.e., elementary, middle, and high school), geography (i.e., borough and neighborhood), CS partner selected, and
other school and student characteristics (e.g., academic performance, size of school, technology access, etc.). Over the course of the 2017-2018 school year, in each school, we are conducting observations of classrooms and planning meetings; interviews with CSEMs, administrators, teachers, and partners; and reviews of relevant documents, such as curricula, lesson plans, student work, and assessments.

We are also preparing to launch the student assessment piece of our evaluation by developing a theory of action and specific research questions about student outcomes based on existing research and prior measures of CS knowledge and skills. We will use our case study sites to pilot instruments that may be used to assess key student outcomes, including measures of CS knowledge and skills, academic achievement and engagement, and relevant non-cognitive outcomes, such as students’ sense of belonging and awareness of computing careers and applications. As with our evaluation of CS4All’s implementation, our assessment of student outcomes will illuminate how CS4All affects different groups of students, particularly those who are typically underrepresented in computer science and other STEM fields. Finally, we will continue to examine student enrollment in CS courses through STARS, exploring important questions about students’ access to and participation in CS and also providing feedback about ways to improve this tracking system.

While it is still early in our evaluation, we hope the findings in this report, the questions they raise, and the various successes and challenges highlighted will help support the development of CS4All in New York City—and inform the work of other districts around the country engaged in similar efforts.
Endnotes


4 “Computational Thinking is the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent.” (Wing, 2010)


6 “Project-based learning (PBL) is a model that organizes learning around projects…projects are complex tasks, based on challenging questions or problems, that involve students in design, problem-solving, decision making, or investigative activities; give students the opportunity to work relatively autonomously over extended periods of time; and culminate in realistic products or presentations.” (Thomas, 2000)

7 Culturally relevant education attempts to engage and empower students by incorporating their cultural backgrounds in classrooms and focusing on issues that are relevant to their lives. (Ladson-Billings, 1994)


9 This and other results from the landscape survey are estimates based on results from a representative sample of schools. We have calculated the margin of error associated with each estimate, reported in Appendix B. The percentages reported should be interpreted as involving some uncertainty, like a political poll’s result would be followed by the clause “plus or minus three percent.” We italicize all landscape estimates to remind the reader of this uncertainty.

10 These data were tabulated by adding the number of teachers attending all CS PD across a school. Some teachers may have been double counted when individuals attended multiple trainings.

11 The percent of schools sending teachers to CS PD at each grade band is calculated from all schools serving that grade level. E.g., when calculating the percent of schools sending teachers of grades 6-8 to CS PD, we consider all schools serving these grades, including K-8 schools, 6-8 schools, and 6-12 schools. The total number of schools we consider is different for each bar, and we include some schools multiple times. For example, 6-12 schools are included when calculating the percent of schools sending teachers of grades 6-8 to CS PD and the percent of
schools sending teachers of grades 9-12 to CS PD. Statistics offered in the text give the percent of schools that could identify the CS PD to which they sent their teachers. The additional percent of schools by grade level sending teachers to non-identified CS PD is: K-2 0%; 3-5 1%; 6-8 7%; 9-12 9%.

For this report, we are focusing on CS instruction offered during the school day, and not extracurricular or out-of-school offerings, to reflect the initiative’s focus on CS instruction supported by the school and accessible to all students.

NB: The percent of schools offering CS at each grade band is calculated out of all schools serving that grade level. E.g., for grades 6-8, the denominator includes schools serving grades K-8, 6-8, and 6-12. The denominator is different for each bar, and some schools are included in multiple denominators. Statistics offered in the text give the percent of schools offering identified CS instruction. The additional percent of schools by grade level offering non-identified CS instruction is: K-2 8%; 3-5 13%; 6-8 10%; 9-12 7%.

The 2017-2018 CS Cohort PD primarily targetted elementary and middle schools interested in offering a unit of CS to students. CS4All recruited additional schools to participate in CS courses (such as AP computer science principles) in 2017-2018. Those schools were not identified at the time of this writing and are not included in this analysis.

While we believe inconsistent use of the STARS system for indicating CS instruction may make STARS data a less than ideal source of data to examine citywide CS course offering, this inconsistency is less likely to present problems for student-level analyses of CS course-taking patterns. It is probable that school-based programmers either consistently used STARS to indicate CS instruction or did not. Put another way, it is unlikely that a programmer would inconsistently indicate CS instruction for one group of students in the school and not for another group of students. Similarly, it is unlikely that the patterns of which students take CS are different in schools that used STARS correctly to indicate CS instruction from in schools that did not use STARS correctly.

The percent of students enrolled in CS by school varied widely. Therefore, we report median enrollment rather than mean as it provides a better indicator of the typical school enrollment.

These statistics are not strictly comparable for a number of reasons. Wang and colleagues asked students if they had ever taken any CS, without specifying whether this took place in school or elsewhere, whereas STARS reports CS instruction during the 2016-2017 school year only. Further, the current STARS analysis is restricted to students in schools that offer CS, whereas Wang and colleagues included all children. Still, we include them to give some sense of how NYC’s landscape compares to the landscape nationally.

Teachers who attended Beauty and Joy of Computing (BJC) and Technology Education and Literacy in Schools (TEALS) PD programs were not included in our survey sample because they both are involved in other external evaluations, and we did not want to over-burden teachers with requests to participate in research. Most if not all of TEALS participants also participated in other course-level PDs. Most participated in BJC.

Here, growth mindset refers to the belief that all students can learn CS and that CS
is not an innate skill, but rather something that can be developed and improved with effort.

Teachers may have attended more than one type of training. Response rates were higher among teachers that attended Code Interactive PDs and lower among from teachers that attended SEP and SEP Jr. Response rates were similar across all five boroughs.

As noted in Chapter 3, survey respondents may have been influenced by social desirability bias; however, we attempted to phrase questions in ways that encouraged teachers to be candid in their responses.

We use the NYCDOE’s school economic need index to divide the respondents into two groups based on their school’s level of economic need. The NYCDOE calculates an “economic need index” for each school for use in its School Quality Guides. More information is available here. We use the percent proficient on grade 3-8 state math and English language arts tests to divide elementary and middle schools into two groups according to performance. We use graduation rates to divide high schools into high- and low-performing groups.

See http://schools.nyc.gov/community/OSFEP/CEP/CEP.htm

References


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