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A Sustainable Model for High-School Teacher Preparation in Computer Science

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***Abstract*—In this Research to Practice paper, we present a sustainable model for teaching training in Computer Science. To address issues related to self-efficacy and teacher preparation, we started a formal program (IDoCode) that not only provides teacher training through the academic year, but also provides teachers the opportunity to obtain a *Masters in STEM Education* degree or a *Graduate Certificate in Computer Science Teacher Endorsement*.**

Through our program, we have shown that teachers feel more confident in their ability to teach computer science courses such as Exploring CS, AP CS Principles, and the Java-based AP CS A, as well as leading the students in a capstone project. In this paper, we present a sustainable approach to make a cultural change in the landscape of Computer Science education in the state of Idaho. We discuss various factors including working with the State Board of Education, local software companies, the university, and other invested partners to help CS courses in high school count towards graduation. We have also been active with respect to community engagement by organizing an annual meeting with counselors and principals to encourage women and minorities to take computer science courses and conducting summer

***Index Terms*—higher education, teacher training, professional development, self-efficacy**

I. Introduction

The introduction of computer science education at the high school level has received considerable attention in recent years from industry, students and parents, federal and state governments, universities, and school districts. There are several challenges in creating *sustainable* and self-perpetuating computer science education in high schools. These challenges require a comprehensive approach to lobbying at the state level for policy changes, certification and funding, creating awareness with administrators in school districts and state departments of education, outreach to students and parents and most importantly, sustainable and incentivized teacher training programs.

In this paper, we present our approach to affecting comprehensive change in the landscape of high-school Computer Science Education in Idaho through the IDoCode project. We address the above mentioned challenges, the pitfalls encountered, and lessons learned in the process. We provide details regarding the elements we found necessary to achieve success - i.e. long-term, significant increases in the number of students taking computer science courses at the high school level. We discovered that the effort required to affect systemic change in the number of students taking Computer Science (CS) courses in K-12 is non-trivial, and requires a holistic approach that includes:

- *Understanding and actively addressing barriers and resource constraints* for teachers and school districts in offering CS courses
- *Identifying the key relationships* that must be cultivated
- Knowing how to influence each of the key constituents and *recruiting them to your cause*
- *Navigating the political landscape* and minefields that are necessary in order to effect formal change at the state level

Perhaps the most important key to success is *developing a sustainable, ongoing pipeline for rigorous training of in-service and pre-service teachers to teach computer science courses*. This is crucial since the ability to roll out a high-quality, state-wide set of CS courses in K-12 is primarily limited by the *pool of qualified teachers* who can teach those CS courses. To achieve this, we chose to develop undergraduate pre-service and multiple graduate in-service training programs. Both the undergraduate and graduate degrees provide prospective teachers with comprehensive training for teaching CS, and are more rigorous and provide better preparation that goes

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beyond summer workshops or one-time training sessions. We have also supported the creation of a community of practice [1] through a variety of events that are discussed later in the paper.

Seventy-four teachers have participated in the program to date in five cohorts. Additionally, we have worked with 8 associates, having prior CS training, to bring the new *Exploring CS* and *AP CS Principles* curriculum to their schools.

We have worked closely with our teachers and their school districts so they can begin teaching the CS courses they are qualified to teach prior to completing the IDoCode program. During the 2016-2017 school year, we had 24 teachers, teaching computer science courses to 22 high schools to over 1200 students. This is significantly more than the 60 students that were taking CS courses in three high schools during the 2013-2014 academic year, when the IDoCode project started.

II. Approach

The IDoCode undergraduate Computer Science Bachelors program with a Secondary Education emphasis was established as part of the IDoTeach teacher training program at Boise State University. This teacher training program is a replication program that is part of the UTeach network [2]. We created a four-year CS bachelors degree designed for pre-service teachers that incorporates additional education courses to prepare teachers to teach CS. Additionally, we designed a graduate program that is a 35-credit Masters of STEM Education (MS STEM) with a Computer Science Emphasis. The graduate degree is designed for in-service teachers, and piggybacks on introductory undergraduate CS courses, adding pedagogical considerations in separate paired seminar sections.

We had envisioned that a Master's program would be attractive to in-service teachers since it also led to a salary increase based on the salary guidelines of the State Board of Education in Idaho. We realized very soon that a number of teachers in the first cohort already had a masters degree. We also found that many students were not able to dedicate as much time as it would take to complete a Masters program with a thesis requirement and a higher course load. Our main goal was to successfully prepare secondary teachers to teach Computer Science and so we created a 20-credit *Graduate Certificate - Computer Science Teacher Endorsement* beginning in the Fall 2015 semester.

Since the Graduate Certificate and MS STEM programs can take anywhere between 19 months to more than three years to complete, we encouraged the teachers and districts to begin teaching computer science classes using the new curriculum as soon as possible - preferably after completing the first graduate course. For example, each new cohort starts in the summer with the "AP Computer Science Principles" course. Upon completion of this course, a teacher is prepared to teach an introductory CS course such as *Exploring Computer Science* [3] course or *AP CS Principles* to their students in the fall semester (**NOTE**: this requires advanced planning with the district to add the course to their course offering and register students prior to the teacher beginning the IDoCode program study). Once a teacher completes the "Teaching and Learning Computer Science I" course from our curriculum they are prepared to teach the *AP Computer Science Principles* course and upon completion of the "Teaching and Learning Computer Science II" course the teacher is prepared to teach the Java-based *AP Computer Science A* course at their respective schools.

The additional Computer Science and Educational course work towards their advanced degree in our program provides a solid foundation for teachers to extend and evolve the material as well as new courses they offer as the students backgrounds and the Computer Science field continues to evolve. We have found that these additional classes provide self-efficacy for the teacher to lead the introduction of the curriculum in their schools and throughout their district, and to become leaders/trainers to other teachers. For example, a teacher in our first cohort became a K-5 trainer for Code.org which resulted in them hosting many events. Two additional K-5 trainers were also recruited by Code.org who have in turn trained 565 elementary teachers to incorporate blended learning into their class rooms. Our first MS STEM graduate is teaching at her high school and has also taken a position with the statewide Idaho Digital Learning Academy (IDLA) to develop and offer online computer science classes using the new curriculum to reach students in a geographically diverse state.

III. Curriculum

In order to establish the degree programs, we worked with the curriculum committees at the college and university level to develop the curriculum and go through the approval process. For each proposed degree program, a curriculum proposal was written and approved by the department, college curriculum committee, and the university curriculum committee. The Idaho State Board of Education required a separate proposal and approval process.

We went through this approval process at the beginning of the project with some positive and negative experiences. The positive aspect was the constructive feedback and revisions from *curriculum experts* at the university level improved the programs. However, we also experienced resistance and received objections from the University Curriculum Committee while reviewing the proposal of creating the "Bachelors in Computer Science Secondary Education Emphasis". A majority of committee members from other disciplines thought the training provided from the degree program will prepare pre-service teachers for higher-paying jobs in the computer industry after graduation, rather than teaching in high schools. Fewer objections were seen when reviewing the two Graduate proposals for creating the "Master of Science in STEM Education with Computer Science emphasis" and "Graduate Certificate for Computer Science Teacher Endorsement." One of the co-authors of this paper chaired the College Curriculum committee and served as a member on the University Curriculum Committee to facilitate the communication process. We found this active participation especially valuable.

The following subsections describe our effort and experience in developing curricula for the three degree programs.

A. Masters in STEM Education with an emphasis in Computer Science Education

The creation of this program was a joint effort between the College of Education and the Department of Computer Science at our university. The College of Education already had a Masters in STEM Education program to which we added a **Computer Science** emphasis. The curriculum requirement for this program contains two major parts:

- *Computer Science Department courses:* These courses are designed for CS content knowledge, including learning tools, hands-on activities, and methodologies for teaching computer science (CS 518 and the seminar sections in CS 503 and CS 505);
- *Education Department courses:* These graduate level educational courses for the Masters in STEM Education emphasized issues with education in general and allowed teachers to reflect upon how they would teach CS content in their respective classrooms.

B. Certificate for Computer Science Teacher Endorsement

The Graduate Certificate was created to address issues related to teachers having a Masters or not being interested in completing all the requirements for a Masters program due to their full-time job as a teacher. To reduce the workload for the teachers without sacrificing the quality of their preparation to teach CS courses, we created the *graduate certificate program* in CS Teacher endorsement. The certificate program requires 20 credits. Additionally, we modified the MS STEM Education degree requirements to provide the student the option of a *project* or a *thesis* to further balance the faculty workload.

In comparison with the MS STEM program's 35-credit requirement, the certificate program keeps the *Teaching and Learning CS courses* without the need to take education-focused courses and the need to undertake a project or conduct research in CS education. The certificate has proven to be adequate for in-service teachers with an educational background and certified training/practice on teaching methodologies, and 4 of the CS credits (CS 518 and seminar sections in CS 503 and CS 505) provide additional approaches and techniques to teach computer science.

The certificate program was created and started during the Fall of 2015, the second year in the IDoCode project. With the addition of the certificate option and broadly promoting the certificate to existing MS STEM applicants, over 50 percent switched to graduate certificate. In the Summer of 2015, the program enrolled additional 19 in-service teachers in cohort 2 with nearly 70 percent applying for the graduate certificate.

The addition of the Certificate allowed us train additional teachers and balance the CS faculty load in our department as they would not have to direct many Master's dissertations.

C. Bachelors in Computer Science Secondary Education Emphasis

Our Computer Science Bachelors program for pre-service teachers was established as part of an teacher-training program at our university. Students enrolled in IDoTeach (the teacher training program) choose a degree to pursue in one of the STEM disciplines, and while pursuing this degree simultaneously take a STEM education course sequence that prepares them for a secondary certificate. The program enables students to obtain secondary teaching certification while earning degrees in science, computer science, engineering, *or* mathematics. Nationally, in 2016, the total enrollment for all UTeach replicas was 6280, in which only 52 were CS majors. Our teacher training program has seen 9 students pursue the CS emphasis of a total of 289 students in the teacher training program at Boise State University. Combining our bachelors with the university-wide teacher training program greatly reduced the resources required to run the pre-service CS teacher training program.

IV. Important Strategic Partnerships

A project with a scope as large as ours needed partnerships at many levels to be successful. Below we describe the significant partnerships that have been instrumental in making the IDoCode program a success. Figure 1 shows a schematic highlighting all the partnerships that played a role in the success of our program.

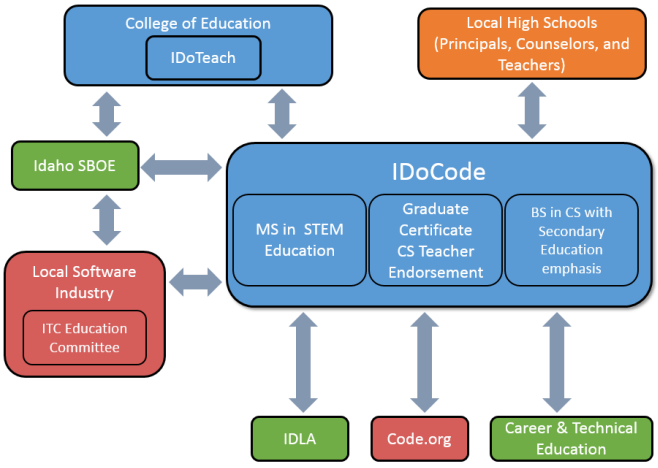

Fig. 1. This schematic highlights all the strategic partnerships that the IDoCode program has fostered to facilitate teacher training and the ability for the trained teachers to teach CS at their respective schools. We worked with the State Board of Education as well as the local software industry to influence the Board of Education through the Technology Council.

A. Partnering with the State Board of Education and College of Education

Our project started off by proposing Computer Science tracks to the Bachelors and Masters program in STEM Education in collaboration with the College of Education. Teacher endorsements are recommended by the College of Education to the State Board of Education (SBE). We worked closely with the College of Education to create a pathway for teachers to receive an *endorsement* to teach Computer Science. Strong support from the Deans of both the colleges (Engineering and Education) was crucial in moving the proposal through the University committees and beyond.

The next step was to create the Computer Science endorsement and to propose that Computer Science would count towards core math or science credit at the high school level. In collaboration with the College of Education and the College of Engineering, we worked with the State Department of Education (SDE) who reviewed the CS endorsement and the Masters in STEM Education (CS Emphasis) program and approved them to be sent to the SBE. Our co-authors served on the statewide working group that created high school CS teacher standards. Serving on the statewide working group helped expedite this process. We ensured that the CS endorsement was in place in time for our first cohort of graduates from our Masters program to teach their first CS course in their respective schools.

The SBE asked for public comments and sent the teacher standards and CS endorsement to the legislature in early 2015, where it was approved. Later, the K-12 CS standards for students was created in 2016. Co-authors served on the statewide working group that created K-12 Computer Science standards for our state students. These were approved by the state legislature in the 2017 session.

B. Involving Local Software Industry

Our program benefited immensely due to its strong partnership with the local software industry. One important step the IDoCode program took was to solicit the help of the Boise State Computer Science department's Industry Advisory Board to champion our project to the community and political leaders.

This required that we needed to connect the dots for the *industry* – student enrollment in high school to enrollment in college level CS programs, and better prepared students, to the talent pipeline for industry. Similarly, we had to connect the dots for *community/political leaders* to the economic benefits of highly trained local employees staying in our state and contributing to the economy. We also had to emphasize to industry about how starting in high school or even earlier (K-8) and being proactive with student recruitment/counseling will help to *address diversity in CS* at the college level and beyond.

The Software Alliance subgroup of the Idaho Technology Council (ITC) created an Education Committee to specifically address K-12 CS education. We actively participated on the committee that has resulted in support for creating a statewide partnership with Code.org and other local tech education organizations.

Additionally, our relationship with local industry and our state Universities resulted in Industry leaders and Universities lobbying the state legislature to support K-12 CS education with several initiatives. The key outcomes included: support for counting AP/dual-credit CSP and AP/dual-credit CS A courses for Math and Science credit, and creating a $2m renewable fund to support the implementation of K-12 CS programs. This includes money for teacher training, devices for schools, and improvements in network infrastructure. Additionally, industry partners such as Kount and Hewlett Packard helped jump start expanding CS programs in local high schools with cash and device donations. In 2018, the state legislature approved a bill requiring all high schools to offer at least one computer science course beginning fiscal year 2020. The legislature unanimously passed this bill.

C. Partnering with CTE (Career and Technical Education) division

Placing Computer Science in the Academic track versus CTE (previously known as Professional Technical Education, PTE) track has received considerable attention [4]. In 2015, Congress passed an act [5] including CS into STEM, which helps put CS on an equal footing with science and mathematics. Our approach has been to incorporate CS courses into both the tracks such that they mirror each other as much as possible. The CTE track added advanced studies, which is a *capstone project* to complete the fourth year of the CTE program.

The extra funding that school districts receive for CTE certified teachers is attractive to the schools. The additional funding resulted in one school district *limiting their CS educational reach* by not allowing IDoCode teachers to teach CS without being CTE certified, which caused one teacher trained in our program to leave the district. The district is currently reconsidering their policy, and due to the overwhelming student demand have chosen to forego the CTE funding for the freshman course. We are working with our state Division of Career-Technical Education (CTE) to simplify the CTE certification process for IDoCode-trained teachers.

CTE provides the added benefit of additional funding; however, at a cost - a CTE program must be located in one school within the district, resulting in additional transportation costs, potential growth restrictions for popular programs, limited CTE qualified teachers and most of all potentially limiting the reach of computer science course availability to the district wide student population.

The *academic* track may solve many of the possible CTE deficiencies; however, funding for schools who do not already have a dedicated computer lab and computer access in classrooms may have challenges with funding classrooms. Since we understand the challenges and benefits of both the academic and CTE tracks, we feel the selection is best left to the districts. See a recent position paper by Code.org on Perkins funding [6] for an in-depth discussion of this topic.

D. Partnering with Local High School Principals, Teachers, and Counselors

Since our goal is to significantly increase CS education at the secondary level, support by principals, teachers and counselors is crucial. Establishing working relationships with these participants helped us understand the challenges faced in schools' ability to introduce new curriculum (e.g. a well-defined curriculum, qualified teachers, hardware funding, equipment needs, student advising/outreach, AP/concurrent enrollment opportunities, and so on).

The West Ada school district, the largest district in the state of Idaho, was just beginning to create a CS magnet program. By partnering with us, they were able to quickly

decide to utilize the nationally supported curriculum available ("Exploring Computer Science" and "AP Computer Science Principles"). These engagements gave the district the opportunities to identify teachers they wished to include in IDoCode teacher training program. The district chose to establish CS as a CTE program; this requires teachers with a CTE background in order to obtain CTE funding. Through continued discussions with IDoCode members, the district realized the importance of offering CS access to *all* students, thus making the "Exploring Computer Science" course a general elective at the students' local high school. Students interested in pursuing additional CS courses would then participate in the CS courses offered at the magnet high school. Students are bused from their home high school to the magnet school to attend the subsequent CS courses.

Through a partnership with the Vallivue school district we were able to share IDoCode resources and advice. These engagements and the great student interest in their school district led the district to decide to forgo CTE funding so an early IDoCode teacher from their district could develop and teach a multi-course CS program for their high school as a pilot program.

Our program has been flexible in admitting a few candidates who may not otherwise directly fit our stated goals. These teachers were teaching at the middle school level, but were certified to teach 9th grade courses or were administrators of the district. This flexibility enabled the Vallivue district to move a motivated middle school teacher to establish the CS courses at a newly built Rivervue high school. Another IDoCode participant was an Assistant Superintendent at Nampa School District. Through her participation in the first course, she learned to appreciate the value the IDoCode program offered and has since helped remove many roadblocks that would have limited participation in their district. She also hired one of the IDoCode teachers as a CS coordinator for her school district.

Through early engagement with *counselors*, we became aware of the urgent need to provide additional information and training to expand the prospective student base that counselors would have directed into CS classes. This lead to the IDoCode program partnering with NCWIT to offer a "Computing by Design" workshop to provide professional school counselors, administrators, and teachers with information and resources to **guide more** - **and more kinds of** - students to explore computing education and careers. It is important to expand the student base to CS education due to the pervasive nature of CS and its impact on a large variety of disciplines. Many current engineers in the CS field chose the field after their initial exposure to the topic, which is why ensuring that a large and diverse student population has access to at least one CS course is so important.

The teachers in our program have re-enforced the power that teachers and principals have to influence the make-up of students in the CS courses to reflect their overall student population.

V. Community Building/Training

A. Professional Development for Teachers

1) CS4HS workshops: For two summers, we have been awarded the *Google Computer Science for High School* (CS4HS) grant to conduct summer workshops to train teachers. Each year we made the curriculum for the workshop exciting and relevant by focusing on topics that may be interesting for the students. To provide a comprehensive view of the computer science industry, we took the attending teachers on a field trip to nearby software companies. We conducted a workshop on the Mobile CSP curriculum [7] that introduces computer science principles through the creation of mobile apps. The curriculum emphasizes creativity, problem-solving, and algorithmic aspects of computational thinking as students learn to create Android apps using the *App Inventor* program [8]. We had 18 of teachers (9 female, 9 male) from 13 different districts who attended the workshop and 6 of them expressed interest in joining our IDoCode program while others chose the Code.org workshops due to time commitment and distance issues for a formal college program.

For the subsequent year, we designed our CS4HS curriculum with a focus on **Music, Art, and Poetry**. We introduced participants to *EarSketch*, which is a browser-based program that allows users to create new songs. The rich library of built-in sounds make it truly possible for teachers (and students alike) to create impressive music. For the 'art' aspect of the workshop, we used *Processing* to introduce graphical components (shapes, colors, composition, animation, etc.). With respect to the 'poetry' component, we showcased how there are some similarities between poetry and coding and discussed National Novel Generation Month (NaNoGenMo) with the participants. Overall the participants in both the workshops provided positive feedback with respect to the material and the field trips.

2) Counselor Workshop: One key step our program took was to contact NCWIT and work closely with them to organize a workshop for high school counselors, principals, and teachers. The workshop titled *Computing by Design* was organized by the Computer Science department at Boise State University and was attended by 56 people. The goal was to train counselors to be proactive to obtain a student population in computer science classes that reflects the school population. We included teachers and other administrators who *influence a student's choice of education and career path.* It is important to reach the workshop participants in a timely manner to provide them useful information and resources to **guide more** - **and more kinds of** - students to explore computing education and careers. For our state, September and October are good months to hold counselor workshops (e.g. in time before the next student registration takes place). NCWIT provided workshop materials and helped by leading the workshop. The success of the workshop is dependent on the ability to attract participants, promote the workshop, arrange key speakers, and assist with facility arrangements.

3) Information Sessions/Recruiting: In the beginning of our project, we held *information sessions* with a variety of different groups in Idaho. Some meetings were arranged with a single district, while other events included representatives from multiple districts. The multi-district meetings were very useful in getting the goals of the IDoCode program to a number of district representatives in starting or expanding computer science education in their districts. The size of each meeting was between 8-20 people using a catered lunch as an incentive to encourage participants to attend - even with their busy schedules. The group meetings was a great approach which drove even more interest in the IDoCode program objectives as the district representatives shared what they were considering or currently doing. These meeting were also held in different locations across the state so as to draw participants from a broader geographic area to target as many schools as possible.

The single district meetings were more focused on working with a district to help formalize programs they were developing. These discussions are very important to ensure the district plans included the our curriculum, sufficient teacher training, and alignment with the university's concurrent enrollment program.

4) Concurrent Enrollment (CE): We collaborate closely with the Concurrent Enrollment (CE) program at Boise State University. Initially they were our best source of contacts with district representatives and helped us arrange the first information session that was held at our university and was attended by a dozen representatives. Since CE's motivation was to bring more students into CE courses they were excited to support our efforts.

As a goal to provide additional value to the high school students, we identified college courses that match AP CS Principles (CS 101, CS Principles) and AP CS A (CS 121, Computer Science I). Since concurrent enrollment CS courses also count for Math/Science credit in Idaho, this provides further incentive for students to select these courses. The state legislature also provided a financial incentive by funding CE credits, which has become a push in our state for students to obtain college credits while in high school.

B. Partnering with IDLA and Code.org

Boise State University, in cooperation with Idaho School Districts, the local Technology Council (ITC) and the Idaho Digital Learning Academy, have begun a comprehensive partnership with Code.org. Our team was involved in partnering with Code.org for K-12 teacher training for all teachers in our state. Code.org has been using our state as a model for statewide agreements with other states for teacher training. They took their partners from our state, Washington, and Kansas to the White House in 2016 to showcase states that are leading the effort to bring CS to K-12. By partnering with other organizations with the same goal of expanding access to quality computer science training, both of our efforts have become more successful. By leveraging Code.org training in K-8, more students have been exposed to computer science driving additional interest at the secondary level which is an important goal of our program.

VI. Potential Roadblocks/Lessons Learned

As the IDoCode program progressed we have learned many valuable lessons and broadened our approach to achieve more significant results. Here are the lessons learned so far.

- **Focus on the goal of your program:** It helps to focus on the critical aspects rather than trying to persuade others on adjacent topics. For example, even though we believe CS belongs in the academic realm and this was the direction of the State Department of Education (SDE), it was important to keep an open mind and let the decision making be done at the appropriate levels. The IDoCode goal is to train more CS teachers and make CS accessible to more and more kinds of students. Thus we are working with both Career Technical Education (CTE) and academic representatives to promote CS and supporting districts who choose to offer CS as either academic or CTE.
- **Selective scope expansion can help open doors:** Initially the IDoCode program was initiated to prepare teachers to teach the AP Computer Science Principles (CSP) course. We reconsidered our goal and incorporated the Exploring Computer Science (ECS) course in our discussion with district representatives and as a vehicle to get our in-service teachers teaching CS at their respective schools after completing the first course with us. This provided an opportunity to work through issues with districts sooner rather than approaching them later with teachers trained to teach the AP CSP course alone. By offering ECS as a "taste" of CS, we have found that more diverse groups of students became interested in CS to continue on and take the AP CSP course. NOTE: The scope expansion allows the formation of a 4-year Career Technical Education (CTE) computer science program (ECS, AP CSP, AP CS A, Capstone Project). Without these courses, CTE focused districts would have developed their own curriculum or substituted IT courses.
- **Be active in all aspects of bringing new curriculum into the classroom:** Due to our active participation in the statewide CS standards, providing legislative support, and working directly with districts, we have built credibility that has led to great working relationships within the state. Our involvement in the legislative discussions at the state level was largely responsible for the creation and funding of the Idaho STEM Action Center.
- **Leverage and develop the expertise of the prospective CS teachers in your program:** A few of our IDoCode teachers have become leaders in other groups promoting CS as well as assisting the IDoCode program to achieve our goals. The first Code.org K-5 trainer came from our first cohort.
- **Meet early and often with district representatives:** It is important to meet with and involve the school and district representatives to promote and support the adoption of

new curriculum into their districts. These relationships can smooth out problematic areas to adoption of new curriculum into their districts. Some issues include:
1) Where does Computer Science fit? Some districts have decided that CS belongs with their Career Technical Education programs. This is sometimes due to the additional CTE funding or alignment with existing IT/computer programs in their districts.
2) If the goal of the school district administrators is to align with existing IT/Computer programs, it is important to have detailed discussions as to the difference between CS and IT.
3) Some well-prepared and enthusiastic academic teachers from our program were blocked from teaching CS in the CTE focused districts. In some cases, these teachers were eventually allowed to teach after an intervention from faculty from our team due to the *student demand for CS classes* and the district's lack of CTE available CS teachers. The model by one large district CTE CS program was for all students to have access to the *Exploring Computer Science classes in their home school*. This exposure to CS as a freshman enabled the new CS CTE program to recruit more students than the district had anticipated. NOTE: As the initial bulge of new students in the ECS program move onto the AP CSP course, the district is concerned about their ability to obtain sufficient CTE certified CS teachers. New program funding and teacher certifications are a challenge a program must recognize and pursue at all levels.

- **Leverage your existing undergraduate courses, but allow some tailoring of the material for secondary teachers:** Our team planned the curriculum in a way that ensures the **sustainability** of the program by including a handful of our undergraduate CS courses and additional learning outcomes that focused on issues related to teaching Computer Science at the secondary level. As such only 4 of the 35 credits in the MS in STEM education are newly created.
- **The college program needs to provide a flexible level of degrees/certificates:** Our team realized the importance of offering a variety of educational options for training teachers. Introductory programming courses at the university level provide an excellent avenue to prepare secondary teachers to teach "Exploring Computer Science" and "AP Computer Science Principles." Additional coursework is required to prepare a teacher to teach Computer Science A or lead students in their capstone projects in a CTE program. The additional coursework provides additional background for teachers to become leaders in their school or district to establish and evolve the computer science program.

VII. IDoCode Recruiting

Our program has taken a number of steps to recruit teachers into the 20 credit Graduate Certificate CS Teacher Endorsement and the 35 credit MS in STEM Education with CS Emphasis programs. Information sessions with school district representatives helped with spreading the word about the program and led to us admitting the first cohort of 21 teachers into the IDoCode program.

Encouraged by the results, our team held additional information sessions at regional superintendent meetings, set up an annual status update luncheon with school district representatives (inviting not only past participants, but expanding the invitation to others districts who may have heard about our program and wanted additional information.) The results of these meetings allowed us to expand our reach.

Additionally, we have the following avenues to reach out to teachers, administrators, students, parents, state educational department and legislatures to provide information and promote their support for expanding CS educational opportunities.

- **The IDoCode web site** (https://IDoCode.boisestate.edu/) provides a wealth of information for teachers and administrators about the CS teacher training opportunities, the CS curriculum, community building, workshops, and news.
- **Direct outreach to teachers** and word of mouth between teachers is an effective way to supplement the tops down approach to the majority of our information sessions with a bottoms up approach. This approach allowed a number of teachers who eventually joined the IDoCode program to become a champion within their districts. A top-down approach may have eliminated candidates without a Math or Science background; over 65%+ of the teachers in the program have non-Math or Science certification.
- **Driving student/parent interest** via the Hour of Code at several schools, summer teacher and student workshops.
- **Workshops, lunches, and meeting with school counselors and administrators** are necessary to insure diversity of students recruited into the CS classes and assist the school staff with integrating newly developed curriculum and recruiting students.
- **Working with other organizations** such as the Idaho Technology Council, Idaho Digital Learning Academy and the newly formed Idaho STEM Action Center to achieve a common goal of providing expanded opportunities to bring Computer Science educational opportunities into the K-12 classroom.

VIII. Results

In this section, we will summarize the major results from the IDoCode project over the last few years. In 2014, Computer Science was approved by the Idaho State Board of Education to count towards high school math or science core requirement. Idaho became the 13th state to pass Legislation providing incentives to school districts to offer CS courses in high schools. Local industry, authors of this paper and other partners played a major role in this process. The authors have also served in statewide working groups to create CS standards for teachers (2014) and for K-12 students (2016). The Masters in STEM Education (CS Emphasis) leading to a Computer Science teaching endorsement was approved by the legislature

and became operational in Fall 2014. The Graduate Certificate in CS Teacher Endorsement was approved in 2015, providing a shorter pathway for teachers. Both programs were the first of their kinds in the country. We also added a Secondary Education track in the Bachelors in Computer Science (a replication of the teacher training program).

To date, 74 teachers have participated in our graduate programs in five cohorts with 22 teachers completing the graduate certificate program and 20 completing the Masters program through Fall 2018. The mixture of teachers is 50 percent female / 50 percent male.

We also have identified 8 additional high school CS teachers who have benefited by adopting the standard curriculum and working with program representatives to expand CS in their schools.

A strong measure of the impact is the number of students enrolled in CS courses in surrounding school districts. In 2013, only three high schools in the two biggest districts in the area were offering computer science, with a total enrollment of around 60 students. None of the other school districts in the metro area offered computer science courses. By the Fall 2016 semester, every high school in the two biggest school districts were offering computer science, with many offering multiple courses.

To date, the program had 3287 students take the ECS or AP CSP courses, and an additional 403 students taking the AP CS A. The vast majority of these students have taken courses in the last two years as growth has accelerated after the first three years of the program beginning.

In addition, every school district in and around the metro area now has teachers who are trained (or are in training) with our program and most of those teachers are offering computer science courses. Additional workshops via partnerships with the Digital Learning Academy and Code.org have resulted in the training of 565 elementary, 102 middle-school and 56 high school teachers.

With our programs and additional workshops, we have been able to create a community of practice for our CS teachers that meets regularly during the year and can reach out to each other via an online forum. We currently have over a hundred members in this community.

Over the last few years, our project and it's partnerships have had a dramatic impact on the awareness of Computer Science in K-12 in our state and beyond. Today, every superintendent and principal in the state has the implementation of CS courses on their agenda.

IX. Related Work

Training Computer Science teachers is a crucial task in addressing the inequity in computer science education. Short professional development workshops are limited in their ability to prepare and train teachers to teach a year/semester long course at their school. Majority of CS teachers in the past have been trained computer scientists, which makes it hard to hire and retain them [9]. Bernier and Margolis found that the Los Angeles Unified School District had 'lost' more teachers than were retained. Training teachers to be better prepared to teach computer science through sustained support by a community of practice [1], [10], [11] is a better way to increase their self-identity [12] and efficacy in the classroom.

Our project was inspired by the National CS10K program led by Jan Cuny [13]. With the vibrant software industry in our Metropolitan area, there was a huge need to train the next generation of computer scientists and that led us to think about the entire pipeline from K-12 all the way through the undergraduate curriculum. To broaden the access to computer science education to women [14] and minorities [15], we created a teacher focused curriculum that incorporates pedagogical considerations as well as computer science education courses such as the Exploring Computer Science [3] as well as the AP Computer Science Principles [16].

As per Goode et al. [17] though, merely an excellent curriculum is not sufficient and requires careful attention to ensure that women and minorities are truly included in the computer science education at the K-12 level. We believe that through our comprehensive education and reflection-based approach to teacher training, we are able to instill a sense of inclusiveness in our teachers to inspire them to provide equal and excellent education in their respective schools. Our comprehensive program instills a sense of identity [18] and self-efficacy [19] into the teachers, which is crucial for teachers with a non-CS background.

desJardins and Martin [20] highlight their efforts in the state of Maryland to provide high quality training for high school teachers through community building, summer workshops, the creation of a local CSTA chapter, and other meetings to increase awareness among educators and administrators at their constituent schools.

Georgia Computes! [21] is a deep rooted program that was started in 2006 to change the landscape of computer science education through summer camps for K-12 students, teacher training, 1-on-1 mentoring for high school students by pairing them with graduate students, creation of educational material that can be used by teachers at the high school level, and so on.

In the state of Massachusetts, the Commonwealth Alliance for Information Technology Education (CAITE) [22] is focused on increasing opportunities for women and minorities in computing. They have worked with local community colleges to create pathways for students to transition into a 4-year college. They have created new alliances with STEM initiatives to train high school teachers and other constituents at local schools such as principals and counselors. They are sustaining their community of practice [1], [10] through professional development workshops for their teachers. The CAITE effort is led by the University of Massachusetts at Amherst. Similar to our program, they have also been involved in the statewide efforts for defining computing curricula and standards for the Massachusetts K-12.

Illinois State University has spearheaded a program to train high school teachers - *Teacher Education in Computer Science* [23]. This program has some similarities with our program

where a teacher can receive Illinois State endorsement through their program for middle-school and high-school teachers.

X. Conclusion and Future plans

The IDoCode project has led to a ten fold increase in trained CS teachers and almost thirty times increase in students taking CS courses in the biggest metropolitan area in our state. The depth of training for the teachers either via the Masters in STEM Education or Graduate Certificate in CS Teacher Endorsement implies that these teachers will be able to teach and grow as CS teachers for the long term. Our partnerships with industry and other educational entities has resulted in a vibrant community that is aligned behind the cause for CS in K-12.

Future plans for our program includes replicating the Graduate Certificate program at other community colleges and universities in our state to increase coverage across the state. We are investigating the creation of a shorter CS Teaching badge (11-14 credits instead of 20 for the graduate certificate) that will take less time for teachers to acquire but still offer more depth than workshops.

We are in talks with the Idaho State Department of Education to allow CS endorsement to be sufficient for students to get Math/Science credits without the teacher having Math/Science certification. This would increase the number of students who can get Math/Science credits for CS courses. Other opportunities include creating a CS Teacher Endorsement Minor for pre-service teacher education students, which will allow pre-service teachers in multiple areas to obtain a secondary CS endorsement.

The most important barrier in offering high quality computer science in high schools is the lack of teachers with the appropriate depth and training. While many institutions and organizations have jumped in to provide high quality computer science professional development workshops for teachers, the shorter duration of these is not sufficient to create CS teachers that are confident in teaching courses in that field. The best long term solution is to create pathways for CS teacher preparation such as ours at colleges and universities that are comparable to other established high school subject areas.

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