Coding Our Future: Creating Equitable Computer Science Pathways in Urban Schools

Early-Phase Grant Request
San Diego Unified School District

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A. Significance

Computer science jobs are expanding across virtually every industry and every state. By the year 2020, there will be **1 million more computer science jobs than qualified candidates** in the United States to fill them (Bureau of Labor Statistics, 2016). Exacerbating the issue, the American technology workforce lacks diversity, with computer science jobs filled by only **24% females**, **8% African Americans**, and **7% Latinx** (Bureau of Labor & Statistics, 2017).

With the support of EIR's Program-Early-Phase Grant, San Diego Unified School District (SDUSD) will address these issues by developing and implementing a promising new evidence-based ***Computer Science Implementation Model***. As the 17th largest school district in the country and the 2nd largest district in California, SDUSD is perfectly positioned to serve as a model for how large diverse urban school districts can **train their teachers and empower their students to learn computer science.** SDUSD proposes to implement the *CS-Urban Implementation Model* over five years in response to EIR's **Absolute Priority 1** and **3**. This model will introduce a promising new strategy as an alternative to existing *Computer Science Exposure Strategies* that schools are currently using.

In addition to strong commitments from the Mayor of San Diego, SDUSD's Superintendent, and the district's administrative and school leadership teams, the project has assembled a world-class team of partners including the **University of San Diego**, **TechSmart**, **LEGO Education,** and the **Classroom of the Future Foundation** (see *Appendix A: Letters of Support*). This project will broadly disseminate information, guidance and strategies to ensure the K-12 Computer Science Implementation Model developed in this project can be replicated in other school districts throughout the country.

A rigorous evidence-based efficacy research component will be utilized to study the efficacy of the project. Both the student-level and teacher-level strands of the project will be the focus of ongoing formative evaluation, building an eventual summative evaluative model of project efficacy. Formative evaluation and feedback will inform necessary changes to meet the project's objectives and outcomes, ultimately determining the efficacy of the *CS-Urban Implementation Model*.

1) National Significance of Proposed Project.

There are more computer science jobs than qualified candidates to fill them.

Computer science and coding power the technology at the heart of our daily lives and our digital economy. Mobile apps, cloud computing, cybersecurity, big data, digital health, machine learning, contextual robotics and the internet of things (IoT) are rapidly changing the way people live their lives and do business, revolutionizing the global marketplace. Many other expanding fields depend on computer science as well, including retail, health information technology, financial services, genomics, medical devices, communications, and clean technology. All these technologies rely on sophisticated software developed by skilled computer science professionals. However, there is a **significant shortage in professionals with computer science and coding skills**. Computer science jobs are the #1 source of new wages in the U.S. (Conference Board HWOL, April 2016), yet there are currently 553,327 computer science jobs available and only 49,291 students entering the workforce with the computer science credentials to fill them (Bureau of Labor Statistics, 2016). These jobs are growing at twice the rate of all other jobs, with 67% of them outside the tech sector (Carnevale, Smith and Melton 2011). By the year 2020, there will be 1.4 million computer science related jobs in the U.S. with only 400,000 qualified applicants to fill them (Bureau of Labor Statistics, 2016). The proliferation of computing jobs has caused an overwhelming and increasing demand for workers skilled in computer science.

Higher education cannot produce enough computer science graduates to meet demand.

Colleges and universities throughout the country are unable to graduate a sufficient number of students with computer science degrees to keep up with the insatiable demand in the workforce. **Only 4% of all bachelor degrees earned are in computer science** (National Center for Education Statistics, 2014). Although 58% of all new STEM jobs are in computer science, only 8% of STEM graduates study computer science. In order to fill the enormous demand for skilled computer science workers, the industry has turned to foreign workers. 59% of H1B "skilled-worker" visas are granted to computer science occupations (US Department of Labor, 2014). California alone employed 28,287 foreign workers in computer science (Office of Foreign Labor Stats, 2014).

Most K-12 schools do not teach computer science.

Only **40% of the K-12 schools in the U.S. offer computer science classes** (csedu.gallup.com, 2015), despite a strong demand from parents, teachers, and students. Over 90% of parents want their students to learn computer science, and over **93% want their child's school to teach computer science** (csedu.gallup.com, 2015). Meanwhile, research shows that students like computer science more than any standard core content subject (C+R research, 2015). However, this universal demand is not reflected in school leadership. Less than half of surveyed principals and superintendents reported that computer science education was considered important by their school board, with the majority of them forced to de-prioritize computer science in favor of subjects included in required testing (csedu.gallup.com, 2015). The absence of any comprehensive K-12 approach leads to fewer students pursuing computer science degrees at the university level and ultimately a shortage of qualified candidates to fill computer science jobs.

There is a lack of diversity in technology, and the problem starts in school.

There is a significant lack of diversity in the computer science workplace, resulting not only in increasing economic inequality, but also unbalanced tech product teams who may develop products and solutions not representative of the needs of our diverse population.

The problem starts in the school system, where Black students, Hispanic students, women, and low-income students alike are less likely to have opportunities to learn computer science. Of the 76,546 computer science degrees awarded in American colleges, only **18% were earned by women, 5% by African Americans, and 3% by Hispanics** (National Center for Education Statistics, 2015). A solution must begin at K-12 schools: women who try computer science in high school are ten times more likely to major in it, and African American and Hispanic students seven times more likely (College Board, 2007). Yet, according to the College Board, only 22% of the AP Computer Science A exam-takers were female, 9% were Hispanic, and 4% were African American (College Board, 2017).

2) Development of Promising New Strategy.

3rd-8th grade Computer Science Implementation Model

This project will develop and implement a promising new evidence-based 3rd-8th grade ***Computer Science Urban Implementation Model*** (*CS-Urban Implementation Model*) as an alternative to existing *Computer Science Exposure Strategies* (*CS-Exposure Strategies*) that schools are currently using. SDUSD's *CS-Urban Implementation Model* will include the following four components:

- In-depth computer science **teacher professional developmen**t.
- Multi-year computer science **curriculum pathway** sequence (grades 3-8, with an emphasis in elementary school) with **differentiated** and rigorous computer science courses.
- Computer science **Competency Certifications** for students and teachers from the California State University of San Marcos.
- Computer science **work-based learning program** to connect students and teachers to the world of work via partnerships with San Diego local corporate businesses.

This *CS-Urban Implementation Model* will be delivered through an innovative public and private partnership with the following organizations:

- **California State University of San Marcos** – Through the leadership of the College of Extended Learning, our higher education partner (CSUSM) will provide development and issuance of Computer Science Competency Certifications for students and teachers, and continuing education credits for teachers who complete CST Bootcamps.
- **University of San Diego -** USD will provide the evaluation model, and will carry out an evaluation to determine the efficacy of the proposed model.

- **TechSmart** – This industry partner will provide teacher professional development and support, computer science curriculum pathway and courses, and a cloud-based platform for teachers and students.
- **LEGO Education** – This industry partner will provide physical computing, kinesthetic student engagement materials, and professional development.
- **Classroom of the Future Foundation** – Our non-profit partner works for the creation of computer science work-based learning programs, industry job shadows, and student internships.

In-depth computer science teacher professional development

School administrators say the main barriers to offering computer science are a **lack of qualified teachers** and lack of budget for those teachers (csedu.gallup.com, 2015). Most K-12 teachers have had little to no computer science experience in their own education, and thus lack the technical depth, content knowledge, and coding skills required to teach their students. Universities are not solving this problem: in 2016 the United States prepared 12,528 math teachers and 11,917 science teachers, but only 75 teachers candidates prepared to teach computer science (Title2.ed.gov, 2016).

Many districts currently employ a computer science exposure approach by providing teachers with introductory self-paced online learning modules or one-to-two day workshops, with the goal of training teachers to facilitate student self-paced online curricula. This approach inadequately prepares teachers to instruct and assist their students, lacking the content, depth, rigor, and support required by teachers new to computer science. The existing approach uses student self-paced curricula to circumvent teachers rather than properly training them. High quality professional development tends to emphasize the importance of **intense content-focused experiences rather than the one day generic workshops** (Whitehurst, 2002). Teachers reported that professional development focusing on content knowledge, opportunities for active learning, and coherence with other learning activities results in a significant positive impact on knowledge and skills in the classroom (Garet, 2001). These focuses will be the professional development cornerstones of SDUSD's *CS-Urban Implementation Model*.

Teacher professional development will be run by SDUSD's industry partner TechSmart, delivered via an in-person cohort model in their Teacher Coding Bootcamps. These Bootcamps utilize TechSmart's curriculum to instruct teachers in the full breadth, depth, and rigor of the curriculum their students will experience. Teachers complete over one hundred coding exercises and write over 2,500 lines of code, then learn the necessary pedagogical approach to teach computer science. The objective is to provide teachers with a strong computer science competency while increasing their confidence and positive self-perception as a computer science teacher. Teachers will build skills around the application of computational thinking in the same coding environment they will use to teach their students. Every exercise teachers code requires applying computational thinking to achieve the objective. They will also learn how to use TechSmart exercises' differentiation levels (*Appendix I*) during the Bootcamp, practicing how and when to use differentiation through mock teaching sessions during pedagogy training.

Teachers learn how to code using the exact same curriculum they will soon be using to teach their students. Bootcamps are taught by highly skilled software engineers with both extensive teacher-education training and the subject matter expertise that is required for high-level professional development (Powell et al, 2010). Teachers continue to build their knowledge over time by training to teach more advanced classes each year. Elementary teachers will experience 3 levels of professional development (CST 10, 20, 30), and middle school educators will experience 2 levels (CST 101, 102).

Multi-year computer science curriculum pathway sequence (grades 3-8)

An exposure to computer science is not enough to prepare students for college or careers. In the existing computer science exposure approach, many schools offer only AP Computer Science and/or stand-alone survey courses. These approach gives students scattered exposure to computer science rather than a meaningful progression of knowledge.

In contrast, SDUSD's *CS-Urban Implementation Model* approach will provide a **comprehensive multi-year computer science curriculum pathway** that will allow students to progress seamlessly through the scope and sequence of material, building an in-depth knowledge of computer science concepts along with confidence in their coding skills. Students will learn algorithmic processes, problem solving, computational thinking, and comprehensive coding skills as they progress from block-based drag-and-drop coding in elementary school (using a coding language designed by TechSmart called Skylark) to professional coding language Python in middle school. At the elementary level, a three-year computer science course sequence will be offered from 3rd-5th grade during SDUSD's daily one-hour STEAM block, in which two blocks will be utilized for computer science instruction. At the middle school level, two sequential TechSmart semester computer science courses will be offered on the master schedule (*See Appendix I for example Syllabi*). These courses prepare students for an additional four-semester TechSmart computer science course sequence at the high school level, which opens the potential for a future project through a Mid phase EIR grant.

Differentiated and rigorous computer science courses

Computer science and coding can be challenging, especially as students progress through a sequential pathway of courses, as it requires solving complex problems using a detailed process. If not scaffolded appropriately, students can become discouraged and give up. The curriculum absolutely must be differentiated, especially for a high need student population. However, research indicates that both beginning and experienced teachers either don't want to, or don't know how to **differentiate their curriculum to accommodate student diversity in their classroom** (Tomlinson et al., 1997). Whereas existing *CS-Exposure Strategies* offer a "one-size-fits-all" curriculum that does not address this issue, SDUSD's *CS-Urban Implementation Model* will provide teachers and students with a fully differentiated and rigorous curriculum provided by industry partner TechSmart. This curriculum provides **five levels of differentiation in elementary school and six levels in middle school** to meet the needs of all students, specifically those with special needs and english learners. As easily as pressing a button, teachers can toggle individual students or groups of students to the appropriate level to accommodate their skills (*See*

Appendix I). To help teachers determine the appropriate level for each student, lessons have clearly defined sets of learning objectives used across formative assessments, summative assessments, and hands-on coding projects. The objective of this differentiation is to keep students of all levels highly engaged and gaining competency, with special attention towards support for underserved populations and increasing the number of Hispanic and African American students taking computer science courses. Every course will be aligned to national *Computer Science Teachers Association (CSTA)* standards (*Appendix I*), with learning objectives aligned with Bloom's Taxonomy (*Appendix I*).

Computer Science Competency Certifications for students and teachers

Industry certifications play a valuable role in career pathways by providing a tangible link between educational proficiency and careers. California offers over 1,200 certifications over 12 industry sectors from business and finance to hospitality and tourism (CA Dept of Education, 2018), but the information technology sector demonstrates a dearth of certificates involving coding. As part of the *CS-Urban Implementation Model,* the California State University of San Marcos' School of Extended Learning (in conjunction with the school of computer science) will **develop and issue Computer Science Competency Certifications** in year one during the planning phase. Students and teachers will receive a certification for each course in the computer science pathway progression that they complete, as well as certificates for the completion of the entire Skylark pathway (elementary) and Python pathway (middle school). The approach to developing these certifications will ensure they are strongly based on the widely used National Computer Science Teachers Association standards.

Computer Science work-based learning program for students and teachers.

Existing *CS-Exposure Strategy* computer science classroom experiences often lack any connection to real-world applications. Providing individuals with a context to find the right work environment by matching their unique personality type to the work's characteristics leads to successful careers (Hidalgo, 2017). SDUSD's *CS-Urban Implementation Model* will develop a computer science

work-based learning program to connect students and teachers to the world of work via partnerships with local San Diego corporate businesses. The Classroom of the Future Foundation, our non-profit partner, will help each student accomplish this through strategies including:

- Allowing students to "meet a pro" through **virtual industry chats**, providing them with exposure to local computer science businesses and the essential skills needed to succeed.
- Facilitating relevant real-world computer science activities in the classroom that provide examples of the tasks professionals perform.
- Facilitating in-person **work-based** computer science learning opportunities for students such as project presentations to industry leaders.

In addition, the Classroom of the Future Foundation will give teachers the necessary industry knowledge to impart to students by partnering with local industries to provide "externship" experiences allowing them to explore the world of work. The goals are to increase educator knowledge of the technical and essential skills needed to succeed in the computer science industry, improve the ability of educators to infuse school sites with the computer science world of work, and shift teachers' mindsets about the role of schools in preparing students for careers in computer science.

3) <u>Project's Exceptional Approach to Absolute Priorities 1 and 3.</u>

SDUSD's *CS-Urban Implementation Model* will serve as a reference model for how school districts can train their teachers and empower their students to learn computer science. This project will broadly disseminate information, guidance, and strategies to ensure the *CS-Urban Implementation Model* developed in this project can be replicated in other school districts throughout the country.

Exceptional Approach to Absolute Priority 1 (Demonstrates Rationale)

This project demonstrates a strong rationale based on the high-quality research findings cited previously (under the "Development of Promising New Strategy, as an Alternative to Existing Strategy" header). The underlying research is summarized in Table 1 below.

Table1: Research findings in support of SDUSD's *CS-Urban Implementation Model*

***CS- Implementation Model* component**	**Research Findings**
1. In-depth computer science teacher professional development.	School administrators cite that the main barrier to offering computer science is the low availability and lack of budget for computer science teachers. (csedu.gallup.com, 2015). Universities are not solving this computer science teacher deficit problem. In 2016, the United States prepared 12,528 math teachers, and 11,917 science teachers, but **only 75 teachers** candidates were prepared to teach computer science (Title2.ed.gov, 2016). Professional development that focuses on: content knowledge, opportunities for active learning, and coherence with other learning activities, results in a significant positive impact on knowledge and skills and changes in the classroom (Garet, 2001). High quality professional development tends to emphasize the importance of more intense, content focused experiences rather than the one day generic workshops, (Whitehurst, 2002).
2. Multi-year computer science curriculum pathway sequence (grades 3-8, with an emphasis in elementary school) with differentiated and rigorous computer science courses.	School districts with high numbers of underserved populations that offer access to career and technical education (CTE) pathway courses significantly improve their graduation rates (Castellano, Marisa, et al., National Research Center for Career and Technical Education 2007). Beginning and experienced teachers either don't want to, or don't know how to differentiate their curriculum to cater to the student diversity in their classroom (Tomlinson et al., 1997) Both students with learning disabilities and gifted students have been shown to especially benefit from classroom differentiation (McQuarrie, McRae, & Stack-Cutler, 2008) (Tieso, 2005).
3. Computer Science Competency Certifications for students and teachers from California State University of San Marcos.	Employers feel certified professionals are better qualified than their non-certified counterparts. Therefore employers often offer a monetary premium to attract certified professionals. (Cegielski, Rebman, and Reithel, 2003) Google, Apple and 12 other companies that no longer require employees to have a college degree (Connley, C. 2018)
4. Computer science work-based learning program to connect students and teachers to the world of	Underserved students perform better academically, have a higher graduation rate, and have much stronger career outcomes when classes connect learning to the real world (Smith, S. 2012). Individuals with a context find the right work environments for themselves, by

work via partnerships with San Diego local corporate businesses.	matching their unique personality type to the characteristics of different work environments. (Hidalgo, May 2017)

In addition, the project's comprehensive approach will be field-tested in SDUSD's schools to ensure that it creates a high likelihood to improve student outcomes in computer science. These findings will also provide valuable research for the development of additional computer science courses, including secondary-level courses integrating coding and computer science into other core curricular areas.

Exceptional Approach to Absolute Priority 3 (Field Initiated Innovations - Promoting STEM with particular focus on Computer Science)

This project will create, develop, and implement the *CS-Urban Implementation Model* as a field-initiated innovation in grades 3-8 at 3 of the 7 school clusters in SDUSD. SDUSD is the 17th largest school district in the country and the 2nd largest district in California, with 131,252 students and a significant underserved population that is 47% Hispanic, 10% African American, 60% free and reduced lunch, and 27% English Language Learners.

A rigorous evidence-based approach will be utilized to study the efficacy of the project. This approach will consist of independent research divided into two main components: formative evaluation and summative evaluation with a cluster-randomized trial design. Formative evaluation and feedback will inform necessary changes to meet the project's objectives and outcomes, ultimately determining the efficacy of the *CS-Urban Implementation Model*.

The project will improve student achievement and outcomes in computer science in grades 3-8. It will be delivered through an innovative public and private partnership between the San Diego Unified school district, higher education, nonprofit, and industry collaborators (described in detail in the previous section).

B. Project Design

1) Measurable Goals, Objectives and Outcomes

The primary goal of the proposed project is to provide students with a rigorous comprehensive computer science pathway from 3rd-8th grade. This has the potential to yield an increase in students studying computer science in college, and ultimately more qualified candidates to fill the demand for computer science professionals in industry. Appendix G displays the Logic Model for this project.

To achieve the primary goal, the issue of teachers not having a computer science knowledge and coding skills must first be addressed. This will be done by providing teachers with **in-depth computer science professional development (GOAL 1)** via intensive Teacher Coding Bootcamps. This Professional development will allow Teachers to build a strong computer science competency, develop coding skills, and learn necessary pedagogical approaches to teaching coding and computer science (see pages 5-6). As a result, teachers will also demonstrate increased confidence and positive self-perception as a computer science teacher.

The next step will be to provide students with a **multi-year computer science curriculum pathway (GOAL 2),** consisting of rigorous and differentiated courses designed to allow students to progress seamlessly through the scope and sequence of material, building an in-depth knowledge of computer science concepts along with confidence in their coding skills. The pathway begins in the elementary grades 3-5, and has a significant presence in the elementary realm to ensure a strong foundation is built. SDUSD believes there is potential for a future Mid-Phase EIR grant to support the growth of the pathway into high school, and to effect the other 3 clusters in SDUSD. The *CS-Urban Implementation Model* will support elementary educators by integrating English, Math, Science, and History exercises and activities into Computer Science curriculum via core content packs, which will present the opportunity to provide students with interdisciplinary problem-solving skills and increase achievement in those core subjects. These Core Content Packs are optional for teachers to utilize, and omittance of them will not negatively negatively impact student performance in the computer science curriculum.

As students and teachers successfully complete each computer science course on the pathway, they will have the opportunity to earn a **Computer Science Competency Certificate (GOAL 3)** from the California State University of San Marcos. In order to help students and teachers make a strong connection between their computer science classes and the world-of-work, this project will create **work-based computer science learning opportunities (GOAL 4)** for students.

To support full implementation of the *CS-Urban Implementation Model*, the following measurable goals, objectives, and outcomes have been established:

TABLE 2: Goals, Objectives and Outcomes (Students and Teachers referenced are from participating samples other than 1A)		
Goals	**Objectives**	**Outcomes**
1. Establish professional development in computer science (CS), coding, and computer science pedagogy for elementary and middle school teachers.	1A: Increase the number of teachers teaching computer science within the district to 5%. 1B. Build participating teacher's proficiency in computer science concepts and writing computer code (coding). 1C. Build participating teacher's proficiency in computer science pedagogy and instruction. 1D. Increase participating teacher's positive self-perception of themselves as a computer science teacher.	1A: The number of teachers successfully completing computer science teacher professional development will be: 310 elementary school teachers (CS 10-30) 15 middle school teachers (CS 101-104) 1B:1 All participating teachers will score an average of 75% or greater on each end of unit summative assessment in the CS professional development courses. 1B:2 90% of participating teachers will successfully complete the hands-on final coding project in the computer science professional development course. 1C:1 90% of teachers will score above 75 % on the computer science pedagogy rubric during their mock teaching practicals. (Appendix I) 1D:1 90% of teachers teaching computer science will score 90% on a qualitative teacher self-perception survey.

2. Improve implementation of computer science & coding via a curriculum pathway on the master schedule grades 3-8 at participating schools.	2A: Each participating elementary school will provide three full-year computer science courses. Each participating middle school will provide two semester computer science courses. 2B. Increase participating student competency in computer science concepts and writing computer code (coding). 2C. Students are engaged and satisfied with their computer science courses. 2D. Increase the number of underrepresented students (African American and Hispanic) taking computer science courses.	2A:1 The percentage of students completing computer science courses in the district will be: 25% of elementary school students 10% of middle school students 2B:1 80 % of participating students will score 75% or higher on each end of unit summative assessment. 2B:2 90% of participating students will successfully complete the hands-on final coding project. 2C:1 80% of students taking a computer science course will score 80% on insight data, which measures students self reported interest and confidence for each item turned in (lesson activity exercise. 2D:1 The number of underrepresented students successfully completing computer science courses will increase by the following numbers at participating school: 15% for African American students 25% for Hispanic students
3. Certify 3rd-8th grade students and teachers who complete CS courses with Computer Science Competency Certifications from the California State University of San Marcos (CSUSM)	3A: Develop a Computer Science Competency Certification for each computer science course in the pathway progression in partnership with CSUSM school of extended learning, and CS school. 3B: Issue a Computer Science Competency Certificate to students and teachers who successfully complete a computer science course in the curriculum pathway progression.	3A:1 The number of Computer Science Competency Certifications developed will be: 3 elementary school certificates 2 middle school certificates 1 Elementary certificate for full completion 1 Middle school certificate for full completion 3B:1 80% of participating students will earn one Computer Science Competency Certificate during the first year. 3B:2 30% of participating students will earn four (or more) Computer Science Competency Certificates over the 5 year grant period. 3B:3 20% of participating teachers will earn three (or more) Computer Science Competency Certificates over the 5 year grant period.

4. Create a computer science work-based learning program to connect 3rd-8th grade students and teachers to the world of work via partnerships with local corporate businesses.	4A: Provide students with out-of-classroom work-based computer science opportunities and experiences (such as virtual industry chats, company visits, job shadowing, student internships) with local corporate businesses. 4B: Develop specific in-classroom work-based computer science activities that are relevant, real-world examples of tasks that professionals perform. 4C: Provide teachers with computer science "externships" at local corporate businesses to increase their exposure and knowledge of technical and essential skills required for success in industry. 4D: Develop or fuel existing interests in studying computer science post secondary and/or pursuing a computer science related career (middle school students only).	4A: The percentage of participating students completing out-of-classroom work-based computer science learning opportunities will be: 50% of participating elementary school students participating in company visits. 20% of participating middle school students participating in virtual industry chats and company visits. 4B: Five in-classroom work-based computer science activities will be developed for each course on the curriculum pathway. 4C: 40% of participating teachers will complete a computer science "externship". 4D: Each year 50% of participating middle school students will express an interest in studying computer science post secondary and/or pursuing a computer science related career as measured by student interest survey.

Table 2 above shows a comprehensive look at the project's goals, objectives, and outcomes within a 5 year timeframe. In order to ensure formative feedback, the project will operate with Objectives and Outcomes on a Proximal/Distal basis, reviewing outcome data at the three year mark (proximal) and at the five year mark (distal). This data will allow the research team to evaluate change over time, and to offer comprehensive feedback to exact change during the implementation of the model, as well as feedback to inform the efficacy of the model after five years.

2) Model of Performance Feedback & Improvement

The *CS-Urban Implementation Model* will be piloted at four elementary schools and one middle school. At the end of this pilot year the research team will gather feedback and make suggestions to revise the plan prior to scaling the implementation to a larger number of schools. The project will then be implemented incrementally based upon a three-phase rollout (Expansion Phase 1 - Expansion Phase 3). At the completion of each phase, a formative evaluation will be conducted to address fidelity of implementation, barriers to fidelity, and lessons learned/recommendations. Combined, this formative feedback will inform adjustments to the model and address system conditions necessary for full implementation with fidelity.

This project intends to build a pathway of CS education in SDUSD, and has a strong base of elementary school participants. For this reason, the sample sizes are larger in the elementary realm comparative to the middle school realm. This approach offers an opportunity for further evaluation in the Mid-Phase EIR grant with middle and high school subject in greater numbers.

3) Project Dissemination to Support Replication

The project will broadly disseminate information and research findings with educators via the following scholarly research conferences: *ACM Special Interest Group in Computer Science Education (SIGCSE) Technical Symposium*, *Innovation and Technology in Computer Science Education (ITiCSE) Conference* and *International Society for Technology in Education (ISTE)*; as well as through publications in peer-reviewed research and practitioner journals (such as *ACM Transactions on Computing Education, Computers & Education, Cognition and Instruction, and the Journal of the Learning Sciences)*. Using existing education networks in computer science education, including the Computer Science Teachers Association (CSTA) and the International Society for Technology in Education (ISTE), the tools, techniques, and lessons learned will be distributed and eventually will serve as an open source for any researcher/teacher who may wish to utilize or build upon this project. Apart from official dissemination routes, we plan to set up a public blog, and use social media tools to distribute and discuss findings with researchers, educators, and others interested in issues related to computer science education. Curricular resources and student CS projects will be published on the project website, making them broadly available to the education community.

C) <u>Adequacy of Resources and Quality of Management Plan</u>

1) Management Plan: Timelines, Milestones and Responsibilities

The project is organized into five distinct phases: Planning, Pilot, Expansion Phase 1, Expansion Phase 2, and Expansion Phase 3. Table 3 illustrates the management plan to achieve the objectives of the project, including detailed milestones, responsibilities and timelines. Each year, the project team will review and update the tasks, timelines and milestones for the next year based on feedback gathered.

Planning Phase

During the Planning Phase of the project, an implementation plan identifying schools, grade levels and teachers by phase will be created. An approach to the process for selection of the treatment group and a control group for the impact analysis (Expansion phase 2) will be established (as mentioned in the evaluation portion). This will be reviewed with district leadership and school administrators throughout SDUSD. Upon approval, detailed planning for the Pilot phase will occur, including: organizing teachers into professional development (PD) cohorts, identifying PD dates, and finalizing the integration of the computer science classes into the elementary school day, and middle school master schedules. CFF will create the initial Computer Science Work-Based Learning programs. CSUSM School of Extended Learning will review the curriculum and create Computer Science Competency Certifications (in conjunction with the School of Computer Science at CSUSM), and the University of San Diego will finalize the evaluation plan.

Pilot Phase

The Pilot Phase will begin implementation in SDUSD's Mission Bay Cluster of schools, consisting of four elementary schools and one middle school. The goal of this phase will be to field test the entire *CS-Urban Implementation Model* on a small scale with the goal of learning, measuring, gathering feedback and revising the plan prior to scaling the implementation to a larger number of schools. During this phase, the first cohort of teachers will complete the Teacher Coding Bootcamps and earn their Computer Science Competency Certification for CST 10 (Elementary teachers) and CST 101 (Middle School Teachers). The first courses of the computer science pathway will be taught: CS10 (elementary school) and CS101 (middle school). Students successfully completing these courses will earn the corresponding CS Competency Certification. At the completion of the Pilot phase, evaluation data will be collected, the results will be evaluated, and the lessons learned will be utilized to revise the implementation plan for the next phase.

Expansion Phases

During each Expansion Phase, additional courses will be added to elementary and middle school pathways. More schools will be included, and teachers will attend additional Coding Bootcamp PD that corresponds to the courses they teach. At the completion of each phase, evaluation data will be collected, the results of the pilot will be evaluated, and an Annual Efficacy Report will be completed. Lessons learned will be utilized to revise the implementation plan for the next phase. The Proximal Research Report will be completed during Expansion Phase 1, and the Distal Research Report during Expansion Phase 3. Table 3 includes details about each expansion phase.

LEGEND:
ES: Elementary Schools, MS: Middle Schools USD: University of San Diego CSUSM: CSU San Marcos
SDUSD: San Diego Unified School District, TS:TechSmart, CFF: Classroom of Future Foundation

TABLE 3: Timeline, Milestones and Responsibilities		
PLANNING: Award Earned - September 2020		
MILESTONE	**SCHOOL CLUSTER**	**RESPONSIBILITY**
Identify by phase, which schools, grade levels and teachers	Begin Training Mission Bay Cluster Teachers in the late portion of this year.	SDUSD, TS
Approval: Implementation Plan		SDUSD
Teacher Cohorts formed - ES, MS		SDUSD, TS
Teacher Professional Development dates established		SDUSD, TS
MS CS course place on master schedule finalized		SDUSD
Deliver: Operational WBL plan for ES and MS		CFF
Deliver: CS Competency Certificates		CSUSM

Deliver: Process for issuing Certificates		CSUSM
Deliver: Final Evaluation Design Plan		USD
Research Analyst and Research Assistant hired		USD
PILOT PHASE: September 2020 - June 2021		
MILESTONE	**SCHOOL CLUSTER**	**RESPONSIBILITY**
Teachers trained: Pilot ES, MS school teachers	Mission Bay Cluster Pilot schools: 4 ES, 1MS, Schools: **ES: 4 schools** Crown Point, Kate Sessions, Pacific Beach, Bernard **MS: 1 school** Pacific Beach Teachers **ES: 44 teachers (CS 10)** **MS: 2 teachers (CS 101)** Students ES: 1,100 students MS: 240 students	TS
Competency Certificates issued for CS10, CS101		CSUSM
ES: CS10 course taught		SDUSD
MS: CS101 course taught		SDUSD
Deliver: documented lessons learned from Pilot schools		SDUSD, TS, Eval Team
Deliver: modified implementation plan for Expansion Phase 1		SDUSD, TS
Students complete Work-based Learning (WBL) Activities		CFF
Deliver: Annual Efficacy Report/Formative Feedback		USD
EXPANSION PHASE 1 : July 2021 - June 2022		
MILESTONE	**SCHOOL CLUSTER**	**RESPONSIBILITY**
Teachers trained: Pilot and Phase 1 teachers	Mission Bay Cluster Expand Pilot schools to CS 20 and CS 102 Morse Cluster: Add Phase 1 schools: **3 ES: (25 Teachers)** Boone, Freese, Pacific View **3 K-8:** Audubon, Bethune, Fulton **ES: (26 Teachers)** CS 10 **MS: (6 Teachers)** CS 101 Schools: 11 (total): ES: 7 schools MS: 1 schools K-8: 3 schools Teachers (total) ES: 51 teachers	TS
Competency Certificates issued: CS10, CS20, CS101, CS102.		CSUSM
ES: CS10,CS20 courses taught		SDUSD
MS: CS101, CS102 courses taught		SDUSD
Deliver: Documented lesson learned from Expansion Phase 1		SDUSD, TS, EVAL
Deliver: Modified implementation plan for Expansion Phase 2		SDUSD, TS
Students complete CS Work-based Learning (WBL) Activities		SDUSD, CFF
Deliver: Annual Efficacy Report/Formative Feedback		USD
Deliver: Proximal Research Report		USD

	MS: 8 teachers Students (total) ES: 1,275 students MS: 660 students	
EXPANSION PHASE 2 : July 2022 - June 2023		
MILESTONE	**SCHOOL CLUSTER**	**RESPONSIBILITY**
Teachers trained: Pilot, Phase 1 and Phase 2 teachers	Mission Bay Expand Pilot schools to CS 30 and CS 103 Morse Cluster: Expand- Phase 1 schools to CS 20 and CS 102 **Add** Morse Cluster: Phase 2 schools: **4 ES: (22 Teachers)** Paradise Hills, Penn, Perry, Zamorano **1 MS: (1 Teachers)** Bell Hoover Cluster: **8 ES: 44 Teachers** Adams, Joyner, Franklin, Rowan, Parks, Normal Heights, Rowan, Cherokee Point **2 MS: 2 Teachers** Clark, Wilson Crawford Cluster: **8 ES: 44 Teachers** Carver, Clay, Marshall, Oak Park, Euclid, Fay, Ibarra, Rolando Park **1 MS: 1 Teacher** Mann Schools 15 (Total): ES: 10 schools MS: 2 schools K-8: 3 schools Teachers: ES: 110 teachers MS: 12 teachers Students: ES: 2,750 students	TS
ES Competency Certificates issued: CS10, CS20 and CS30		CSUSM
MS Competency Certificates issued: CS101, and CS102		CSUSM
ES: CS10, CS20 courses taught		SDUSD
MS: CS101, CS102 courses taught		SDUSD
Students complete CS Work-based Learning (WBL) Activities		SDUSD, CFF
Deliver: Documented lesson learned from Expansion Ph-2		SDUSD, TS
Deliver: Modified implementation plan for Expansion Ph-3		USD
Deliver: Annual Efficacy Report/Formative Feedback		Eval Team

	MS: 1,320 students	
EXPANSION PHASE 3 : July 2023 - June 2024		
MILESTONE	**SCHOOL CLUSTER**	**RESPONSIBILITY**
Teachers trained: Pilot, Phase 1, Phase 2 and Phase 3 teachers	<u>Mission Bay Cluster</u> Expand Pilot middle schools to CS 104 <u>Morse Cluster:</u> Expand Phase 1 schools CS 30 CS 103 Expand Phase 2 schools CS 20 CS 102 <u>Hoover Cluster:</u> Expand Phase 2 schools CS 20, CS 102 **Add:** <u>Hoover Cluster:</u> **ES 44 Teachers** Adams, Joyner, Franklin, Rowan, Parks, Normal Heights, Rowan **MS 2 Teachers** Clark, Wilson <u>Morse Cluster:</u> **ES 22 Teachers** Paradise Hills, Penn, Perry, Zamorano **MS 1 Teacher** Bell <u>Crawford Cluster:</u> **ES 44 Teachers** Carver, Clay, Marshall, Oak Park, Euclid, Fay, Ibarra, Rolando Park **MS 1 Teacher** Mann **<u>Schools 35 (Total):</u>** ES: 27 schools MS: 5 schools K-8: 3 Schools **<u>Teachers 332 (Total):</u>** ES: 315 teachers MS: 17 teachers	TS
ES Competency Certificates issued: CS10,CS20, CS30		CSUSM
MS Competency Certificates issued:CS101,CS102		USD
ES: CS10, CS20, CS30 courses taught		SDUSD
MS: CS101, CS102 courses delivered		SDUSD
Students complete CS Work-based Learning (WBL) Activities		SDUS, CFF
Deliver: documented lesson learned from Expansion Ph-2		SDUSD, USD
Deliver: Annual Efficacy Report/Formative Feedback		Eval Team
Deliver: Final Distal Research Report	**<u>Students 10,400 (Total):</u>**	Eval Team

	ES: 7,850 students MS: 2,550 students	

2) Key Staff and Partners

SDUSD has assembled a world-class team of industry, higher education, research and not-for-profit partners to ensure successful delivery of the project.

Higher education partner the **California State University of San Marcos** is ranked 31st for public universities in the nation by US News and World Report. Their renowned interest in serving underserved populations, research, writing, and integrating technology into education matches them perfectly with this initiative.

Higher education partner the **University of San Diego** will create and carry out the necessary evaluation plan in order to inform the team of challenges and success, resulting in a research driven process lead by Dr. Vitality Popov.

Industry partner **TechSmart** has extensive experience implementing computer science education at school districts across the country. Over the last eight years, they have developed and delivered a pathway of computer science courses (3rd-12th grade) via their platform, along with training and supporting thousands of teachers who have taught tens of thousands of students nationwide.

Industry partner **LEGO Education** has delivered hands-on curriculum-based resources for teachers and students worldwide since 1980. For 38 years, they have been working with teachers and educational specialists to deliver engaging learning experiences that bring subjects to life in the classroom, making learning fun and impactful.

Not-for-profit partner **Classroom of the Future Foundation** has been a convener of business, community, and educational leaders around education innovation in San Diego since 1997, serving the 42 school districts in San Diego county. Their board of directors consists of 20 senior executives at prominent corporations across the region. Their extensive experience designing work-based learning experiences and placing students and teachers in internship and externship in San Diego corporate businesses will ensure a strong connection to the world or work.

Table 4 provides a list of key staff and partners.

TABLE 4: Key Staff and Partners	
Name/Organization	**Biography**
Michael Goodbody M.Ed. *STEAM Program Manager* ***San Diego Unified School District***	Michael is the STEAM Program Manager for San Diego Unified School District. He is responsible for developing districtwide strategic partnerships and STEAM programs. He has bridged business, government, non-profit and higher education through the development of innovative initiatives that are the first of their kind. He has a focus on illuminating the possibilities in STEM today and providing a glimpse into the tech driven world of tomorrow. Michael will serve as the project coordinator/manager.
Corey Bess M.Ed. *Director of Operations* ***TechSmart Inc.***	Corey is the Director of Operations for TechSmart. Previous to his work with TechSmart, Corey worked in education for 13 years as a math/science teacher, as well as an administrator at both middle and high school levels in North County San Diego. Corey earned his masters degree in Education Administration, studying the use of technology in the classroom. Corey helped develop and implement framework for CCSS and NGSS in his district. Corey will serve as the liaison between TechSmart and SDUSD.
Andrew Lo *Product Manager/Lead Trainer* ***TechSmart Inc.***	Andrew graduated from the University of Washington in 2015 in Human Centered Design and Engineering with a focus in Human Computer Interaction. Andrew has led the team in the UX design of the TechSmart Platform. Andrew has trained teachers in the teacher coding bootcamps since they began and has been qualified as a Master Trainer. Currently Andrew serves as the Product Manager for TechSmart working with the software and curriculum development team to deliver high quality features and curriculum. Andrew will manage training and PD.
Stephanie Mao M.A. *Lead Trainer* ***TechSmart Inc.***	Stephanie Mao is one of TechSmart’s lead trainers and additionally works on curriculum development. She was born and raised in China, coming to Canada for high school, grades 10-12. She studied Electrical and Computer Engineering at Carnegie Mellon University, achieving a B.S. in 2015 and an M.S. in 2017 in Computer science. Her industry engineering experience includes time at Comcast, NetApp, and Microsoft. Through both school and work experience she has become proficient in Java, Python, C, HTML/CSS/JS, as well as Assembly. Stephanie enjoys being able to pursue her passion for teaching while also leveraging her technical background in her role at TechSmart. Stephanie will assist with the management of training and PD, as well as customer success.
Kyla Furey M.FA. *Director of Curriculum* ***TechSmart Inc.***	Kyla is the Curriculum Director at TechSmart, a Master Trainer, and a former teacher of TechSmart's after-school classes. Before coming to TechSmart, she received a Bachelors in computer science and creative writing at Hamilton College and a Masters of Fine Art in interactive media at the University of Southern California. After school she worked for several years with a small independent game company in

	Los Angeles and also as a private tutor in computer science and game design. Her history as a game designer supports her work designing curriculum and learning as an interactive experience. Kyla will assist with technical support, customer support, and integration of core curriculum into the computer science (grades 3-5). will continue to assist with Professional Learning, and assistance with customer support.
Mike Sennott M.FA. *Creative Director* ***TechSmart Inc.***	Mike has been the creative director at TechSmart since 2014. Previously, he ran multiple small game studios, publishing critically acclaimed titles for the iOS and Steam platforms. Mike holds an MFA in Interactive Media from the University of Southern California, along with a BFA in Computer Science and Creative Writing from Hamilton College. He has also worked as a gamification consultant, a computer science tutor, and an educational game researcher at USC's Game Innovation Lab. Mike will oversee iteration of student coding activities for engagement, as well as assisting with technical support, customer support, and integration of core curriculum into the computer science (grades 3-5).
Leanna Prater Ed.D *Solutions Engineer* ***LEGO Education***	Leanna is a Solution Engineer at LEGO® Education. In this role she helps provide content area-expertise and strategic solutioning to support activities specific to the instructional goals and program needs of LEGO Education customers. Prior to joining LEGO® Education, she taught in the elementary grades and served as a District Technology Resource Teacher for Fayette County Public Schools in Lexington, KY. She is currently an adjunct professor at Georgetown College in Georgetown, KY where she teaches an undergraduate educational technology course and a graduate class on coding for teachers. Lenna will serve as a liaison for LEGO Education to SDUSD.
Jenny Nash Ed.D *Senior Strategic Education Manager and Curriculum Specialist* ***LEGO Education***	Jenny serves as the Senior Strategic Education Manager for LEGO® Education North America, where she provides direction and leadership in delivering meaningful education opportunities for districts. She works closely with districts to design implementation plans and support teachers in using inquiry-based teaching through hands-on experiences. Jenny will serve as a liaison for LEGO Education to SDUSD.
James Wright *Chief Executive Officer* ***Classroom of the Future Foundation***	James, the Chief Operations Officer of CFF, has more than six years' experience developing, leading, and delivering work-based learning solutions. He has served as Director of Development and Marketing at Feeding America San Diego (FASD), the largest distributor of donated food in San Diego County. He helped raise more than $5.3 million in private support in the past year. Prior to joining FASD, Wright served for two years at the Federation of American Scientists, a national science policy think tank in Washington D.C. James will serve as the coordinator and liaison for the work-based education portion of this project between SDUSD and the workplace.

Dr. Vitaliy Popov PhD *PI Evaluation Researcher* **Dr. Yaoran Li PhD** *co-PI Evaluation Researcher* ***University of San Diego***	Dr. Vitaliy Popov will be the lead evaluator for the grant. Dr. Popov is a learning scientist with a background in engineering education. He has over 12 years of successful experience designing, implementing and evaluating studies, primarily in STEM fields. Dr. Popov has a proven track record in conducting original research, serving as a Co-PI on the STEM education related National Science Foundation grants, and publishing in highly ranked peer-reviewed journals in the fields of educational technology, teacher education, learning and cognition, and STEM education (such as *Computers in Human Behavior*; *Journal of Computer-Assisted Learning*; *Technology, Pedagogy & Education*; and *Technology, Knowledge, & Learning*). Dr. Yaoran Li, holds a MA in Statistics and a PhD in Educational Psychology with an emphasis in quantitative research methods, social emotional learning, and mathematical learning from the University of Missouri-Columbia. Prior to coming to the University of San Diego, Dr. Li worked at ACT Inc. for the statistical research team. At the University of Missouri, Dr. Li worked for David Geary, PhD, and was involved with the NIH-founded 10-year longitudinal study on mathematical development and learning disabilities. Dr. Li's research has been presented at international conferences such as AERA and APA and published more than 10 papers in high-impact peer-reviewed journals such as Developmental Science, Journal of Educational Psychology, and Learning and Individual Difference (Wiley).
Mike Schroder *Dean of Extended Learning* ***California State University of San Marcos***	Mike Schroder joined CSUSM in 2011 and immediately led the university's effort to expand Extended Learning (EL) programming. In partnership with CSUSM's academic colleges, Extended Learning today offers 19 graduate and undergraduate degrees at the main campus in San Marcos and the satellite campus in Temecula. In addition, EL offers 35 certificates and certification exam preparation programs, a comprehensive international program, a full selection of online courses, and Osher classes for students age 55 and above.
Aaron Guy M.A./MB.A. *Associate Dean of Extended Learning* ***California State University of San Marcos***	Aaron Guy is currently the Associate Dean of Extended Learning at California State University San Marcos (CSUSM). Aaron's responsibilities include program development and oversight of the numerous graduate and undergraduate degree and certificate programs, along with workforce and professional development programs offered through Extended Learning. As Associate Dean Aaron is focused on keeping his finger on the pulse of workforce trends to ensure Extended Learning programs are relevant and responsive to the needs of employers in the region and around the world. He completed a Master's of Science in Applied Information Technology at Towson University and then an MBA at the University of Baltimore.

3) Sustainability

The grant funds will allow for a comprehensive, rigorous pathway to be established in the participating clusters in SDUSD. This allocation of funding will ensure that teacher training will be completed in 2 of the 3 clusters for all elementary and middle schools by the end of the 5th year of this grant. At that point, the district will incur only the cost of licencing a curriculum. The allocated funding will leave the district with teachers who are proficient in the subject matter, and who are competent and confident teaching computer science to students in grades 3-8.

D. Project Evaluation

1) Overview

The proposed evaluation includes both formative evaluation and summative evaluation of the proposed program activities. The formative evaluation aims to provide evidence of the fidelity of implementation as well as the process monitoring of ongoing implementation from year 2 to year 5 while the summative evaluation aims to examine the impact of the proposed activities on students and teacher outcomes using an experimental design in year 4-5.

2) Formative Evaluation

Extensive qualitative evaluation efforts will be conducted which, in conjunction with the quantitative data from the summative component, will be used to measure program success and make course corrections as needed to further strengthen the program.

Formative Questions

The formative evaluation process will be guided by the following key questions:

- How do teachers implement the designed curricular units?

- What sorts of adjustments or accommodations do teachers make to use the project resources?
- What do teachers report on the value of the resources on student achievement and engagement?

Goal #1: Provide in-depth teacher professional development in computer science (CS), coding and computer science pedagogy for elementary, middle and high school teachers.

Fidelity of PD Implementation			
Evaluation Question (s)	**Data Collection Activities**	**Data Collection Instruments**	**Data Collection Schedule**
1. Are teachers participating in the summer Bootcamps?	Monitor attendance and participation at summer Bootcamps	Sign in sheets	At the end of each Bootcamp
2. Does the Bootcamp provide pedagogical support to the teachers?	Evaluate Bootcamp syllabus Teacher focus group	Textual Analysis Teacher focus group protocol	Pilot phase At the end of each Bootcamp
3. Is the Bootcamp curriculum aligned with the [state standards]?	Evaluate Bootcamp syllabus	Textual Analysis	Pilot phase
4. Does teacher perceive the PD as effective to their knowledge building?	Teacher survey	Teacher survey	At the end of each Bootcamp
Strategy 2 If there are other support to provide to the teachers throughout the year, please put the activities here.			

Process monitoring of teachers' ongoing implementation			
Evaluation Question (s)	**Data Collection Activities**	**Data Collection Instruments**	**Data Collection Schedule**
1. Are teachers using the computer science & coding curriculum?	Export TechSmart log data	Log data (the system automatically detects and logs how many lesson units are unlocked; amount of time spent actively using the TechSmart platform)	At the end of each school year

2. How many students participated in the CS course?	Export TechSmart log data	Student participation log data collected through the TechSmart platform	At the end of each school year
3. What's the progress the student has made in the CS course?	Export TechSmart log data	Log data of the difficulty levels mastered collected through the TechSmart platform.	At the end of each school year
Strategy 2 If there are other support to provide to the teachers throughout the year, please put the activities here.			

Formative Evaluation Methods

Focus Group Interviews with a Representative Participant Sample: The lead evaluator and other project staff will conduct at least 2-3 focus group interviews with the project participants representing elementary and middle school by the end of each year. This qualitative data will enable the project team to build a complete integrity of implementation model that is faithful to the generative commitments of the project, yet malleable enough to function well across a variety of contexts.

Professional Development Evaluation: The project team will collect and interpret the software auto-graded assessments during each CS PD course. During each PD lesson a "lesson check" is given, formatively assessing progress on conceptual understanding as well as application (often resulting in a few lines of code being written). There is a quiz at the midpoint of each instructional unit (consisting of 3-6 lessons), and a test near the end (quizzes generally require around 10-15 lines of code, and tests up to 75 lines). Each unit concludes with a capstone project.

In addition, evaluation forms will be filled out by participants after every PD course; these evaluations are critically important in assessing the impact of each of the various programmatic activities the grant conducts, whereas summative evaluations only assess the impact of the grant overall.

Year End Surveys: At the end of each year, program participants will take an extensive online survey, which will collect feedback about the program as a whole. The surveys will be summarized and reported to project staff, and will be used to make course corrections.

Usage Data: Given the high number of learning opportunities teachers have in this program (such as computational thinking, writing computer code, learning algorithmic processes, problem solving, and computer science pedagogical techniques), we will assess to what extent the teachers make use of each opportunity. We will use this data to further improve the opportunities available, and to help make sure that teachers are *aware* of the opportunities. We will collect usage reports from "early adopter" teachers, and share them with the rest of the cohort.

Formative Reporting

The evaluation team will summarize and condense the collected data and report it to the project administration on an ongoing basis. At the end of each year, Dr. Popov will work with the project manager to prepare an annual report summarizing the progress of the grant toward meeting its objectives and stating which changes will be made in the future to further improve the grant. At the end of the grant, Dr. Popov together with the research analyst will work with the project staff to generate a final report summarizing the project success in enduring and replicable CS teacher professional development, the number and traits of students served, measurable success engaging underserved audiences and at-risk students in STEM education, and dissemination of curricular resources and lessons learned to applicable audiences.

3) Summative Evaluation

The Jacobs Institute will conduct a rigorous impact evaluation of the *CS-Urban Implementation Model* over the last two years of the grant. The evaluation will use a cluster-randomized trial design to examine the effects of CS-Urban Implementation Model on students' outcomes (CS skills, interest in learning CS, and confidence in using CS knowledge to solve problems) and teachers' outcomes (CS skills, CS teaching skills, confidence in teaching CS).

Research Questions

The evaluation questions are outlined below. Research questions 1-3 examine the impacts of the intervention on students' outcomes; research questions 4-6 examine the impacts of the intervention on teachers' outcomes; and research question 7 examines the moderation effects of students' characteristics.

1. For students whose teacher participates in the CS-Urban intervention, what is the effect of the intervention on their CS knowledge and coding skills (measured by the Computational Thinking Test (CTt) developed by Gonzalez (2017)) compared to students whose teacher does not participate in the CS-Urban intervention?
2. For students whose teacher participates in the CS-Urban intervention, what is the effect of the intervention on their confidence in using CS knowledge and coding to solve problems (measured by self-reported Computational Thinking Scale developed by Korkmaz, et al., 2015) compared to students whose teacher does not participate in the CS-Urban intervention?
3. For students whose teacher participates in the CS-Urban intervention, what is the effect of the intervention on their interest to learn computer science (measured by self-reported Computer Science Attitude survey developed by Wiebe et al. (2003)) compared to students whose teacher does not participate in the CS-Urban intervention?
4. For teachers who participate in the CS-Urban intervention, what is the effect of the intervention on their CS knowledge and coding skills (measured by the Computational Thinking Test (CTt) developed by Gonzalez (2017)) compared to teachers who do not participate in the CS-Urban intervention?
5. For teachers who participate in the CS-Urban intervention, what is the effect of the intervention

on their CS teaching skills (measured by 'Teacher Perspectives on Computational Thinking and Computing' survey by Pears, Dagiene, and Jasute, 2017) compared to teachers who do not participate in the CS-Urban intervention?

6. For teachers who participate in the CS-Urban intervention, what is the effect of the intervention on their confidence in teaching CS (measured by 'Teacher Perspectives on Computational Thinking and Computing' survey by Pears, Dagiene, and Jasute, 2017) compared to teachers who do not participate in the CS-Urban intervention?
7. What are the subgroup differences (e.g., Gender, Free-reduced lunch status, ethnicity, ELL status) in the impacts of the CS-urban intervention on students' outcomes (CS skills, interest in learning CS, and confidence in using CS knowledge to solve problems)?

Comparison Condition

The comparison condition will consist of business-as-usual instruction in the classes. In business-as-usual classrooms, teachers will deliver instruction in the traditional lecture format, with homework, readings, and group assignments to be conducted on the students' own time. The students in the business-as-usual classrooms will not have access to the TechSmart platform.

Eligibility and Recruitment of Study Participants

The study design is a cluster-randomized trial. At the end of Year 3, approximately 244 teachers of the 20 schools from two school clusters who have not participated in any of the intervention will be recruited for the impact study to allow for some attrition from the study while still maintaining adequate power. For interested teachers at each school, their enrollment of the boot camp, as well as the access to the online curriculum and technology platform, will be randomly assigned – half to the treatment condition and half to the control condition. The treatment group teacher will participate in the summer boot camp PD at the beginning of Year 4 while the control group teachers will not participate in the PD until the beginning of Year 5. Teachers who leave the school or drop out of the study during Year 4 will not be replaced.

Approximated 2400 students will participate in this study. Students who were transferred from a school which received the intervention will not be included in the study. However, all students of the teachers who participate in the *CS-Urban* intervention will be able to access the platforms and participate in the CS courses even though they are not in the study sample. The student sample for each classroom/teacher will be defined as students who have enrolled by one week before the first course starts. Students who enroll in study class after the start of the semester will be excluded from the study sample. Teachers who are recruited in the impact study will be given a $40 gift card each time when they participate in a pre or post assessments and surveys, and students who are recruited in the impact study will be provided a catered lunch every time when they participate in a pre or post assessments and surveys.

Sample Size and Power Analysis

To meet the WWC guidelines of examining the main effects on students' outcomes, a power and sample size estimation was conducted to determine the sample size based on the unit of randomization and the sources of clustering. Specifically, the statistical power estimates assume: (1) an alpha threshold of 0.05, (2) 50% of the variance in student-level outcome can be explained by student level covariates, (3) 10% of the variance in teacher-level outcome can be explained by teacher level covariates, (4) the Intraclass Correlation (ICC) equals to 0.25; (5) a power of 0.8, and (6) a minimum detectable effect size (MDES) of 0.25 standard deviations. Under these assumptions, the suggested sample size of the cluster is 123, so the proposed sample size should be sufficient to detect the MDES on the student outcomes even with a 10% teacher attrition rate.

Outcome Measurement

Students' computer science skills, confidence, and attitude outcomes will be measured by validated instruments. Specifically, we will utilize the Computational Thinking Scale (Korkmaz, et al., 2015) and the Computational Thinking Test (CTt) developed by Gonzalez (2017). Both instruments have reliability estimates >.75. To measure attitudes towards computer programming and computer science in general, we will use Computer science attitude survey developed by Wiebe et al. (2003). This instrument has five subscales (i.e., confidence in learning computer science and programming; attitude toward success in computer science; computer science as a male domain; usefulness of computer science and programming; and effective motivation in computer science and programming). Values of Cronbach's alpha range from 0.83 and 0.91 for the five subscales. The selected measure will be administered to both the treatment and comparison groups at baseline and end-of-year. Teachers' computer science skills, teaching skills, and confidence will also be measured by previously validated instruments, such as the Computational Thinking Test (CTt) developed by Gonzalez (2017) as well as the adapted questionnaire 'Teacher Perspectives on Computational Thinking and Computing' by Pears, Dagiene, and Jasute (2017) (the survey is available here https://bit.ly/2CFslpm). In addition, we will use the insight data teachers provide during the Bootcamp. Each time they turn in an assignment, they answer two questions: how confident are you and how interested are you (1-10 scale). Importantly, the identification and possible refinements to the assessments (given the lack of reliable and valid instruments in the literature to measure CS teaching skills and teacher confidence in teaching CS) – as well as the characterization of the target constructs which the assessments are intended to measure - will be an ongoing focus of the formative evaluation, as preliminary findings are developed and the instruments become amenable to psychometric examination. The development of a statistically valid instrument that can reliably measure the constructs under question will be a goal of the evaluation and could well turn out to be a valuable and innovative contribution to the knowledge base.

Impact analyses

To determine the intervention's impact on the students' outcome measures (research questions 1-3), we will fit a two-level hierarchical linear model (HLM) to each student outcome measure using the R "lme4" package (Bates, Maechler, Bolker, & Walker, 2014). Level 1 of the model is represented by Equation 1.

$$Outcome_{ij} = b_{0j} + b_{1j}Pretest + \sum b_{Ij}Demographics_{ij} + e_{ij} \quad [1]$$

Level 2 of the model is represented by Equation 2.

$$b_{0j} = g_{00} + g_{01}Tx_j + g_{02}TP_j + g_{03}TT_j + m_j \quad [2]$$

And the full mixed model is represented by Equation 3.

$$Outcome_{ij} = g_{00} + g_{01}Tx_j + g_{02}TP_j + g_{03}TT_j + b_{1j}Pretest_{ij} + \sum b_{Ij}Demographics_{ij} + m_j + e_{ij} \quad [3]$$

In this model, subscripts *i* and *j* denote student and teacher, *Outcome* represents student outcome on the posttest measures of students' knowledge, confidence, and interest, *Tx* is a dichotomous variable indicating treatment assignment, *TP* represents teachers' performance on the baseline CS knowledge test, *TT* represents teachers' teaching experience, *Pretest* represents students' performance on the pre-test, *Demographics* is a vector of student demographic variables, and *m* and *e* respectively represent random error at the teacher and student levels. In this model, the main effect of the intervention is captured by g_{01}.

To determine the intervention's impact on teachers' outcomes (research questions 4-6), we will run an ANCOVA test with each teacher outcome measure, with teacher-level covariates controlled.

$$Outcome_j = l_0 + l_{01}Tx_j + l_{02}Pretest_j + \sum_I lDemographics_j + e_j \quad [4]$$

In the model [4], subscripts *j* denote teacher, *Outcome* represents teacher outcome on the posttest measure of teachers' knowledge, skill, and confidence, *Tx* is a dichotomous variable indicating treatment assignment, *Pretest* represents teachers' performance or ratings on the pre-test, *Demographics* is a vector of teacher background variables, and *e* respectively represent random error of the teacher. In this model, the main effect of the intervention is captured by l_1.

Characteristics that are nonequivalent at baseline will be adjusted by including those variables at the appropriate level of the model. If there was significant attrition from the study, we will also compare the results of the complete case impact analysis with results obtained by multiply imputing missing post-test data, performing separate imputations for treatment and control, to better understand to what extent the attrition may have biased the findings.

Test of moderation effects

To address research question 7, we will conduct tests of moderation effects. Specifically, interaction terms between the treatment condition and students' characteristics will be added to the HLMs for the research questions 1-6 to examine whether the impacts of the intervention vary between student characteristics. Significant interaction terms will be plotted through the moderate.lm function of the R "QuantPsyc" package (Fletcher & Fletcher, 2010) to help interpretation.

4) Non-Experimentally Evaluated Objectives

Project Objective #1A, #2A, #2C, #2D, & #3A: Maintain High Levels of Participation and Program Satisfaction

Instrument: The project manager will maintain professional development (PD) completion records and attendance logs for all project activities.

Timeline: PD completion records and students' attendance logs will be updated with each event in the program.

Analysis: The percentage of participants that are on-target to meet the goal will be calculated on an ongoing basis throughout the year.

Targets:

- The number of teachers successfully completing computer science teacher professional development will be 310
- The percentage of students completing computer science courses in the district will be 40% of ES students and 26% MS students
- 80% of students taking a computer science course will score 80% on insight data, which measures

students self reported interest and confidence for each item turned in (lesson activity exercise.)

- The number of underrepresented students successfully completing computer science courses will increase by 20% for African American students, and 25% for Hispanic students at participating schools

Reporting: Teacher and student participants that are falling behind on these project objectives will be offered programmatic support to help meet the target; at the end of the year, the final total will be reported in the annual report.

Project Objectives #1B, #3B, #4A: Participating Teachers and Students will Complete Grant Activities

Instrument: The project manager will maintain records of all relevant activities.

Timeline: Records will be kept on an ongoing basis.

Analysis: Progress toward meeting these simple objectives will be calculated throughout the year.

Targets:

- All participating teachers will score 75% or greater on each **end of unit summative assessment** in the computer science professional development course.
- 90% of participating teachers will successfully complete the **hands-on** final coding project in the computer science professional development course.

- 30% of participating **students** will earn **four** (or more) Computer Science Competency Certificates**.**
- 20% of **teachers** at participating schools will earn **one** Computer Science Competency Certificate during the first year.
- 80% of participating **students** will earn **one** Computer Science Competency Certificate during the first year.
- The percentage of participating students completing **out-of-classroom** work-based computer

science learning opportunities 50% of participating elementary school students participating in company visits. 20% of participating middle school students participating in virtual industry chats and company visits.

Reporting: Participants that are failing to meet one or more objectives will be contacted by the project manager to ensure that they meet the target; at the end of each year, progress on each objective will be reported in the annual report.