The Research Alliance for New York City Schools

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

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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[i] 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.[ii] 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[iii] 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),

Figure ES-1: Percent of Initiative and Non-Initiative Schools Training Teachers in Computer Science, 2015-2016 School Year
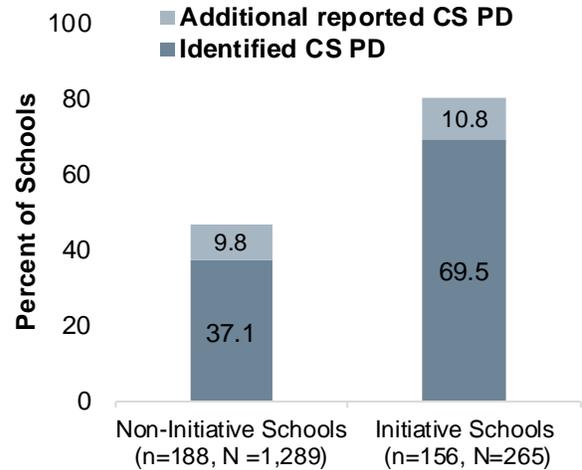
Source: Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2016-17 Landscape Survey.

Note: "n" indicates the number of schools in the survey sample, and "N" indicates the number of schools the sample schools are representing.

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.
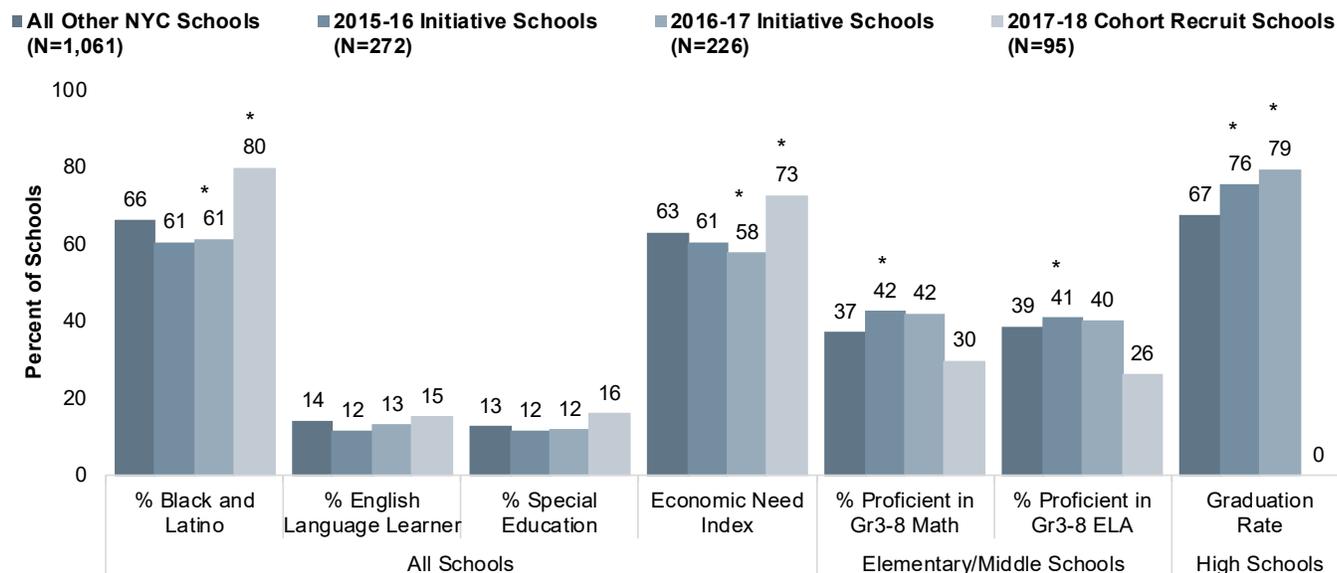
Figure ES-2: Comparison of Demographics and Academic Performance of Successive Waves of Schools Participating in CS4All

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 for them. 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.

- **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%*).**[iv] 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,[v] 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[vi] 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
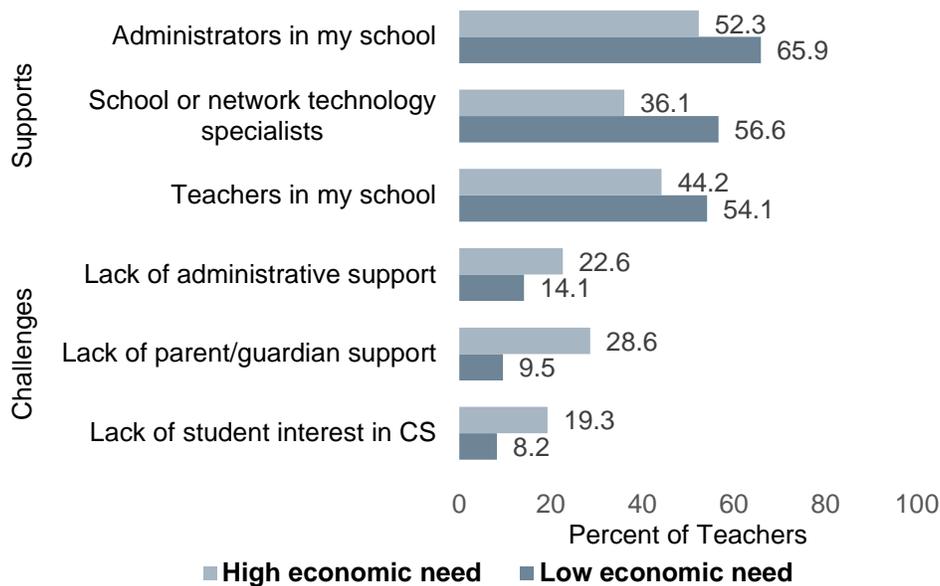
Source: Research Alliance calculations based on data obtained from the Research Alliance and EDC CS4All 2017 Teacher Survey and from the NYC DOE.

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).

ii Google Inc. & Gallup Inc. (2016). *Diversity Gaps in Computer Science: Exploring the Underrepresentation of Girls, Blacks and Hispanics*. Mountain View, CA: Google Inc. & Gallup Inc.

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: http://www.hr.virginia.edu/uploads/documents/media/Writing_SMART_Goals.pdf

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