A MOOC-based Professional Development Model for CS Principles

*Ralph Morelli, †Chinma Uche, *Pauline Lake, ‡Lawrence Baldwin, ‡Jennifer Rosato, ‡Chery Takkunen

*Trinity College
‡College of St. Scholastica
†Computer Science Teachers Association of Connecticut
‡Baldwin Institutional Research

Abstract. In an effort to address the relative lack of interest in computer science at the high school level, the National Science Foundation has supported the development of new College Board Advanced Placement (AP) course, Computer Science Principles, designed to appeal to a broader range of students, including girls and underrepresented minorities. The Mobile Computer Science Principles project (Mobile CSP) is an NSF-funded effort to prepare high school teachers to teach the CS Principles course when it becomes an official AP course in 2016-17. It employs a highly scalable MOOC-based professional development (PD) model that has proved to be effective at providing teachers with the content knowledge and confidence needed to teach the CSP course.

Introduction

The crisis in computer science education has been well articulated. Despite our dependence on computing in virtually all aspects of contemporary life, the U.S. graduated fewer CS majors proportionally in 2012 than it did in 1986; in 1986, 4.2% of all bachelor degrees awarded were in computer and information science, whereas in 2012 only 2.6% were.[1] Similarly, according to statistics compiled by Code.org, based on Bureau of Labor Statistics projections, 2/3 or all new jobs in STEM fields will be in computing-related occupations. Yet, only 7.5% of STEM graduates study computer science. Despite the clear need for a well-trained computing workforce and the obvious need for well-educated citizens to be able to use and understanding computing, fewer than 1 in 4 U.S. schools offer computer science courses that include programming.[2]

In order to address this crisis the National Science Foundation has undertaken two related initiatives: (1) Since 2009, it has supported the creation by the College Board of a new AP-level computer science course, the Computer Science Principles course[3], and (2), since 2011 its CS 10K initiative has supported an effort to train 10,000 high school computer science teachers[4].

The goal of the CS Principles (CSP) project has been to create a broadly accessible introductory computing course designed to increase participation in computer science by attracting more high school girls and underrepresented minorities to the discipline. Rather than focusing entirely on programming – as does the current AP Computer Science A course – CSP is based on a language-neutral curricular framework that emphasizes seven *big computing ideas* (creativity, abstraction, data and information, algorithms, programming, the Internet, global impact) and six computational thinking

practices (connecting computing, creating computational artifacts, abstracting, analyzing problems and artifacts, communicating, and collaborating).

The Mobile CSP project (mobile-csp.org) has been involved in both NSF-supported efforts – the CS Principles project and the CS 10K initiative. The Mobile CSP course began an undergraduate course at Trinity College in Spring 2011. The motivation behind the course was to capitalize on student interest in their mobile phones as a way of getting them engaged in computer science. The course uses App Inventor (appinventor.mit.edu), an innovative blocks-based programming language, that makes it possible for novices to create sophisticated mobile apps for Android devices (Figure 1).

In 2011-2012 the Trinity course was piloted as an College Board CS Principle course, where it was offered concurrently at Trinity College and as a year-long course at a local high school, the Greater Hartford Academy of Math and Science (GHAMAS). It proved to be highly successful at attracting and engaging the type of students who had otherwise avoided computer science.

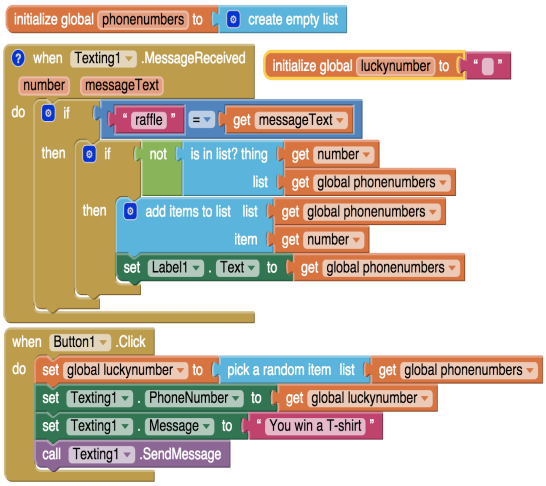

Figure 1: An App Inventor raffle app.

With the support of NSF funding starting in 2013, the Mobile CSP project has now trained 38 Connecticut high school teachers, from a wide range of disciplines, almost all of whom have gone on to successfully teach the Mobile CSP course in their schools.

In summer 2014, in collaboration with colleagues at the College of St. Scholastica (CSS) in Minnesota, the Mobile CSP course was ported to Google Course Builder (GCB), an open source massive open online course (MOOC) platform. In summer 2015, with additional NSF-funding support through a grant to CSS and through several smaller Google CS4HS grants, the Mobile CSP project trained approximately 100 high school teachers, almost 60 of whom are currently teaching the course in their schools.

Currently, the Mobile CSP project is a combined effort between Trinity College and the College of St. Scholastica (CSS). Together, we offer a MOOC-based course and professional development process that has the potential to train a significant number of high school teachers at U.S. schools that intend to teach the AP CS Principles course when it comes online beginning in 2016-17.

The Mobile CSP Professional Development (PD) Model

Because there are so few qualified computer science teachers in the U.S., the PD model must be capable of working for teachers from a wide range of disciplines. This is not like training Biology teachers to teach AP-Biology. For example, among the 38 Connecticut teachers trained so far, the following disciplines were represented: Math (15), Tech Ed (9), Science (3), Business (3), Social Studies (2), Vocational (2), English (2), Art (2). Of these, only 18 (48%) had prior experience teaching a computer science course at the high school level and 11 (30%) had no prior programming experience at all. Thus, the PD has to focus on computer science content – i.e., teachers need to be taught enough computer science in the PD to feel confident that they can teach the course to their students.

In its current form the Mobile CSP course consists of approximately 60 lessons hosted on the MOOC platform, half of which are programming[5] – or app development – lessons, while the other half are non-programming CS Principles lessons[6]. The MOOC-hosted lessons contain all resources needed to teach the course and they serve a dual purpose: they are used to train the teachers and then used by the teachers in their classrooms.

Our PD approach has been to focus on course content. For the first two years of the project, teachers were enrolled in a 6-week summer PD course[a] that covered the entire Mobile CSP curriculum. A typical PD lesson involves two parts: (1) Teachers work through the classroom lesson individually or in pairs, (2) Teachers review and discuss the lesson plan and resources that accompany the classroom lesson.

The lessons and lesson plans are organized into parallel branches on the MOOC, a student-facing branch (https://ram8647.appspot.com/mobileCSP) for classroom use, and teach-facing branch (https://ram8647.appspot.com/teach_mobileCSP) that is only available to the teacher. Each of the individual content lessons contain numerous self-test exercises, giving teachers ample opportunity to assess their understanding of the material. Also, for every content lesson, teachers are asked to assess their confidence in their ability to teach that lesson using the curriculum and resources provided.

As described below, we have found this PD approach to be effective: teachers express confidence in their ability to teach the individual lessons and score well on the final exam that is administered at the end of the summer course.

MOOC-based Course and PD

The fact that the course is MOOC-based makes it possible to offer PD for teachers in a variety of formats:

a Because a 6-week, full-time commitment is difficult for many teachers, we will be shortening the PD to a 4-week course in summer 2016.

- **In-person.** Teachers meet in-person for the full duration of the course, which is facilitated by a college computer science instructor or master teacher. Mentoring is provided by experienced teachers.

- **Hybrid (online and in-person)**. Teachers meet in-person for only part of the PD course and participate online for the remaining part. The in-person meetings are facilitated by a college computer science instructor or master teacher. Mentoring is provided by experienced teachers.

- **Online Paced PD**. Teachers work entirely online but at the same pace and concurrently with the hybrid sessions. Teachers are mentored by project staff and experienced Mobile CSP teachers.

- **Online Self-paced PD.** Teachers work entirely online but at their own pace. Mentoring is provided by the community.

In summer 2015, and to a less formal degree in summer 2014, we experimented with several of these formats. The primary PD was held for 12 teachers at Trinity College in Hartford, CT, facilitated by the Trinity Mobile CSP PIs and staff. Weeks 1, 3 and 6 were conducted in-person and weeks 2, 4 and 5 were conducted online[b].

During the same time period, three satellite hybrid PD's were held in San Francisco, Manchester, NH, and Boston, MA for a total of 47 teachers. These were facilitated by collaborating college faculty or, in one case, by a master teacher. On many occasions teachers at the satellite locations participated virtually, via Google Hangout on Air, in the Trinity PD, which was broadcast during those weeks when the Trinity session was meeting in-person.

In addition to the hybrid PD's, a concurrent *paced* online PD was held for 41 teachers around the U.S. who were mentored by experienced Mobile CSP teachers in small groups of 10 or fewer. Of the 100 teachers who participated in these various PD's, 53 (the Trinity cohort plus the 41 in the paced online cohort) were committed to teaching the course during the 2015-16 school year. Currently 44 of these teachers are teaching the course and sharing student demographic and performance data with the project. Teachers in the satellite PD's, which were supported by Google CS4HS grants, were not necessarily committed to teaching the course and are not sharing data with the project.

Finally, the Mobile CSP MOOC is open and is always freely available in self-paced mode. An undetermined number of teachers have participated in the PD in this manner.

b The classroom was available for teachers to meet together on their own if they were interested in doing that. Several teachers took advantage of that opportunity for at least some of the online weeks.

Results

The MOOC-based PD been effective at achieving its two primary goals: (1) giving teachers from a wide range of disciplines the confidence to teach the Mobile CSP course, and (2) giving teachers the basic content knowledge needed to teach the course.

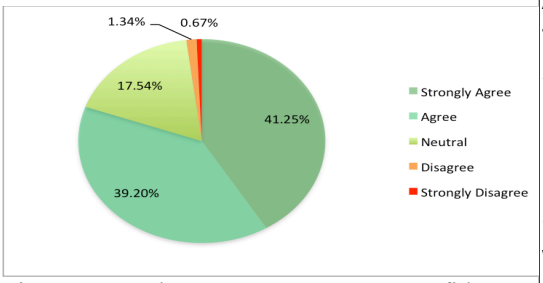

Figure 3: Teacher responses to "I am confident I can teach this lesson."

At the end of each lesson during the PD, teachers were asked to respond to the statement, "I am confident I can teach this lesson." Figure 2 shows the breakdown of the responses received from teachers who have used the MOOC since 2014.[c] Overall, confidence levels in the PD itself are very high, with only 2% of the responses displaying a lack of confidence.

At the end of the PD teachers are given a final exam – the same exam that Mobile CSP students take. In 2015 the average score among the online cohort was 89%; for the Trinity cohort it was 88%. In 2014, the scores were similar – 92% for the online cohort and 84% for the Trinity cohort. These scores are significantly higher than student averages, which was 72% among the 500+ students in the 2014-15 cohort. Teacher performance on the final exam and on other aspects of the course – e.g., on the programming projects -- provides some evidence that they are mastering the course content during the PD. Also, the fact that the scores of online participants are about the same as those for the in-person cohort provides some evidence, at least, that the online PD is no less effective than the models that involve face-to-face instruction.

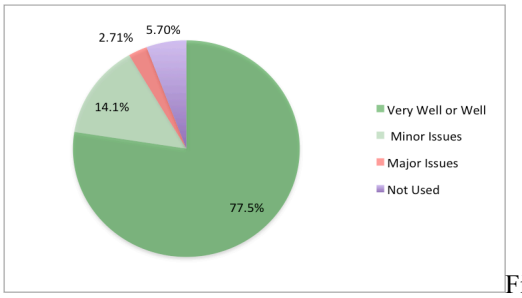

Figure 2: Teacher rating of the effectiveness of classroom use of Mobile CSP lessons -- "How well did this lesson work?"

Finally, we also asked teachers to rate the effectiveness of the lessons that they used in the classroom. For each of the lessons in the curriculum we asked teachers to tell us whether they used the lesson in class or not and then how well it worked. Responses were received from the 23 teachers in the 2014-15 Trinity cohort – a total of 1105 responses for 47 lessons.

All of the lessons were used by at least some of the teachers. Only 7% of the 1105 responses

c A total of 7316 responses were received from the many teachers who have used the online PD since its inception in 2014. That's an average of 130 responses for each of the 56 lessons in the PD. Responses are optional.

were that a particular lesson was not used. As Figure 3 shows, teachers reported having success with the lessons in the classrooms, with less than 3% of the responses reporting major issues.

Conclusion

Mobile CSP's MOOC-based PD model has achieved some success in training more than 150 teachers over the past three years. Among the chief benefits the MOOC-based approach are the following:

- **Temporal and Geographical Flexibility**. Teachers have options that better fit their summer schedules and geographic situation. In urban locations, where a sufficient number of teachers can be found, an in-person or hybrid PD can be organized. For teachers from rural areas or where there are insufficient numbers to justify a local PD, the online option is available.

- **Experiencing the Complete Curriculum.** Teachers are taking and reflecting upon the same lessons that they will teach to their students. All classroom materials and resources are hosted on the MOOC platform and teachers have several options for how they can use the materials.

- **Unified Community of Practice.** The fact that all teachers are working on the same materials, at the same pace, allows for a strong community to emerge where teachers help and support each other. This community gets created during the summer and persists throughout the school years.

For the 2016-17 school year we plan to offer the Mobile CSP PD in a hybrid format at several geographic locations in the U.S. but also online, for teachers who prefer or are otherwise unable to attend one of the in-person PD's.

Bibliography

1. Bachelors degrees conferred by postsecondary institutions, 1970-71 through 2011-12, *National Center for Education Statistics,* http://nces.ed.gov/programs/digest/d13/tables/dt13_322.10.asp.
2. Summary of source data for Code.org infographics and stats, Code.org, https://code.org/promote.
3. CS Principles Project, http://csprinciples.org.
4. National Science Foundation, *STEM-C Partnerships: Computing Education for the 21st Century,* https://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503582.
5. Mobile CSP App Inventor Programming Lessons, https://docs.google.com/document/d/1tTPjFQNbkzFurF4BEc0lyQrAcGiccalQ_6jQSo2128s.
6. Mobile CSP Computer Science Principles Lessons, https://docs.google.com/document/d/1hZ6BqqsMzjeOTc6HeRGmCcyBhP60bpw4t32oyscvxSY.

Acknowledgment. This work is supported in part by NSF grants CNS-1240841, CNS1440947, TUES-1225976 as well as grants from Google's CS4HS program.