Building a Computer Science Teacher Pipeline for New York City

A Gathering of Teacher Preparation Programs

Leigh Ann DeLyser, Director of Education and Research
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By Michael Preston, Executive Director, CSNYC

CSNYC is proud to be a partner of the City of New York and the NYC Department of Education on Computer Science for All (CS4All). Announced in September 2015, CS4All is an $80 million, 10-year initiative to ensure that every student in the NYC public schools receives meaningful opportunities to learn computer science (CS). Recognizing that CS education is both a social and economic imperative, CS4All depends on collaboration across many sectors, including government, industry, nonprofit, philanthropy, and high education.

CS4All is fundamentally a teacher training initiative that will support professional learning opportunities for nearly 5,000 current classroom teachers over a 10-year period. In nearly all cases, these teachers will (1) be the first to offer CS in their schools and (2) represent a wide array of subject area certifications and academic backgrounds—a necessary strategy in the absence of a formal CS teacher pipeline. Training current teachers is the first step in a long-term plan to create equitable, sustainable access to CS for all of NYC’s public school children. To ensure that CS4All continues long after its first 10 years, we need to construct a pipeline of qualified teachers who can enter the system ready to teach CS at all grade levels and with the depth and richness of other subjects.

We must rely on teacher preparation programs at schools of education to make this happen. These programs have the opportunity to address many of the criticisms of the short-term, content-specific training that comprises the majority of CS teacher education today. With formal CS education coursework and degree programs in place, schools of education will have the opportunity to build teachers’ depth of knowledge well beyond what they are expected to communicate to students. We need teachers with deep and fluid knowledge of CS so they can deliver accurate and thorough explanations and make curricular modifications to address the needs of their students and the ever-changing technological landscape.

With our Building a Computer Science Teacher Pipeline for New York City event and this report, CSNYC seeks to highlight existing programs that have been designed by our local CS education community in response to the needs of schools and teachers. These programs suggest a range of promising models. We hope you find this report a useful contribution to the development of CS teacher preparation programs in NYC and beyond.
Over the last 10 years, the United States has seen an increasing focus on STEM and, more recently, computer science education. The challenge of preparing today’s students to contribute to tomorrow’s society is complex and requires investment in research, infrastructure, teaching and learning.

In September 2015, NYC Mayor Bill de Blasio announced CS4All: an unprecedented $81 million public-private partnership to provide CS to every child in NYC public schools. CS4All is being executed through a partnership between the NYC Mayor’s Office, the NYC Department of Education (DOE), the Fund for Public Schools, and private partners including CSNYC, Robin Hood, AOL Charitable Foundation, and others. Its central strategy is training nearly 5,000 teachers through high quality professional development (PD) in select CS programs. Owing to its scale and the diversity of CS programs offered, CS4All more closely resembles a state rather than school district model for CS implementation. Alone, NYC public schools would rank as the 13th largest state in the US by student enrollment (US DOE, 2015). In addition, NYC schools are characterized by diverse school sizes and student populations and varied resources, including access to technology. According to the NYC DOE, the majority of NYC students are from ethnic backgrounds underrepresented in CS (27.8% Black, 40.4% Hispanic). NYC also has a high population of English language learners (13.1%) and students with disabilities (18.2%). Most (78%) NYC school children qualify for free or reduced lunch programs.

Unlike other district initiatives (e.g., San Francisco or Broward County), NYC’s CS4All will not mandate a specific curriculum. Instead, schools must offer one unit of CS to every student at each school level—elementary, middle, and high school. What is a unit? The DOE is developing a blueprint for CS education that will define level-based outcomes for students in an effort to redefine and guide the selection of “units.”

The CS4All initiative builds on several years of implementation work, during which CSNYC, together with partners, directly supported the growth of CS through various programs in NYC schools. Each program had a unique curriculum and represented a unique approach to integrating CS into a school. Fred Wilson, the tech investor and philanthropist who founded CSNYC, initially funded the development of two new software engineering-themed public high schools. In 2012, the Academy for Software Engineering (AFSE) opened in Manhattan and served as a proof of concept.
that all NYC students could learn CS if the material was appropriately selected and taught well. The following year, the Bronx Academy for Software Engineering (BASE) was opened to build upon the success of AFSE. Both AFSE and BASE are district (non-charter) schools with student enrollments from the regular high school lottery process\[NYCDOE\]; neither school selects its students, and no priority is given to students based on prior academic performance or an entrance exam.

The creation of AFSE and BASE enabled the CS teaching staff at each school to build a CS curriculum from the ground up. However, these schools together serve only about 1,000 students annually, and new programs were needed for existing schools in order to scale access to CS equitably across the city. In 2013, the DOE launched the Software Engineering Pilot (SEP) to offer a multi-year curricular sequence to existing middle and high schools. Unlike AFSE and BASE, SEP does not hire CS teachers but instead works with existing teachers identified by participating schools’ leadership and trains them in the SEP curriculum for 100 hours per year for three or four years depending on school level.

CSNYC has also funded the launch and expansion of several other programs in NYC. These programs include Bootstrap, Exploring Computer Science (in partnership with Code.org), Scalable Game Design, ScriptEd, and TEALS. CSNYC also partners with UC Berkeley, EDC, and the DOE on the development of BJC - the Beauty and Joy of Computing, a new AP Computer Science Principles course based on a Berkeley intro to CS course of the same name and funded by the National Science Foundation. Descriptions of these individual programs can be found on CSNYC’s website. The programs represent a broad spectrum of teacher preparation models, some focused on training currently employed teachers and others using volunteer software engineers to support classroom teachers or teach students directly.

With CS4All, the DOE will expand on CSNYC’s approach and support schools in either choosing from approved curricula, including some of the programs listed above, or–when schools implement their own programs–assessing whether these curricula meet the district’s requirements. The success of CS4All depends on the efficacy of PD in CS education to build teachers’ knowledge in ways that will lead to growth in student learning.

As stated earlier, CS4All is a teacher development initiative that primarily focuses on training in-service teachers. However, while not funded directly by CS4All, the creation of a CS teacher pipeline via preservice institutions will play a critical role in the initiative’s long-term sustainability and success.
3. Computer Science Teacher Education

3.1 Teacher Education in the United States

In the US, education is a local endeavor. While there is a federal department of education, individual states have control over their educational systems and the preparation and certification of teachers for the classroom. However, the federal government does maintain records of teacher preparation through Title II reports available online\(^1\).

In 2015, the US had approximately 465,000 teachers and preservice teachers enrolled in more than 27,900 Teacher Preparation Programs (TPP) across 2,100 institutions. These programs vary as widely as the positions held by the teachers enrolled in the programs. Regardless of whether you would like to be an elementary school teacher, a library media specialist, a high school mathematics teacher, or a special education teacher, TPPs are the way to meet the standards and requirements necessary to achieve certification in a desired area. There are some programs focused on placing college graduates in classrooms without prior completion of a TPP, such as Teach for America, but these numbers are relatively small compared to overall TPP enrollment\(^2\).

Teacher preparation and certification pathways require a mix of content knowledge and pedagogical practice. According to the US Department of Education, 14 states require a content-specific bachelor’s degree for an initial credential in middle school, and 15 states require a content-specific bachelor’s degree for an initial credential in high school. Other states do not report a specific requirement or have inconsistent standards across preparation programs.

3.2 Computer Science Teacher Education in the United States

The preparation of CS teachers in the US has historically been a challenge for many reasons. Prior to recent movements to teach CS to all students, CS was often treated as an elective subject or embedded in career and technical education programs. Fewer than 10% of schools even offered CS

\(^1\)All data presented in this section comes from the Title II reports (title2.ed.gov) unless otherwise specified

\(^2\)Teach for America teachers are certified under a provisional license and required to complete coursework at the same time they are teaching.
prior to 2012 [16], and the schools that did offer CS relied upon the expertise of a few teachers who were either self-taught or had prior work experience in technology before entering the classroom.

Until recently, funding for the expansion of CS education most often came through sources external to public school systems. Universities and nonprofits have relied on grants from organizations like the National Science Foundation or private sources, such as Google’s CS4HS program, in order to conduct workshops for existing teachers in either a specific curriculum or methods that were believed to increase the participation of underrepresented groups in CS. These efforts were not necessarily focused on “all” students, nor were they concerned with teacher certification preparation and requirements, because the participating teachers were already certified in something and teaching in schools.

CS education now has a “chicken and egg” problem. National organizations [Yad+15] and the news media [Dev16] have pointed out the lack of a viable certification or preparation pathway for CS teachers. Universities prepare approximately 88% (Traditional Higher Education) + 5% (Alternative Higher Education) of teachers in the US. Postsecondary institutions align their preparation programs to the certification requirements of the state. Unfortunately, many states are reluctant to create new certification pathways without (1) evidence that there will be jobs for teachers with the new certification, and (2) exemplars of what coursework is necessary for teacher preparation in the domain. Yet current initiatives to increase access to CS would like to move quickly. For example, the White House’s Computer Science for All initiative, announced in January 2016, requested $4 billion for a three-year period.

Many initiatives, like some of the CS4All efforts in NYC, have turned to short-cycle PD to prepare teachers quickly to offer CS in their schools. These efforts often mirror the early workshops to prepare teachers for a particular curriculum or course [AB12; GM11]. Although they have the benefit of being expedient, many do not develop deep and flexible knowledge that teachers can use to modify and adapt curriculum over time. Additionally, while sensible for in-service teachers, the PD model does not address the long-term need of a teacher pipeline for sustainability, nor does it provide the teachers with portable credentials enabling school administrators to hire new teachers for CS courses with confidence in their content knowledge. Finally, the PD model is also expensive, as schools or teachers themselves take on the financial burden of attending workshops with little opportunity for financial aid or support.

3.3 Computer Science Teacher Education in NYC

NYC’s implementation of teacher development in CS is a reflection of the larger national situation. Prior to the founding of CSNYC, CS courses were concentrated in a few schools, primarily serving a selective student population. Although NYC has more than 430 high schools, in 2012, 50% of the Advanced Placement CS A exam takers came from three high schools.

In addition to a lack of schools offering CS, there are also few resources defining what CS should be taught at the K12 level. Unlike mathematics, for which standards, curricula, and textbooks are plentiful, there is little consensus around what CS looks like in K-12. Connected to the short-cycle PD efforts funded by outside groups, many research teams also have created their own curricula and materials, designed to cover content in a way that would engage students from sub-populations typically underrepresented in computing. The Computer Science Teachers Association (CSTA) has published recommended K-12 CS standards [See+11] since 2011, and many of the curricula promoted in the PD workshops for teachers are aligned to a subset of the standards3.

3 CSTA is currently in the process of revising the K-12 CS standards and draft versions of the standards indicate an
CSNYC has endeavored to address the issues facing districts nationwide, identifying curricula and PD programs with data supporting the success of the innovation and providing funding to expand such programs within NYC public schools. Since 2013, and before the announcement of New York City’s Computer Science for All initiative in September 2015, CSNYC partnered with programs to train more than 200 teachers in 150 schools. Although short-cycle PD has drastically increased the number of schools providing access to CS, there is still no sustainable pipeline of teachers to fill new programs, or to replace the trained teachers when they leave the classroom for other positions or retirement. This pipeline must also include a trajectory that does not end at the classroom door, but continues to provide ongoing opportunities for growth and development, even to relatively experienced teachers.

New York State (NYS) teacher credentialing has also complicated the issue of producing a pipeline of CS teachers. NYS currently does not have an initial academic certificate for CS. There is a Career and Technical Education (CTE) title, Computer Technology, which is appropriate for a CS teacher, however the certification is primarily for teachers in schools with a specific CTE program, and requires two years of work experience in a technology position. The Computer Technology certificate is also problematic in the requirement of 30 hours of related coursework, which may not even be appropriate for some industry professionals who came to CS through alternative pathways and learned while on the job.

In NY state, CS can count as a math, science, or elective course. If the course is classified as math or science, a teacher with either a math or science certification may teach the course and still be considered in-subject, even if their preservice preparation involved no CS.

Similar to the national effort, postsecondary institutions in NYC that prepare teachers are asking for guidance to help create programs that will prepare graduates for CS teaching jobs in NYC. Although the CTE credential requires more than adequate coursework, it is only appropriate in a small subset of schools. Compounding the problem, many schools do not have the course offerings to justify a teacher for only CS classes. Instead, a teacher who can teach two subjects would be preferable, yet completing the coursework for a dual certificate is almost impossible within an undergraduate or single masters program.

In this document, we offer examples of a few models of preservice teacher preparation programs currently offered at postsecondary institutions in the NYC area. Some of these programs were produced in consultation with CSNYC, but the majority of the design and final decision of the program’s requirements were made by the respective postsecondary institution. This document is not meant to be an exhaustive list. Rather, it reflects the programs represented at the CSNYC-sponsored event Building a Computer Science Teacher Pipeline for New York City held on March 23, 2016.
4. Preservice CS Teacher Education in NY

This section introduces the programs presented at the *Building a Computer Science Teacher Pipeline for New York City* event on March 23, 2016. These programs are from diverse institutions and are representative of both secondary and elementary teacher preparation options. Each program was designed and proposed at the individual institution, although CSNYC did provide some consultation.

Although there is a need for programs specifically targeted to teachers who will be certified to teach only computer science, there is also a need for programs to expand the CS knowledge for teachers of other disciplines. Some implementations of CS at the secondary school level take an integrative approach. These integrative units or courses are often taught by a teacher with formal training in another subject. These teachers may appreciate opportunities for certificates or smaller programs of study that will provide them the content they need without a full degree.

### 4.1 Queens College, City University of New York

#### 4.1.1 About the institution

Located in a residential area of Flushing in the borough of Queens—America’s most ethnically diverse county—Queens College has students from more than 150 nations. A member of Phi Beta Kappa, Queens College is consistently ranked among the leading institutions in the nation for the quality of its academic programs and student achievement. Recognized as one of the most affordable public colleges in the country, Queens College offers a first-rate education to talented people of all backgrounds and financial means.

The Queens College Division of Education has over 97 registered programs preparing teachers and other school professionals for Post Bachelors and Post Masters New York State certification. The undergraduate and graduate programs give students the tools to persevere in the field of education. The Division is comprised of three programs: Secondary Education and Youth Services; Educational and Community Programs; and Elementary and Early Childhood Education. Because of its geographic location, cultural diversity, and reputation as a strong liberal arts college it is one of the national leaders in Urban Education. In fact, Queens College is the third largest traditional teacher preparation institution in the United States.
4.1.2  MSED Degree in Teaching Math and CS (Dual Certification Mathematics and Computer Technology — under review by NY State)

Queens College has proposed a Masters of Science Education degree in Teaching Math and Computer Science. The program would lead to a dual certification in both Math Education and Computer Technology.¹

The MSED in Teaching Math and CS is comprised of 15 credit hours of Math Education and coursework from the Department of Secondary Education and Youth Services (SEYS), and 15 credit hours of computer science coursework. The proposed program has passed the approval process at Queens College and is awaiting state approval. Table 4.1 shows the relevant coursework for the proposed program.

<table>
<thead>
<tr>
<th>Course Area</th>
<th># Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEYS Historical, Philosophical, and Social Foundations of Ed</td>
<td>3</td>
</tr>
<tr>
<td>SEYS Psychological Foundations</td>
<td>3</td>
</tr>
<tr>
<td>SEYS Curriculum Methods in Secondary Math Education</td>
<td>3</td>
</tr>
<tr>
<td>SEYS Research</td>
<td>6</td>
</tr>
<tr>
<td>CSCI Advanced Programming in C++</td>
<td>3</td>
</tr>
<tr>
<td>CSCI Advanced Programming in Java</td>
<td>3</td>
</tr>
<tr>
<td>CSCI Data Structures</td>
<td>3</td>
</tr>
<tr>
<td>CSCI Discrete Structures</td>
<td>3</td>
</tr>
<tr>
<td>CSCI Computer Organization and Assembly Language</td>
<td>3</td>
</tr>
</tbody>
</table>

In addition to a rigorous preservice computer science program, Queens College has also taken steps to help prepare some of the Math Education majors for potential CS coursework they may be asked to teach. Many schools do not require a full time CS teacher, and will often ask a teacher from another subject area, such as math or science, to teach a CS course in the school. Students in the Time 2000² program are required to take two computer science courses as a part of their degree sequence. Together with CSNYC, Queens College has revisited those courses, updating them to be CS90: Computational Thinking in High Schools, and CS112: Introduction to Algorithmic Problem Solving in Java. The content of these courses is meant to familiarize teachers with the most popular HS CS offerings (ECS, CSP, and AP Java).

Queens College has also partnered with CSNYC and Bootstrap to offer Bootstrap workshops for preservice math teachers. Together, the MSED in Teaching Math and CS, the required coursework for preservice math teachers, and the supplementary workshops make Queens College an excellent example of a multi-pronged approach to preparing teacher candidates to fill anticipated school needs in NYC.

¹NYSED Certification is granted providing the teacher candidates complete and pass state exams and other non-coursework components of certification.

²Program Webpage: http://www.qc.cuny.edu/Academics/Honors/Time2000/Pages/default.aspx
4.2 Lehman College, City University of New York

4.2.1 About the institution

As the only senior liberal arts college in the CUNY system located in the Bronx, Lehman upholds the University’s goals for educational and personal advancement by offering 51 undergraduate and 46 graduate programs to approximately 12,000 students each year. Lehman serves a diverse population of traditional-age and adult learners who come from heterogeneous ethnic, racial, cultural, and socioeconomic backgrounds. Many are from immigrant families, have acquired English as a second language, and are first-generation college students.

The School of Education reflects the diversity of the College as a whole. With an enrollment of approximately 1,500 students, the School offers 25 nationally recognized and/or New York State-approved courses of study designed for those who will enter the profession as well as for experienced educators who choose to add new areas of certification. The School of Education is actively engaged with over 200 schools, most located in the Bronx. Each of these collaborations and partnerships represents a commitment to make a positive difference in the lives of children and their families.

4.2.2 A Proposed Extension Certificate (Does not meet any current NYS Certificates)

Lehman College, under the direction of Niki Fayne, Dean of Education, has engaged in a collaborative process with industry leaders, the NYC DOE, and Bronx and NYC based CS education groups to determine what is needed in a preservice computer science teacher. Over the course of six months, Lehman reached out to organizations such as Knowledge House, CSNYC, and Code/Interactive in order to specifically determine the right CS content knowledge for teachers and students that not only meets national standards, but also local employment opportunities.

A significant finding in their process was that many schools will not need a full-time computer science teacher, but instead a teacher of another subject who can also teach CS. This finding has lead Lehman to develop an ‘Extension Certificate’ model. Extension certificates also require the preservice teacher to complete fewer credit hours, as it is assumed they get general liberal arts and education coursework as a part of their primary certificate.

The proposed certificate recommends that students take at least one course in each of the five areas. Table 4.2 describes each area and the associated Lehman College course titles. Students are expected to complete coursework that covers the CS topics commonly taught at the HS level, and some additional coursework for depth of knowledge. In addition, they will complete pedagogical coursework that assumes CS content knowledge (through required prerequisites) in order to focus on classroom best practices and opportunities for students to present lessons and receive feedback.

4.3 Brooklyn College, City University of New York

4.3.1 About the institution

Brooklyn College is an integral part of the civic, urban, and artistic energy of NY and uses the entire city as a living classroom that broadens our students’ understanding of the world around them. Brooklyn College enrolls over 17,000 students from 150 nations who speak over 100 languages. The college offers 120 degree programs.

Brooklyn College offers degrees in both early childhood and elementary education and subject specific secondary education. Completion of the Bachelors of Arts degree with a major in childhood education.

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3In New York State, extension certificates add on to an existing teaching license. A teacher cannot obtain an extension certificate without a full certification in another discipline.
Table 4.2: Extension Certificate, Lehman College

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Coursework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals of Computing</td>
<td>The Fundamentals of Computing topic is meant to introduce students to the broad range of computer science topics and applications in the world. Students would engage in problem solving activities that not only emphasized the technical aspects of computing, but also the societal implications as well.</td>
<td>Fundamentals of Computing</td>
</tr>
<tr>
<td>Programming Language</td>
<td>A common course offered in high schools is AP Computer Science A in Java. Preservice teachers should have an equivalent experience.</td>
<td>Programming Methods</td>
</tr>
<tr>
<td>Data Structures</td>
<td>Abstract characterizations of data will be studied along with the algorithms that make use of such structures.</td>
<td>Algorithms I</td>
</tr>
<tr>
<td>Computer Organization and Assembly Language</td>
<td>Introduction to digital logic and assembly language</td>
<td>Computer Organization</td>
</tr>
<tr>
<td>Pedagogical Content Knowledge</td>
<td>Coursework in this category will emphasize the teaching of CS, relying on the content knowledge students will gain in the other coursework.</td>
<td>Teaching Methods/Practicum</td>
</tr>
</tbody>
</table>

education qualifies students to receive NY State initial teacher certification (grades 1-6) and prepares students for employment in NYC schools.

4.3.2 An Elementary Subject Area Concentration in CS (NYS Elementary Certificate)

In addition to completing the core coursework for the childhood education major, students must complete a liberal arts and sciences concentration or a second major. Brooklyn College has had a NYS approved concentration in Computer Science for the past 15 years. This concentration loosely defined to require foundational coursework in CS, but also to allow freedom in upper division coursework for students to pursue interest related topics.

Table 4.3 describes the components of the Concentration in Computer and Information Science for childhood education majors. Students may choose between a CS concentration and an informational technology concentration and need to complete additional elective CS coursework in order to meet the mandated 30 credit hours.

4.4 New York University

4.4.1 About the institution

Located in the heart of Greenwich Village, NYU’s Steinhardt School of Culture, Education, and Human Development prepares students for careers in the arts, education, health, media, and psychology. Since its founding in 1890, the Steinhardt School’s mission has been to expand human capacity through public service, global collaboration, research, scholarship, and practice. The Department of Teaching and Learning at NYU prepares teachers for urban schools in a wide range of subject areas, as well as offering professional, post-certification master’s degrees for practicing teachers and
### Table 4.3: Childhood Education Concentration, Brooklyn College

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Coursework</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer and Information Science Foundations</td>
<td>These courses are the traditional introduction to programming one would expect in a major or minor.</td>
<td>Introduction to Programming in C++, Computers and Ethics, and Introduction to Computer Applications.</td>
</tr>
<tr>
<td>Pedagogical Coursework</td>
<td>Students are expected to complete coursework on instructional techniques with computers in the classroom</td>
<td>Microcomputers in Education</td>
</tr>
<tr>
<td>Options: Computer Science Option or Information Technology Option</td>
<td>This option contains coursework in advanced programming, data structures, and discrete mathematics.</td>
<td>Advanced Programming Techniques, Intro to Discrete Structures, Data Structures</td>
</tr>
<tr>
<td></td>
<td>This option contains coursework focused more on the information science side of the CISC department at Brooklyn College.</td>
<td>The Internet, Multimedia Production for the World Wide Web, Computing Workshop I, Advanced Personal Computer Techniques</td>
</tr>
<tr>
<td>Additional Courses</td>
<td>Students must complete additional coursework as necessary for at least 30 credits in the CISC department</td>
<td>Various.</td>
</tr>
</tbody>
</table>

preparing doctoral students to become education researchers and teacher educators. The Steinhardt School has a strong, established network of partner schools throughout New York City and faculty work closely with practicing teachers in the field to improve urban PK-12 education.

### 4.4.2 A Computer Science Education Minor (Does not meet any current NYS Certificates)

The Steinhardt School of Education offers three minors in education. These minors are offered to all New York University students regardless of major. The Computer Science Education minor consists of 18 credit hours covering a variety of disciplines. Students need to complete 12 credit hours in Computer Science, and 6 credit hours in Computer Science Education. The minor also offers other courses for additional electives for interested students. Table 4.4 shows the relevant coursework.

The 12 computer science credits consist of an introductory programming course, a course in data structures, and a course in either systems or logic. These courses are meant to provide a foundation in the content knowledge of computer science. The 6 credit hours in Computer Science Education represent two courses. One of the courses is entitled Teaching of Secondary Computer Science. The Teaching of Secondary CS course uses micro-teaching experiences to give students the opportunity to design, implement, and receive feedback on lesson plans for a CS classroom. The second course is titled Introduction to Computer Science Education, and focuses on the different models of implementation of CS education in K12 schools. Students develop a map of implementations, comparing stand-alone CS coursework with interdisciplinary options (CS embedded in Math or Science) and learn about existing curricula as well as channels for staying current of new curricula and initiatives.
<table>
<thead>
<tr>
<th>Course Area</th>
<th>Description</th>
<th>Course Titles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Science</td>
<td>Students will complete 12 credit hours of CS coursework covering introductory programming (PR), data structures (DS), and either computer systems organization or digital logic (Sys).</td>
<td>PR: Introduction to CS or Object Oriented Programming, DS: Data Structures or Data Structures &amp; Algorithms, Sys: Computer Systems Organization or Digital Logic &amp; State Machine Design or Computer Architecture &amp; Organization</td>
</tr>
<tr>
<td>Computer Science Education Courses</td>
<td>Students will take two courses specifically focused on the teaching of CS and the goals of CS education in K12.</td>
<td>Introduction to CS Education and Teaching of Secondary Computer Science</td>
</tr>
<tr>
<td>Electives</td>
<td>Students who complete parts of the minor for their major may chose electives from Human Development, Teaching of Mathematics, or other education coursework.</td>
<td>Various</td>
</tr>
</tbody>
</table>

The minor in CS Education is meant to help students develop flexible knowledge of both CS concepts and current practices surrounding the teaching of age-appropriate concepts at the K-12 level. Depending on their complementary major, students of the CS Education minor could become qualified to teach CS in schools, work with organizations such as TEALS or ScriptEd to help bring CS Education to schools, or companies like Codecademy producing online content for student learning.
On March 23, 2016, CSNYC held a workshop to discuss proposed and current models of computer science teacher education at institutes of higher education. This section details the agenda for the day, the topics covered in each section, and offer a summary of conversation from notes that were taken during the event. The workshop involved 21 participants from 16 institutions. Table 5.1 provides a list of participants, their positions at the time of the workshop, and the institutions they represented.

The participants were invited to the workshop through email. Presenters and participants from private institutions were contacted directly by Leigh Ann DeLyser, while City University of NY (CUNY) faculty members were invited by Ashleigh Thompson, University Dean for Education for CUNY. Participants were asked to RSVP through a website. The meeting was held at the Microsoft Times Square offices from 9:30am to 1pm.

5.1 Welcome

Participants were welcomed by Michael Preston, Executive Director of CSNYC, and Ashleigh Thompson of CUNY. Both Michael and Ashleigh highlighted the importance of adequately preparing teachers for classrooms where computer science is either the focus, or an integrated part of, the curriculum. The efforts of CS4All will not be sustainable if NYC is unable to develop, implement, and fill a pipeline for preservice teachers who can teach computer science.

Represented in the workshop were institutions who currently serve 9,357 students preparing for, or expanding their knowledge of, the classroom. With the expansion of computer science into public schools, it is important that preservice programs expand to include coursework and potentially certification pathways to prepare teachers for CS and CS-integrated classrooms.

5.2 Introduction to CS4All

Although there has been significant media and press coverage of CS4All, there has been little description of the structure of the initiative and the details of the 10 year plan. In this session, Leigh Ann DeLyser presented a detailed description of the CS4All strategic initiative to clarify the goals
### Table 5.1: Event Attendees

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
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<tr>
<td>Alice Artz</td>
<td>Queens College</td>
<td>Education</td>
<td>Professor of Mathematics Education</td>
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<td>Lauren Birney</td>
<td>Pace University</td>
<td>Education</td>
<td>Professor of STEM Education</td>
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<td>Ric Campbell</td>
<td>South Bronx Early College Academy (former Bard College)</td>
<td>Education</td>
<td>Executive Director (Former Dean)</td>
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<td>Kara Chesal</td>
<td>NYC DOE</td>
<td>CS4All</td>
<td>Sr. Director, Strategic Partnerships and Industry Engagement</td>
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<td>Cass Conrad</td>
<td>City University of NY</td>
<td>School Support and Development</td>
<td>Executive Director</td>
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<td>Leigh Ann DeLyser</td>
<td>CSNYC</td>
<td>N/A</td>
<td>Dir of Education and Research</td>
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<td>Harriet Fayne</td>
<td>Lehman College</td>
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<td>Dean of Education</td>
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<td>Orit Hazzan</td>
<td>Cornell Tech &amp; Technion</td>
<td>Education</td>
<td>Professor</td>
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<td>Johnathan Hill</td>
<td>Pace University</td>
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<td>Maya Israel</td>
<td>University of Illinois at Urbana Champaign</td>
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<td>Lecturer</td>
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<td>Jasmine Ma</td>
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<td>Craig Michaels</td>
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<td>Aaron Pallas</td>
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<td>Education</td>
<td>Professor of Sociology and Education</td>
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<td>Marta Panero</td>
<td>New York Institute of Technology</td>
<td>School of Eng. and CS</td>
<td>Director, Strategic Partnerships</td>
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<td>Wesley Pitts</td>
<td>Lehman College</td>
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<td>Deputy Chair/Program Coordinator</td>
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<td>Michael Preston</td>
<td>N/A</td>
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<td>William Sakas</td>
<td>Hunter College</td>
<td>Computer Science</td>
<td>Department Chair</td>
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<td>Nicole Simon</td>
<td>John Jay College</td>
<td>Computer Science</td>
<td>Deputy Director of Strategic Initiatives</td>
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<td>Ashleigh Thompson</td>
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<td>University Dean for Education</td>
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<td>Mike Zamansky</td>
<td>Hunter College</td>
<td>Computer Science</td>
<td>Coordinator of CS Education</td>
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and outcomes. This section provides a brief overview of the material presented at the workshop. More detail of the CS4All initiative can be found in [DeL14; DP15].

The CS4All initiative is a policy answer to both a moral and economic imperative. The lack of access to computer science education affects both the economy and industry in NYC, as well as
students in different communities disproportionately. The lens of diversity is important in NYC both for political and historic reasons. NYC schools are some of the most segregated schools in the nation [15]. From AP CS data collected in 2012, the students with access to, and taking, CS classes were not representative of the populations of students in the district1.

Although NYC has over 430 high schools, over half of the students who took the AP Computer Science A exam in NYC in 2012 came from three high schools. In addition, the gender and ethnic breakdown of students taking the APCS did not well represent the general population in NYC. A majority of the APCS test takers were Asian (58%) or White (22%), when those two sub-populations combined make up only 30% of the student population in NYC public schools. Additionally, although girls are 49% of the total school population, they represent only 29% of test-takers.

CS4All seeks to address these inequities through a 10-year, $81 Million dollar initiative to offer computer science in every school in NYC. Primarily, the effort is a teacher training initiative, with a goal of providing between 30 and 100 hours of professional development to nearly 5,000 teachers. The goal is to train an increasing number of teachers every year, reaching the full number of teachers by 2025. In addition to the teacher training efforts, a robust evaluation of the project will be undertaken through a proposal process beginning in the late spring of 2016. The selected evaluator will be responsible for assessing the roll-out and impact of CS4All, especially with regards to the equitable access to CS for target sub-populations.

Owing to the meeting’s focus on post-secondary engagement, the presentation covered specific ways post-secondary institutions could contribute to CS4All, including developing preservice programs for future computer science teachers, creating clear pathways for students who studied CS in school and would like to continue at the college level, and training teachers in short cycle PD by hosting workshops.

5.3 Presentation of CS Education Programs (NY and Israel)

Queens College, Lehman College, Brooklyn College, and the Technion presented during the presentation of CS Education programs from NYC and Israel. The full description of the programs from Queens, Lehman, and Brooklyn is available in section 4 of this report. Orit Hazzan, professor of computer science and software engineering education at the Technion, presented on the state of CS Education in Israel. The CS education programs presented are described in Section 4 of this report.

5.4 Opportunities for Funding

The design and development of new academic programs at the postsecondary level often require funding for curriculum development and new faculty. To support institutions in this work, CSNYC presented a session on Opportunities for Funding in order to highlight funding opportunities from the National Science Foundation as well as Departments of Education in order to help defray the costs of initiating preservice teacher programs in Computer Science Education.

5.4.1 National Science Foundation

At the time of the workshop, the National Science Foundation (NSF) had recently released their computer science education focused Dear Colleague letter2. The letter called for 5 particular areas

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1We recognize that APCS data is not complete, and offer it here as a singular data point and not a complete picture of CS in NYC

Chapter 5. Event Summary

of focus including (emphasis added by Leigh Ann DeLyser for presentation purposes):

- **models of preservice preparation** for teachers who will teach computer science and computational thinking;
- scalable and sustainable **models of professional development** and ongoing support for teachers;
- **tools and models for teaching** and learning aimed at supporting student success and inclusion in computing within and across diverse populations;
- **instructional materials and high-quality learning opportunities** for teaching CS and, especially at the elementary and middle school levels, for integrating computational thinking into STEM teaching and learning; and
- collaborations and partnerships that support **integration of computing and computational thinking in K-12 STEM** curricula and instruction.

To boost efforts in these areas, the federal government has committed $120 million over the next 5 years to CS education research. This commitment spans multiple NSF programs including: STEM+C, DRK-12, ITEST, Cyberlearning, EHR Core, Noyce, and additional EAGER, supplements, and conference funding from PPAG. CSNYC offered to partner or write letters of support for any programs addressing the need for CS teachers in NYC with one of these programs.

Additionally, the United States Department of Education (US DOE) proposed and committed various funds to the CSforAll national initiative\(^3\). The most well known of the funding is the proposed $4 billion budget proposal. This proposal would support teacher training over a 3 year period to explicitly increase the number of CS teachers in the US. Additionally, the US DOE has set aside $100 million in competitive CSforAll development grants available to districts to support the expansion of CS education.

These funding opportunities are excellent ways for colleges to help identify critical curricular pathways for initiating CS education programs, and can help defray the local costs in starting programs. Ultimately, the goal is for CS education programs to become an integrated part of the university and have general tuition dollars and university funds provide the necessary support for long-term implementation.

\(^3\)http://innovation.ed.gov/what-we-do/stem/computer-science-for-all/ and http://innovation.ed.gov/2015/12/07/a-new-chapter-for-computer-science-education/
6.1 Perspective from Israel

By Orit Hazzan, Senior Lecturer, Department of Education in Technology and Science, Technion – Israel Institute of Technology

In March 2016, I began a few months’ stay in New York City to study the ecosystem of computer science (CS) education at both the K-12 and higher education levels. Prior to my arrival, I had heard about the city’s Computer Science for All (CS4All) initiative and saw the attention that CS education was receiving nationally and in NYC. Because the city’s population is similar in size to Israel’s, I could understand the challenge faced by the CS4All partnership to ensure that all of NYC’s 1.1 million public school students would have access to a high-quality CS education that puts them on a pathway to college and career success.

Luckily, NYC can learn from the experience of other places in the world. Israel, for example, is known as a leading country in CS education on all levels, and especially high school (Tucker et al., 2003), with broad participation across ethnicities (Eidelman and Hazzan, 2008). Specifically, we identified five elements that makes CS education a success: a well-defined curriculum; a mandatory CS teaching license; teacher preparation programs; a national center for CS teachers; and research in CS education (Hazzan, Lapidot and Ragonis, 2015). Academia, it turns out, has a major role in positioning Israel as a leader in CS education at the K-12 level by offering CS teacher preparation programs and fostering advanced research on CS education (Hazzan, Gal-Ezer and Blum, 2008).

Therefore, I was happy to hear that the CS4All initiative will focus on CS teacher preparation, and I was honored to present the Israeli perspective at the Building a Computer Science Teacher Pipeline for New York City workshop. Recognition of the need for adequate CS teacher preparation programs is extremely important because it has been recognized worldwide that “the quality of an education system cannot exceed the quality of its teachers.”

From our experience in Israel, it seems that three barriers still exist: teaching certification, designated CS teacher preparation programs, and content knowledge in CS, on which I elaborate.

1. **Teaching certification**: If teaching certification is not a mandatory requirement for teaching CS, teachers will not have the motivation to acquire it. Indeed, as Dr. Leigh Ann DeLyser...
clearly declares in this report, “To say that CS education has a ‘chicken and egg’ problem is an understatement. National organizations and the news media have bemoaned the lack of a viable certification or preparation pathway for computer science teachers.”

2. **Designated CS teacher preparation programs**: A report written by a special Computer Science Teachers Association (CSTA) task force states, “Teachers must acquire both a mastery of the subject matter and the pedagogical skills that will allow them to present the material to students at appropriate levels.” (Tucker et al., 2004, p. 18). This report also recommends defining standards for CS teaching licensing, a fact that, in itself, will eventually determine the contents of CS teacher preparation programs. The message sent by the 2004 CSTA report is also reinforced in another CSTA report that states, “The lack of consistent and readily available information concerning certification requirements make it almost impossible to determine how one should go about preparing [to] such a career” (Stephenson et al., 2005, p.20). Hazzan, Gal-Ezer and Ragonis (2010) propose the Establishment of Computer Science Teacher Preparation Program (ECSTPP) workshop targeted at computer scientists and CS curriculum developers interested in launching CS teacher preparation programs at their universities but lacking knowledge about the actual construction of such programs.

3. **Content knowledge in CS**: Shulman (1986) asserts that teachers need actual content knowledge in addition to Pedagogical Content Knowledge (PCK). Therefore, it is recommended that the CS4ALL initiative include computer scientists (in addition to teachers, educational researchers and administrative authorities) who express interest in CS education and can share their CS knowledge. Their role in the CS4ALL initiative would be to teach potential teachers the relevant CS content in parallel to the introduction of CS-related PCK. Furthermore, when CS material is introduced to teachers, it would be natural to demonstrate a variety of teaching methods (that is, PCK) relevant to the content.

These recommendations may mislead and give the impression that it is almost impossible to accomplish the goals of CS4All. This, however, is incorrect. There are thousands of initiatives around the world and within the US on which the local CS education community can rely. Indeed, in NYC the goal is not to implement a single framework for all; rather, the intention is to let each school decide what program fits its specific student and teacher population and to assimilate the program in a way that fits its culture and environment.

Furthermore, there are dozens of supporting organizations from all sectors—academia, industry and public sector—that will be eager to contribute to the success of the initiative. Some of them bring CS content knowledge; other bring the pedagogical knowledge; still others bring the needed organizational knowledge. With a supportive and collaborative system that exposes students to a diverse group of role models, NYC cannot help but succeed in achieving its goals. As I see it, research and evaluation efforts will vividly articulate the initiative’s challenges and achievements and help NYC become a model for other places that hope to initiate a similar transition in their educational systems.

### 6.2 Summary

The desire for rapid expansion in CS education has lead to a movement of short-cycle professional development outpacing the creation of more traditional preservice pathways. A variety of public and private funding has supported the professional development initiatives. Without a self sustainable pipeline of CS teachers, however, the United States may find itself back in a position where CS teachers are in short supply in a few short years.
This report details a one-day workshop focused on existing and proposed preservice programs for CS teachers in NYC. These programs are in various states of development, and may or may not lead to teacher state certification. It is the hope that sharing these models will help start the conversation at other institutions around community needs for CS teachers, appropriate preparation coursework, and the needs of schools.

CSNYC anticipates future events to discuss these matters and welcomes interested parties to contact the author, join the CS Education Meetup Group¹, or follow our newsletter².

¹http://www.meetup.com/csnyc-education-meetup/
²https://medium.com/@csnyc


