The Academy for Software Engineering: Coding for Every NYC Student

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Abstract
The Academy for Software Engineering is a public unscreened high school in New York City (NYC). In our mission to provide meaningful computer science for every child, we are focused on identifying appropriate instructional outcomes, best pedagogical practices, and techniques for addressing a diverse student body. Over the past three years the academy has grown to include over 350 students who are representative of the NYC public school demographics, in ethnicity, socioeconomic status, and measures of academic preparation (8th grade math and ELA assessment scores). In this position paper we unpack the mission statement focusing on the components of "Every Child", "Computer Science" and "meaningful". In this paper we take a position emphasizing real world connections, learning objective decomposition, and differentiated assessment. We also present research challenges associated with educating a general school population.

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Introduction
In 1980, Seymour Papert wrote "In my own research I've demonstrated that most children who have access to such computers will learn to program them as well, thus acquiring intellectual skills that go beyond what is now being taught in schools."[1] Despite Papert's predictions, the current generation of students have increasing access to computers at school, at home, and even in their pocket. Yet, the nation is entering a period where we cannot find enough skilled professionals, the adults these children grow into, who have programming skills to fill the available jobs. The US Bureau of Labor Statistics estimates that should current trends continue, by 2020 there will be 1 million more technical jobs in the US than people with appropriate skills.

In addition to the employment statistics, many people argue that reasoning (and computing as the practical application of that skill) is the 4th "R" and should make its way into the definition of a literate citizen, regardless of their occupational training. The inclusion of computing for all children has been discussed for the past 35 years, beginning with Papert in the 1980s, and continuing today with the work of code.org, and in NYC

by the NYC Foundation for CS Education (CSNYC). Unlike Papert's time, students do not only need reasoning skills for possible transfer to other domains, now these skills pervade every discipline, every company. Websites, apps, and the use and interpretation of data is important for almost every industry in the modern global economy, and in NYC 21% of employers employ "tech talent" specifically [2]. These skills and concepts have real meaning for all members of the digital society.

In 2012 the NYC Department of Education, in partnership with Fred Wilson of Union Square Ventures, opened the Academy for Software Engineering [3], a public high school with the mission of providing a meaningful experience in Computer Science for every child who enrolls in the school. In this paper we attempt to unpack the mission of the school, focusing specifically on three components of the mission, Every Child, Computer Science, and Meaningful Experience as it relates to AFSE. In this paper we hope to clarify some of the challenges of working in K12 for computer science education researchers, policy makers, educational technology companies and non-profits who are attempting to address the myriad of issues facing computer science education.

Every Child

The Academy for Software Engineering (AFSE) is a NYC public, non-selective high school. NYC students have school choice in 8th grade, having the ability to rank up to 12 schools they would like to attend. As a non-selective, or unscreened, high school, AFSE does not evaluate potential students based on academic performance. Instead, priority is given to students who attend an open house showing interest in the school, and students who live in Manhattan, the location of the school, are also given priority. With the location-based priority, approximately 50% of AFSE students come from Manhattan, and the remaining students come from the other 4 boroughs. In the recruitment for the freshman class starting in the fall of 2015, over 2400 students listed AFSE as one of the 12 schools on their school choice form.

Although students at AFSE are self-selected, the demographics of incoming 9th grade students are representative of the larger NYC non-selective high school population. Currently, AFSE students are 45.5% hispanic, 28.7% African American, 9.6% Asian, and 9.1% Caucasian. In terms of prior academic performance, AFSE students are also representative of NYC non-selective 9th grade students. Of the students entering 9th grade at AFSE in 2014 less than half of students achieved an 8th grade level in English Language Arts and slightly more than half achieved an 8th grade level in mathematics on end of year assessments in 8th grade.

Students attending AFSE have very different prior experiences with computer science, and technology in general. The school has no required prerequisites and we assume that students have had no prior experience with computer science. Despite the challenges of working with a diverse population, AFSE offers a 9th grade introductory course in computer science for every student enrolled at the school. Throughout the course we use differentiated assessment, not differentiated instruction, to provide entry points for each student with the discipline of computer science. Each student receives the same instruction, and all students have the same "entry points" for assignments. Each assignment is differentiated at the upper end, as students work through expansions that align with levels of Bloom's Taxonomy they increase their grade for the assignment as they have demonstrated deeper mastery of the content.

In Computer Science

AFSE is trying to marry rigorous CS/software engineering skills students require to write complex code with the opportunity to produce artifacts that are meaningful, creative, and relevant to the population of students we serve. To that end, we've devised a

curriculum framework for thinking about CS instruction in all classes. In particular, at AFSE we categorize all curricular objectives into 5 large categories. These categories extend across all CS/Software Engineering classes at the school and are meant to provide a framework for student experiences that appropriately reflect the demands of CS/software engineering outside the school. The AFSE Curriculum Framework categories are as follow:

1. *Project Management & General Engineering Practice*
2. *Professional Behavior*
3. *Computational (Algorithmic) Thinking*
4. *Problem Solving*
5. *Role of Computers in Society*

Within that framework the teachers at AFSE work to decompose topics, especially in Computational (Algorithmic) Thinking. A specific example is the decomposition of conditionals (if statements) into three distinct learning objectives.

1. Predict the output of a program by tracing through non-nested (and possibly single nested) conditionals.
2. Identify the conditionals necessary to implement a program (in natural language).
3. Provided the conditionals (in natural language) necessary to implement a program, construct the code to implement the program.

This careful decomposition of objectives is an important part of addressing Computer Science as it applies to all students at AFSE. Each of the three above outcomes are measured separately by assessments (both formative and summative) and help teachers identify specific weaknesses in student thinking and habits in order to provide ongoing individualized support.

Meaningful Experience

There are many competing ideas for "meaningful experiences" with regards to computer science classes. AFSE is a Career and Technical Education (CTE) school focused on computer science and software engineering and our definition of meaningful focuses on bringing authentic experiences to students through the use of professionals and connections to the professional community, authenticity of projects and process, and appropriate rigor for students.

As a CTE school students are required to engage in work based learning (WBL) activities. At AFSE students are each paired with a mentor in their 9th grade year, through a program called iMentor. Additionally, we bring speakers into classrooms and take field trips to companies in order to connect students to real workplaces.

A second component of meaningful experiences for students is authenticity of projects and process. Projects are designed to allow student self expression in a structured assignment, or are focused around common themes of student interest (games, movies, music, etc.). At AFSE we use a modified agile software process for all of our assignments, requiring students to plan, build, test (often with peer feedback) and reflect on the projects they create.

Finally, we believe in rigor. In addition to creating programs where students can work together and are encouraged to seek help from each other, students prepare for and take paper and pencil assessments (tests) to measure skills and progress. Students increase their confidence when they earn passing or high test scores and can demonstrate the skills they learn.

Research Challenges

Although we acknowledge the broad diversity of potential research topics for CS education, here we focus on the questions that arise specifically from the mission of AFSE which we feel are broadly generalizable to the community. Much of the current research into the pedagogical approaches of teaching CS, available largely in the SIGCSE community, has focused on a screened or highly self selected group. College

students majoring in computer science, or summer programs that include an application process, even if they target underrepresented student populations, do not represent the realities of educating every child. Additionally, although the Academy for Software Engineering does include a significant portion of students who are interested in studying computer science as a major in college, there are still students at the school who were matched because their primary choices were full, a parent pushed the student to list the school on the student's form, or were matched late in the summer to fill seats left by students who chose not to attend for a variety of reasons. The success of the school only magnifies this effect, as many students, parents, and guidance counselors are simply looking for "good" public schools for their students to attend regardless of specialization or interest. Approximately 40% of our students report that they do not wish to major in CS after high school, although many plan to minor in CS or pursue another STEM degree.

If the CS Education community is to advocate for computer science for every child, or "Every Child a Coder", we must explore the impact of coding a non-selective, previously uninterested group of students. The correct pedagogical approaches and assessment metrics should be tailored to fit the needs of the broader population and not the individual programs seeking validation. We believe the following major research questions are currently unanswered, and will be exploring some of these questions in partnership with the NYC Foundation for CS Education (CSNYC) in the coming years.

- How do we evaluate students with a wide variety of backgrounds against some common metric? (This challenge should also include students not reading/writing on grade level.)
- External validation - Aside from the AP exam what is the validated assessment? AP is by definition post-secondary, what is appropriate for HS CS?
- What are appropriate pedagogical practices that will make CS an accessible subject for all students?
- What is the appropriate level of teacher preparation for integrative coursework? (How much does an English, History, Mathematics, or Science teacher need to understand in order to appropriately facilitate interdisciplinary lessons containing CS?)

Conclusions

In this paper we take the approach that "Every Child a Coder" and the mission of AFSE to provide a "meaningful experience in computer science for every child" are complimentary and aligned. We have decomposed our mission into three components, focusing on the student population, the academic content, and the engagement with the curriculum. As a part of our presentation we will share more details about the program and its implementation.

References

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